The importance of organisational slack as an unexplored determinant of firm level innovation and performance in the construction context

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The Importance of Organisational Slack as an Unexplored Determinant of Firm Level Innovation and Performance in the Construction Context

*Nihil simul inventum est et perfectum*

by

Christopher Anthony James Horsthuis

Submitted in partial fulfilment of the requirements for the award of Doctorate of Philosophy of Loughborough University

School of Civil and Building Engineering

Monday, 02 March 2015

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Abstract

Construction literature forwards innovation as a desirable objective for firms. Innovation is argued to; improve the firm’s performance, increase market share, establish a competitive advantage, and ultimately ensure firm survival. Literature has overlooked the role of organisational slack within construction firms as a determinant of innovation despite the concept being well developed within the general management literature. This research uncovers and examines the impact of organisational slack on firm-level innovation as a determinant of innovation within the construction sector. This work forwards organisational slack as an unexplored firm level determinant of innovation within the construction context. Using the resource-based view of the firm, as a framework for firms, the thesis develops links between previously established firm level determinates of innovation to and slack to support its proposal as a determinant of innovation. Following this traditional measures of innovation argued fail to accurately capture innovation in the construction context, with patents represent inventions, while R&D expenditure is not applicable within the construction. Due to these failures of traditional approaches to measuring innovation, firm level performance is forwarded as a proxy measure for innovation outcomes. Developing existing slack literature, this thesis develops hypotheses proposing inverse U-shaped (∩) and U-shaped (∪) relationships between the level of slack and innovation outcomes.

The thesis presents mixed method research. Study 1 adopts a deductive research strategy, incorporating statistical analysis to test the hypothesised relationships. The Research Design develops and Archival analysis research method; mirroring the approaches of econometric research found in slack literature. The data analysis explores two contexts: construction and manufacturing, allowing a comparative baseline to be established. The analysis of data from this study reveals that discrepancies in the $R^2$ between the contexts is largely the result of the inability of control variables (Age, Size and Number of employees), to explain variation in firm performance (as a proxy for innovation outcomes) in a construction context, rather than the unsuitability of slack in the construction context.

In construction firms, Unabsorbed Slack and Financial Slack demonstrated statistically significant results supporting an inverse U-shaped relationship with firm performance (∩) supporting Hypothesis 1a and 1b. Contrary to this Absorbed Slack and Human
Resource Slack demonstrated statistically significant results demonstrating a U-relationship (\(\cup\)) between slack and performance supporting hypothesis 2b (H2b).

Study 2 adopts a deductive research strategy, incorporating semi-structured interviews as a source of primary data in order to explore the slack-innovation relationship in greater depth. Primarily, this study provided evidence to suggest that construction firms do not directly measure innovation. Instead, firms choose to measure outcomes of changes within the firm, typically in terms of measure relating to firm financial performance. Evidence from this study supports the proposal of firm financial performance as a viable proxy for innovation outcomes in Study 1. In addition to this when faced with changes to their environment, participants responses typically supported a positive linear relationship between the level of organisational slack and the firm.

This research is the first to examine the impact of organisational slack on construction firm financial performance (as a proxy for innovation). This relationship is curvilinear in nature, however, the results are inconclusive if it is inverse U shaped (\(\cap\)) or U shaped (\(\cup\)) based upon conflicting evidence from different slack variables. What can be ascertained however, is that the level of slack impacts firm level performance and theoretically impacts firm level innovation.

Key Words: Innovation, Construction, Organisational Slack, Mixed Method, Interview, Econometrics, Multiple Regression, Deductive
LIST OF CONTENTS

ACKNOWLEDGEMENTS .......................................................................................................................... I
ABSTRACT .................................................................................................................................................. III
LIST OF CONTENTS ........................................................................................................................................ V
LIST OF FIGURES .......................................................................................................................................... IX
LIST OF TABLES ........................................................................................................................................... X
LIST OF EQUATIONS ..................................................................................................................................... XII

CHAPTER 1. DEFINING THE RESEARCH PROBLEM .............................................................................. 1
  1.1 IMPORTANCE OF INNOVATION WITHIN UK CONSTRUCTION SECTOR ............................................ 1
  1.2 EXPLAINING THE CURRENT LACK OF INNOVATION ................................................................. 2
  1.3 DEFINING CONSTRUCTION .............................................................................................................. 3
  1.4 ESTABLISHING A UNIT OF MEASUREMENT ................................................................................... 4
  1.5 STIMULATING INNOVATION ............................................................................................................ 7
    1.5.1 Research Problem (RP) ........................................................................................................... 7
    1.5.2 Research Objectives (RO) ........................................................................................................ 13
  1.6 GUIDE TO THE THESIS .................................................................................................................. 14

CHAPTER 2. REVISITING INNOVATION IN CONSTRUCTION .............................................................. 18
  2.1 INTRODUCTION .................................................................................................................................. 18
  2.2 THE STUDY OF INNOVATION .......................................................................................................... 19
  2.3 CURRENT STATE OF INNOVATION IN CONSTRUCTION ............................................................... 20
  2.4 EXPLAINING THE CONCEPT OF INNOVATION ............................................................................. 22
    2.4.1 Disambiguating Innovation ‘object’ from Innovation process .................................................... 23
    2.4.2 Distinguishing Inventions from Innovations ........................................................................... 24
    2.4.3 Differentiating Innovation to Change ........................................................................................ 25
  2.5 DEFINING OF INNOVATION .............................................................................................................. 25
    2.5.1 Types of Innovation .................................................................................................................. 27
  2.6 APPROACHES TO INNOVATION ...................................................................................................... 30
    2.6.1 The process of innovation ......................................................................................................... 30
    2.6.2 Market and resource based views of innovation .................................................................... 32
    2.6.3 Innovation generation and Adoption: The purpose of Innovation ........................................... 34
  2.7 LEVELS OF ANALYSIS OF INNOVATION IN CONSTRUCTION .................................................... 39
    2.7.1 Cross sector analysis .................................................................................................................. 39
    2.7.2 Sources of Innovation in the Construction Supply Chain ....................................................... 41
    2.7.3 Project based perspective of innovation in construction ....................................................... 44
    2.7.4 Differentiating innovative and non-innovative firms in construction ..................................... 46
    2.7.5 Summary .................................................................................................................................. 51
    2.7.6 Focusing upon firm level differences ....................................................................................... 52
  2.8 A GAP IN THE KNOWLEDGE OF INNOVATION IN CONSTRUCTION ........................................ 53
    2.8.1 Positioning ‘slack’ as an determinant of innovation ................................................................. 54
  2.9 CHAPTER SUMMARY ....................................................................................................................... 56

CHAPTER 3. EXPLORING ORGANISATIONAL SLACK ...................................................................... 58
  3.1 INTRODUCTION .................................................................................................................................. 58
  3.2 INTRODUCTION TO THE CONCEPT OF ORGANISATIONAL SLACK ............................................ 59
  3.3 DEFINING THE FIRM AS THE UNIT OF ANALYSIS FOR THE STUDY OF SLACK ......................... 60
  3.4 DEFINING AND CONCEPTUALISING ORGANISATIONAL SLACK .................................................. 61
    3.4.1 Origins ..................................................................................................................................... 61
    3.4.2 Developments of the concept ................................................................................................. 62
  3.5 TYPES OF SLACK WITHIN THE FIRM ............................................................................................. 64
    3.5.1 Available, Recoverable and Potential ..................................................................................... 64
    3.5.2 Absorbed and Unabsorbed .................................................................................................... 65
    3.5.3 High and low discretion ....................................................................................................... 66
    3.5.4 Financial and Human resource slack ...................................................................................... 67
    3.5.5 Developing an alternative typology ....................................................................................... 68
  3.6 MANIFESTATIONS OF SLACK WITHIN THE FIRM ....................................................................... 71
    3.6.1 Inducement ............................................................................................................................. 71
    3.6.2 Conflict resolution ............................................................................................................... 73
LIST OF FIGURES

Figure 1 - A Model For Construction Economics: A New Approach After Myers (2013:17) .................. 5
Figure 2: The Theoretically Formulated Framework After Bassioni Et Al. (2005) ............................ 7
Figure 3: A Model Of Stages In The Innovation-Decision Process (Rogers, 1995) ........................... 31
Figure 4 - Value-Added Chain In Construction As Sources Of Innovation (After Slaughter 2000: 4) . 43
Figure 5: Two Moment Model Of Construction Innovation (Winch 1998:273) ............................... 45
Figure 6: Slack In The Chain .................................................................................................................. 60
Figure 7: Typology Of Slack After Stan Et Al (2013) ........................................................................... 69
Figure 8: Re-Developed Typology Of Slack Constructs ........................................................................ 70
Figure 9: Opposing Views On The Impact Of Organisational Slack On The Firm (A) Positive (B)
Negative. ................................................................................................................................................. 82
Figure 10: Alternative Resolutions Of Conflicting Slack Perspectives (A) Inverse-U Shaped (B) U-
Shaped ................................................................................................................................................... 83
Figure 11: The Complexities Of Capturing Organisational Slack Within The Firm ......................... 86
Figure 12: Typology Of Operational Definitions Of Organisational Slack (Adapted From Marino And
Lange (1983) ....................................................................................................................................... 89
Figure 13: Alternative Perspective Of The Curvilinear Relationship Between Slack And Benefit To The
Firm: Inverse U-Shaped (A); And U-Shaped (B).................................................................................. 103
Figure 14: Rbv Generation Of Rent Via Innovation ............................................................................ 114
Figure 15: Product And Process Views Of The Relationship Between Innovation And Performance 128
Figure 16: Constructed Process View Of Innovation Model ............................................................... 132
Figure 17: Synthesised Model Of Perspectives Determining Firm Innovation And Performance ...... 133
Figure 18: Purely Deductive And Inductive Research Processes, After Kovács & Spens (2005:137) 142
Figure 19: Matrix Of Research Designs, After Easterby-Smith Et Al. (2002) .................................... 152
Figure 20: Choice Of Research Method Based On Research Control, Adapted From Buckley Et Al. (1976)
............................................................................................................................................................. 153
Figure 21: Redeveloped Typology Of Slack Constructs ....................................................................... 170
Figure 22: Data Generation And Analysis Protocol ............................................................................. 205
Figure 23: R² Results From Regression Analysis Against Roa, T-1....................................................... 217
Figure 24: Durbin-Watson Statistic Using Roa As A Performance Measure, Construction, T-1 ....... 219
Figure 25: R² Results From Regression Analysis Against Profits, T-1 ................................................ 223
Figure 26: Durbin-Watson Statistic Using Profits As A Performance Measure, Construction, T-1 ... 225
Figure 27: R² Results From Regression Analysis Against Roa, Manufacturing, T-1 ....................... 229
Figure 28: Durbin-Watson Statistic Using Roa As A Performance Measure, Manufacturing (T-1) ... 240
Figure 29: R² Results From Regression Analysis Against Manufacturing Firm Profits (T-1) .......... 244
Figure 30: Durbin-Watson Statistic Using Profits As A Performance Measure (T-1) ......................... 246
Figure 31: Comparison Of R² Results, Profits ..................................................................................... 255
Figure 32: Comparison Of R² Results, Roa ......................................................................................... 256
Figure 33: Re-Developed Typology Of Slack Constructs ....................................................................... 289

IX
LIST OF TABLES

Table 1: Organisational type and innovation (after Damanpour & Wischnevsky 2006:271)........................................... - 36 -
Table 2: Managerial actions to mobilise mechanisms inducing commitment and motivation after Hartmann (2006:162) ........................................................................................................................................... - 39 -
Table 3: Typical measures of slack constructs .......................................................................................................................... - 50 -
Table 4: Functions of slack within firms adapted from Bowen (2002) .................................................................................. - 71 -
Table 5: Issues measuring slack adapted from Bourgeois (1981:32 and 35) ........................................................................ - 87 -
Table 6: The logics of the four research strategies after Blaikie (2007:8) ............................................................................. - 141 -
Table 7: Polarities and assumptions adopted by researchers, adapted from and Burrell and Morgan (1979:3) .... - 145 -
Table 8: Contrasting implications of positivism and social constructivism, after Easterby-Smith et al. (2002) .... - 148 -
Table 9: Research choices, adapted from (Yin 2009:8) ........................................................................................................... - 156 -
Table 10: The virtues of ‘good’ theory against the theory of slack, adapted from Wacker (1998) ..................... - 162 -
Table 11: Firm type dummy variables ................................................................................................................................. - 183 -
Table 12: Variables for study ........................................................................................................................................................ - 184 -
Table 13: Manufacturing firm type dummy variables ........................................................................................................... - 186 -
Table 14: Blank Data sample selection strategy ................................................................................................................... - 187 -
Table 15: Choosing among Statistical techniques, after Tabachnick & Fidell (2001:27) ................................................. - 188 -
Table 16: F.A.M.E. selection procedure for the construction context .......................................................................................... - 190 -
Table 17: Example of multiple regression analysis results table ........................................................................................... - 195 -
Table 18: Methods used to construct validity - adapted from Yin (2009:41) ........................................................................ - 203 -
Table 19: Descriptive statistics of final construction context sample at t-1 ........................................................................... - 208 -
Table 20: Pearson's correlation, construction at t-1 ................................................................................................................. - 211 -
Table 21: Pearson's correlation, construction at t-2 ................................................................................................................ - 211 -
Table 22: Durbin Watson boundaries, after Gujarati (2012:688) ............................................................................................. - 213 -
Table 23: Multiple regression results: ROA, construction, t-1 .............................................................................................. - 215 -
Table 24: Multiple regression results: Profits, construction, t-1 ........................................................................................... - 216 -
Table 25: F-Ratio results of validity of ROA as performance variable, construction, t-1 .................................................... - 218 -
Table 26: VIF of predictor variables, construction, t-1 ............................................................................................................. - 220 -
Table 27: F-Ratio results of validity of Profit as performance variable, t-1 ........................................................................... - 224 -
Table 28: Manufacturing firm types included in sample ....................................................................................................... - 231 -
Table 29: F.A.M.E. selection procedure for the manufacturing context ................................................................................ - 232 -
Table 30: Descriptive statistics of final manufacturing context sample at t-1 ................................................................. - 233 -
Table 31: Pearson correlation table, manufacturing at t-1 ....................................................................................................... - 236 -
Table 32: Pearson correlation table, manufacturing at t-2 ....................................................................................................... - 236 -
Table 33: Multiple regression results: ROA, manufacturing, t-1 ........................................................................................... - 238 -
Table 34: Multiple regression results: Profits, manufacturing, t-1 ...................................................................................... - 239 -
Table 35: F-ratio results of validity of ROA as performance variable, manufacturing, t-1 .............................................. - 241 -
Table 36: VIF results of predictor variables from manufacturing context (t-1) ....................................................................... - 242 -
Table 37: F-ratio results of validity using Manufacturing firm Profits as performance variable (t-1) .................. - 246 -
Table 38: Summary of beta coefficients from regression analysis, construction ............................................................... - 258 -
Table 39: Summary of beta coefficients from regression analysis, manufacturing ........................................................... - 258 -
Table 40: Summary of regression analysis relationships ................................................................................................... - 260 -
Table 41: Interview Respondent information ........................................................................................................................... - 264 -
Table 42: F.A.M.E selection procedure for the construction context ................................................................................... - 336 -
LIST OF EQUATIONS

Equation 1: Absorbed Slack After Love & Nohria (2005) ................................................................. - 171 -  
Equation 2: Unabsorbed Slack After Herold Et Al. (2006) ................................................................. - 172 -  
Equation 3: Hr Slack After Mishina Et Al. (2004) .............................................................................. - 173 -  
Equation 4: Financial Slack ................................................................................................................. - 173 -  
Equation 5: Multiple Regression Equation (Continuous Variables) .................................................... - 192 -  
Equation 6: Regression Model Equation For Dummy And Control Variables (Model 1) .................... - 193 -  
Equation 7: Regression Model Equation For Single Slack Variable Example (Models 2 to 5) ............ - 194 -  
Equation 8: Regression Model Equation For Multiple Slack Variables Example (Model 6) .......... - 194 -  
Equation 9: Regression Model Equation For Non-Linear Slack Variables Example (Model 9) ...... - 194 -  
Equation 10: Critical Variation Inflation Factor Value Developed From Field (2005) ................. - 196 -
Chapter 1. Defining the Research Problem

1.1 Importance of Innovation within UK Construction Sector

Innovation is argued to be vital for firms both within construction and in other sectors. However, innovation in itself is complex, non-linear and dynamic, and consequently is variable in its definition and conceptualisation (Leiringer 2003; Aouad et al. 2010). Innovation represents a point of interaction between a relevant unit, for example a construction firm, and a concept that it perceives to be new. A clear definition is important as it distinguishes innovation from other concepts such as change, invention and imitation (Leiringer 2003). For the purpose of this work innovation is defined as “the effective generation and implementation of a new idea, which enhances overall organizational performance” (Barrett & Sexton 2006:337). Ensuring that an innovation is applied ensures a distinction from novel ideas that are not used within the firm, and therefore are not of interest.

Innovation is widely recognised to provide firms within the construction sector and other industries with a means of creating a competitive advantage (Kissi et al. 2012), allowing firms to distinguish themselves from the competition (Damanpour & Wischnevsky 2006; Bowen et al. 2010; Abadi & Fenn 2012). In construction, innovation is argued to be driven by a number of purposes including: problem solving on-site (Shaw et al. 2010); environmental sustainability (Thorpe et al. 2008); improved project performance; responding to expectations from clients; and ultimately profit maximisation (Kissi et al. 2012). Within this work, focus is placed upon the drive for improved business performance though innovation in construction firms.

Considerable attention is also paid by research and government initiatives to encourage construction firms to innovate in order to navigate increasingly competitive markets (Erbil & Akincitürk 2010; Larsen 2011). Government initiatives look to innovation in order to improve the construction sector as a whole, concerning both environmental performance (Hardie & Newell 2011; Whyte & Sexton 2011) and improved sector performance (Sexton et al. 2006; BIS 2013). Moreover, construction firms face the challenges of increased competition. To face and respond to these challenges, and to remain competitive in the market, construction firms are urged by construction researchers to develop and/or adopt innovations (Shaw et al. 2010; Larsen 2011).
Construction is considered to be a vital sector, which contributes to a significant proportion to not only the UK economy, but also economies globally (Seaden et al. 2003; Thorpe et al. 2008; Aouad et al. 2010). Within the UK, construction contributes 6.7% of the Gross Value Added (GVA) and employs the equivalent of 10% of the total UK workforce (BIS 2013). These contributions are also seen to be replicated internationally (Thorpe et al. 2008). Barrett et al. (2007) indicate that in its broadest sense construction can contribute up to 20% of the national GDP, when both upstream and downstream activities are included such as; manufacturing, mining and real estate activities. Developing a greater understanding of the antecedents of firm level innovation in construction is not only a firm or sector level issue, but also one that connects to the national and global economy.

1.2 Explaining the current lack of innovation

The demand for innovation, detailed above, faces a significant obstacle. Within construction, firms are argued to fail to innovate as readily as other sectors within the global (Thorpe et al. 2008; Hardie & Newell 2011; Larsen 2011) and UK economies (Barrett et al. 2007). Innovation rates within the construction sector have been argued to be below sectors such as manufacturing, electricity, gas & water supply and communications (Thorpe et al. 2009). Within the construction sector, there is argued to be a lack of not only technical innovations, but also a lack of Research and Development investment across the industry. In relation to this, Barrett & Sexton (2006) note that investment in R&D, within the construction industry, has fallen by 80% since 1981. This is more recently supported by BIS (2013) which also notes that the construction sector has lower R&D expenditure compared to other sectors, and has continued to decline since 2000.

As an explanation for the lack of innovation within the construction sector, literature points to several industry characteristics, which are argued to inhibit the rate of innovation. Among these explanations, emphasis is often placed upon (i) the project based nature of construction activities, (ii) high level of fragmentation, (iii) relationships between firms that are not only temporary but adversarial, (iv) risk adverse attitude, and finally (v) a lack of both surplus financial and time resources for investment (Nam & Tatum 1988; Blayse & Manley 2004; Hardie & Newell 2011; BIS 2013). Whilst these characteristics might appear in other industries, it has been argued that the combination
of them makes construction unique (Hillebrandt 1985; Koskela & Vrijhoef 2001), thus warranting individual attention distinct from other industries.

However, it is argued that the construction characteristics fail to provide an explanation for the disparity of innovation rates between construction firms within the construction sector, and thus fail to provide a complete explanation of the lack of innovation within the sector as a whole. The majority of emphasis within construction literature overlooks mainstream management research on the significance of excess resources. Whilst it cannot be denied, the characteristics of construction are pertinent in explaining some degree the deficiency of innovation within the construction sector as a whole, research must look elsewhere to explain why some firms within construction are capable of innovation and others are not. It is argued this can be revealed through the understanding of the determinants of firm level innovation, more specifically the effect of excess resources, termed ‘slack’.

1.3 Defining Construction

Prior to investigating innovation, it is important to first clarify the context with which the research will be done, in this case ‘construction’, as managerial practice does not function in a vacuum and is heavily influenced by its context (Fernie et al. 2006). Construction, however, is not so easily defined, due to the various firms types that work within the field of construction, there is argued to be an overlap with several other industries (Groåk 1994). The conventional conceptualisation of construction as an industry is limited to firms directly involved with the erection of construction projects. According to O.N.S (2007:149) construction is classified as consisting of: “the complete construction of buildings (division 41), the complete construction of civil engineering works (division 42), as well as specialised construction activities, if carried out only as a part of the construction process (division 43)”. However, Groåk (1994) notes that construction in fact overlaps with many other industries and has ill-defined boundaries. As seen in Barrett et al. (2007) value adding construction activities can include manufacturing, mining and quarrying, architectural and technical consultancy, and real estate activities.

Whilst the above definition is precise, selecting only firms involved in the construction process excludes the design and growing number of consulting practices that have emerged with the prominence of construction management as a distinct practice with the
construction process (Wegelius-Lehtonen 2001; Winch 2003; Reichstein et al. 2005). A broader conceptualisation of the construction as a ‘sector’ is considered by Reichstein et al. (2005:634), whereby it is considered that construction includes contractors, manufacturers, suppliers, surveyors, engineers, consultants and architects, and any other firms relating to the development of a construction project, which are not considered in the above. The broader definition of construction is also adopted in BIS (2013), an economic survey of construction within the UK. Here construction is defined as: (i) construction contracting industry (representing the SIC (2007) definition above); (ii) provision of construction related professional services; and (iii) construction related products and materials. Although this definition excludes distribution and sales of construction products, this much broader conceptualisation provides a more realistic perspective of construction, than the restricted SIC (2007) ‘industry’ definition.

For this work, it is argued that the broader conceptualisation of the construction sector be adopted. The boundaries of construction sector in this research is defined following BIS (2013), the full list of firms as represented by their 2007 Statistical Industry Classification (SIC) code system for industry statistics, is included in Appendix 1. This list of firms broadens the population from which this research might sample. Incorporating firms involved with the design, materials supply and management with those involved with its assembly provides a more practical representation of the construction sector. By broadening the number of firms under investigation, it might include a larger number of innovative firms for analysis.

1.4 Establishing a unit of measurement

Returning to innovation as a subject for inquiry, from a theoretical perspective, innovation can be measured from any discernible level within the economy, from sectors to sub-units and even to individuals. Therefore, it is necessary to fix the unit being investigated, thus providing a relevant unit of analysis, so that innovation theories surrounding this unit can be explored and objective comparisons made. From an established unit it is possible to establish benchmarks and thus compare the units that ‘innovate’ to those that do not, and extract information about why units differ in terms of innovative capabilities. In the approach to analysis, Deng et al. (2012) note that investigations may be broken down into three main areas of focus:

1) Project purpose: evaluating individual projects or processes.
2) Business/Firm purpose: examining individual construction organisations both at a set point in time and continuously.

3) Industry Purpose: assesses the construction industry both nationally and internationally.

![Figure 1 - A model for construction economics: a new approach after Myers (2013:17)](image)

Similarly, Figure 1 above, taken from Myers (2013) illustrates the levels of economic analysis seen with research, in this case including a fourth category of the economy as a whole. The levels (industry, firm and project) correspond to the foci presented by Deng et al. (2012) above. These three areas explore different levels of the economy, from the broad conceptualisation of industry such as construction, to the individual projects being conducted. The following provides a rationale for first rejecting project and industry level analysis, then support for selecting the firm as a unit of analysis when examining innovation.

Firstly, construction projects are rejected as a viable unit of analysis within this research. Although construction firms do gravitate around projects (Groák 1994; Gann & Salter 2000), due to project complexity and variability (Wegelius-Lehtonen 2001) it is inappropriate to examine innovation at the project level. Project teams, project sites and design are continually different (Wegelius-Lehtonen 2001), therefore cannot be meaningfully compared, and are consistently novel within some regard thus are, more often than not, novel in themselves. In contrast, firms are well established units of analysis within general literature, are distinct and comparable in nature, and operate within the same context. Therefore might be meaningfully compared in order to extract
information relating to innovation, negating emphasis on the characteristics of construction.

Industries or sectors as units of analysis are similarly difficult to compare, as there is a tendency for overlapping and ill-defined borders placed around industry levels (Groák 1994). Furthermore, a like-for-like comparison is not suitable, nor possible due to the heavily contextualised nature of industries as a unit (Winch 2003). While the construction sector shares a number of its characteristics with other industries, such as mining (Koskela & Vrijhoef 2001), the combination of characteristics seen in section 1.4 are argued to only appear in construction (Hillebrandt 1985). The treatment of cross industry comparisons can lead to an overemphasis of these characteristic differences between industries as opposed to the features shared that promote innovation (see Reichstein et al. 2005). While cross industry comparisons remain somewhat viable, the researcher must ensure that the appropriate information extract is not overshadowed by its differences in relation to other industries. In essence, cross-industry comparisons are argued to reveal differences between industries, as opposed to the determinants of innovation.

Within construction research, the majority of the developments of the understanding of innovation focus upon either the sector or the project level issues, consequently impairing the firm as a viable unit of analysis within construction (Reichstein et al. 2008). In order to further the understanding of innovation in construction, focus must be placed upon ‘the firm’ as the unit of analysis. It is argued that the rate of innovation at a sector and project level is determined by the capabilities of construction firms, collectively within the sector, or those engaging with a specific project. The use of the firm as a unit of analysis also allows comparison with developments relating to innovation in mainstream management research, which is otherwise not possible.

Support for the adoption of a firm level perspective comes below in Figure 2, taken from Bassioni et al. (2005), in the assessment of performance factors. The figure illustrates a number of driving factors ultimately lead to business results. The management of innovation, learning and knowledge (see Driving factors) all support project results, indicating that innovation aids project performance. However, further on, these project results ultimately conclude in the business results or firm level performance. As stated earlier, innovation is argued to improve firm performance.
through profit maximisation and a number of other benefits. The figure illustrates that innovation at the deployment stage, and project results, ultimately support business results. Following this logic the author proposes that project level innovations, if codified by the firm, leads to firm level innovation. Therefore, innovation that occurs at the project level can be demonstrated at the higher firm level also.

Within this research, the firm is selected as the unit of analysis, as it offers a fixed comparable unit, removed from the variation and complexity of projects, and the overshadowing characteristics demonstrated at the sector level. The adopted definition of a firm is taken from Myers (2013:97): “A firm is an organisation that brings together different factors of production, such as labour, land and capital, to produce a product or service which is hoped to be sold for a profit”. Utilising construction firms as units of analysis will allow for comparisons to be made, and a deeper understanding of how innovation emerges at the firm level.

![Figure 2: The theoretically formulated framework after Bassioni et al. (2005)](image)

1.5 Stimulating Innovation

Although some argue that there is a lack innovation in construction (Thorpe et al. 2008; Hardie & Newell 2011; Larsen 2011), and while others contest this position (Winch 2003; Barrett et al. 2007), what endures from these arguments is that within construction
some firms are capable of innovation and some which are not. It is argued by the author, having selected the firm as the unit of analysis, that through the examination of firms capable of delivering innovations it is possible to extract the factors that might stimulate innovation throughout the sector.

Barrett & Sexton (2006) state that small to medium construction firms, which are noted to dominate the construction sector, lack essential organisational slack (excess resources) to deliver innovations. Nam & Tatum (1997) further reference the concept of slack (as excess resources) as a determining factor in enabling leaders to aid the delivery of innovation within construction firms. The lack of resources as a whole within the firms is also seen as a diminishing influence on the ability of the entire construction industry to innovate compared to other industries (BIS 2013), however, the importance of resources at the firm level is argued within this thesis to be overlooked within construction research. It is proposed by the author that the concept of organisational slack is vitally important to understanding how firms innovate, and the disparity between those that can and cannot innovate. Despite the importance of ‘organisational slack’, it is often not defined, explored or conceptualised within the construction literature, which examines the understanding and improvement of firm level innovation.

It is argued by the author that firms use organisational slack to develop and maintain factors that determine firm level innovation. For instance innovation determinants such as organisational culture (Egbu et al. 1998; Hartmann 2006); leadership (Nam & Tatum 1997); internal capabilities (Geroski et al. 1993); and inter-organisational networks (Sexton et al. 2006) all rely upon and a pool of resources within the firm to fund their development and maintenance. Firms rely upon access to excess resources within the firm not committed to current activities, to support, fund and deliver innovation. The presence of organisational slack arguably provides the necessary resources to enable these factors to exist within the firm. The concept of ‘slack’ has been more widely developed within general management literature, and has been used in the study of a variety of contexts including but not limited to: domestic airlines (Cheng & Kesner 1997); high technology and low technology industries (George 2005); Chinese State owned enterprises (Tan & Peng 2003); Multi-national corporations (Nohria & Gulati 1997); and a wide variety of manufacturing industries (Wefald et al. 2010; Bradley, Wiklund, et al. 2011). However, organisational slack is yet to be explored within a
Defining the Research Problem

construction context, a context that is argued to be distinct from other sectors both in terms of structure (Halpin & Senior 2011) and characteristics (Hillebrandt 1985).

For this research, organisational slack is defined within general management literature as “the pool of resources in an organisation that is in excess of the minimum necessary to produce a given level of organisational output” (Nohria and Gulati 1996: 1246). It has been proposed that certain firms within the construction industry lack sufficient Organisational slack or ‘slack’ (Barrett & Sexton 2006; Hardie & Newell 2011) resulting in an overall lack of innovation within construction. Thus, were these firms able to amass greater/higher levels of organisational slack they would be capable of innovating more readily. The level of slack within the firm is argued to underpin firm level innovation and performance, offering an explanation to the discrepancy between high and low innovating firms.

Within general management literature, proponents argue that organisational slack is used to both enable and motivate the firm’s ability to innovate through a number of functions afforded by the presence of excess resources. The presence of slack enables firms to not only actively finance innovation (Cyert & March 1963), but also affords the time necessary to engage with such associated activities (Bourgeois 1981), and resources to motivate individuals to innovate (Penrose 1959; Pitelis 2007). For instance, uncommitted staff time, generated by excess human resources, allows for the autonomy and flexibility to engage with problem detection, learning and problem solving (Singh 1986; Salge & Vera 2013). Slack exists as excess resources in the firm, which enables and legitimises experimentation, allows for inducement and rewards, and provides a cushion against the risk of failure associated with innovation (Tan & Peng 2003). Without the necessary levels of organisational slack, firms are unable to engage with the functions demonstrated above, are unable to innovate, and ultimately become stagnant.

Slack is also associated with firm level performance as well as firm level innovation. Slack’s relationship with performance is formed by slack ability to protect the firm from internal and external variation, by providing a cushion that protects the activities of the firm (Bourgeois 1981). Whilst innovation is often argued to lead to improved firm level performance, it is argued that greater levels of organisational slack fuels not only greater levels of innovation, but also greater firm level performance through innovation, and also improved performance in its own right. Therefore slack is capable of influencing
both innovation and performance at the firm level, this is essential to this research which requires and deeper understanding of the slack-performance relationship.

Whilst assertions might be made regarding organisational slack within the construction context, these statements have not been theoretically or empirically explored. Within other industries, it has been demonstrated that organisational slack has a relationship with both firm level innovation (Chen & Huang 2010; Mousa & Chowdhury 2014) and firm level performance (George 2005; Bradley, Shepherd et al. 2011). These relationships are most commonly demonstrated by measuring organisational slack within the firm using econometrics in order to measure the level of resources within the firm. Although econometric measures are a proxy for the full extent of the slack resources within the firm (Love & Nohria 2005), strong statistical relationships have frequently been demonstrated (Daniel et al. 2004). The measures used within previous slack research target metrics which might indicate the accumulation of excess of resources within the firm, these generally relate to the constructs of resource types within the firm. For instance, resources that more are heavily absorbed by firm activities such as sales general and administrative expenditure (SG&A) (Love & Nohria 2005), these are referred to as absorbed slack. Alternatively, resources less absorbed and consequently freer for allocation within the firm such as cash reserves (Bradley, Shepherd et al. 2011), are termed unabsorbed slack. Firm resources are conceptualised is such a way to aid the understanding of different resources within the firm. Whilst it has been suggested that different slack resources affect the firm differently (Chen & Huang 2010), presently evidence has failed to support this statement (Tan & Peng 2003) and comparative studies have demonstrated that different slack types commonly resources share the same relationships with firm outcomes (Daniel et al. 2004).

Existing research on slack, both theoretically and empirically supports a number of relationships between slack and firm outcomes such as innovation and performance. It is argued that by replicating the methods demonstrated extensively within existing slack literature, a relationship can be demonstrated within the construction context between organisational slack and firm innovation. Thus providing evidence for organisational slack as a determinant of innovation within construction. Literature has demonstrated not only positive linear relationships (Bromiley 1991; George 2005), but also negatively linear (Daniel et al. 2004); curvilinear inverse-U shaped relationships (∩) (Nohria & Gulati 1997; Tan 2003; Tan & Peng 2003; Chen & Huang 2010; Bradley, Wiklund et
al. 2011); and curvilinear U-shaped relationships (∪) (Chiu & Liaw 2009; Lin et al. 2009). Whilst Daniel et al. (2004) concluded, following a meta-analysis of a wide range of slack studies, that organisational slack has a positive influence on the firm, at least concerning firm level performance, the debate of the impact of slack still continues. It remains unclear if a positive relationship, or any relationship, might be replicated within the construction context. It is maintained that managerial practice, including organisational slack, does not exist in a vacuum distinct from the context of its application (Fernie 2005; Fernie et al. 2006). Although construction management process are not fundamentally different from mainstream management processes, construction is viewed as different, therefore unexplored concepts must be examined prior to being accepted (Bresnen & Marshall 2001). Prior to adopting and testing a relationship with slack in the construction context, its functions must be understood within the construction context.

The vast majority of research discussing organisational slack has been predisposed towards manufacturing industries. Moreover, despite references to the concept of organisational slack by construction academics (Nam & Tatum 1997; Sexton et al. 2006; Barrett & Sexton 2006; Manley 2008; Jeong et al. 2010; Hardie & Newell 2011), the concept has not been examined within a construction context. Finally, it is possible that the unique combination of industry characteristics in construction (Hillebrandt 1985; Blayse & Manley 2004), and the unique accounting methods within construction (Halpin & Senior 2011) prevents organisational slack from being operationalised in construction as is does within other industries. Slack functions within industries such as manufacturing based upon a number of established functions relating to organisational behaviour (Cyert & March 1963) and resource dependency of activities (Wernerfelt 1984) it cannot be assumed that these functions operate, or materialise in the same manner in a construction context.

Conversely, there is no information to suggest that construction is so unique that the development of innovation and improved firm level performance do not rely upon the presence of organisational slack. Therefore, it put forth by the author that that organisational slack has an undetermined relationship with firm level innovation and performance within the construction context. Organisational slack forwarded as an explanation of the discrepancy between innovative and non-innovative firms,
unexplored within the construction context. This therefore slack represents a gap in knowledge within construction research.

Due to the lack of research regarding organisational slack within the construction context, there is the gap in knowledge in applying the concept in this new context, and the opportunity to test a previously undetermined relationship that underpins the levels of innovation and performance within the construction industry. Due to the variability of innovation discussed above, only testing the relationship between slack and firm level innovation within the construction context is insufficient for the adoption of slack as a concept. It is necessary to demonstrate a theoretical understanding of innovation and slack, and then develop theoretical linkages between the concepts. Thus, providing a framework to understand the importance of organisational slack within the construction context. From his framework, research may be conducted within the construction context. Primarily the development of these linkages ensures the robustness of positioning of slack as a determinant of innovation in construction, secondly supports the rational of the empirical model regarding the presence of higher levels of slack. Through the development and testing of an organisational slack model, it will be possible to reveal to important factors: First, if the results from construction replicate those within a previously explored context, it will demonstrate that the construction sector is not unique in regards to the concept of organisational slack. Second, if there is a lack of organisational slack resources within construction.

Considering the discussion in the above sections, this research begins adopting a number of assumptions that will guide the research. This work reasons that:

- Innovation is an essential for construction firms and is driven by the desire to develop a competitive advantage, improve firm level performance and ultimately survive.
- The characteristics of construction used to explain the lower rate of innovation in construction fail to explain the discrepancies between high and low innovating firms, therefore do not aid in improving firm level innovation.
- Organisational slack explains the discrepancy of innovation rates between firms.
- Due to organisational slack not being previously being explored within the construction context, its assessment against a previously established context will
be able to reveal if: 1) slack impacts innovation in construction 2) if this relationship is comparable to previously explored contexts.

Following these considerations, this research faces a number of initial issues that must be addressed, grounded in a need for this work to.

- Develop a theoretical understanding of innovation in construction and the determinants, which encourage firm level innovation.
- Develop a theoretical understanding of the concept of ‘organisational slack’ and the previously established relationships it shares within firm level innovation.
- Develop theoretical linkages between the concepts innovation and organisational slack, extrapolating conceptual linkages between the prevailing determinants and functions.
- Construct a model that enables the impact of organisational slack within construction firms to be tested.

In addressing the above aims, deeper associations between not only organisational slack and innovation will emerge, but also between innovation and performance. This research demonstrates that whilst a number of determinants of innovation are identified, each in turn relies upon the resources within the firm, which must be free to be allocated to innovative activities to allow innovation to occur. Due to the complexity, variability and project-based nature of construction innovation it is not possible to measure innovation directly. Moreover, although innovation is argued to support improved performance, both concepts are argued to be underpinned by the presence of organisational slack, which improves the internal capabilities of the firm, which determines innovation and improved performance.

The following research will address the following Research Problem (RP1) and Research Objectives (RO1-RO5)

1.5.1 Research Problem (RP)

The rationale for the research problem is as follows: Ever progressing technological developments and an increasingly complex economic environment continue to pressure construction firms to innovate in order to not only perform better, but to survive. The concept of organisational slack offers an explanation to the distinction between innovative and non-innovative construction firms, thus a means by which firms might
Defining the Research Problem

become more innovative. Despite the concept of organisational slack being well established within general management literature, within construction literature there is as a lack of awareness and understanding of organisational slack. Moreover, due to the unique nature of the construction context, and construction products, it is unclear if the functions organisational slack operates within the construction context. Consequently, if organisational slack can be an explanation for the discrepancy between high and low innovating firms in the construction context, as it does in manufacturing. As such, the concept of organisational slack cannot be transposed as a viable explanation for firm level innovation within construction concept without developed linkages and empirical support. Therefore, this work must first develop theoretical linkages between existing innovation concepts within construction literature to validate the concept within the construction context, prior to testing these linkages by examining the relationship between the level of organisational slack within the firm, and its level of innovation. The problem for this research is as follows:

RP1. Construction firms require innovation to continue to function within the marketplace. Organisational Slack explains the difference between high, and low innovating firms within construction. Whilst Organisational Slack has been theoretically and empirically explored and developed in other industries, this concept has not been expanded to involve the construction context. The problem therefore, is first explore and understand how Organisational Slack benefits the firm and its ability to innovate, and second to empirically test if organisational slack is a viable explanation for variation in firm level innovation within the construction context.

1.5.2 Research Objectives (RO)

RO1. Define innovation and explore the approaches to innovation in the construction context.

RO2. Develop a broad theoretical understanding of the concept of organisational slack.

RO3. Develop theoretical linkages to position organisational slack as a determining factor of innovation based upon prior research in construction firms.

RO4. Develop hypotheses and test the relationship between slack and the firm.
Defining the Research Problem

RO5. Analyse the findings in order to determine the validity of the theoretical links in RO3.

RO6. Draw conclusions from, limitations of, and recommendations for the research

1.6 Guide to the Thesis

Chapter 1 provides an outline and develops the initial arguments of the thesis in support of the examination of firm level innovation in construction, and the proposed relationship with organisational slack as a determinate of innovation.

Chapter 2 explores the concept of innovation, examining its definition and approaches within literature. In defining innovation, it is distinguishes the concept of innovation clearly from other concepts, and communicating the author’s interpretation of what constitutes innovation. Following this the approaches to innovation within mainstream management literature are examined, specifically: the innovation process, market and resource based view of innovation; and the purpose of innovation between innovation generating and innovation adopting firms. The innovation process is viewed as a black box, the resource based view of innovation a more appropriate basis for examining firm level propensity for innovation, and construction firms are typified as innovation adopting organisations (IAOs). Following this, the thesis critiques the levels of analysis of innovation within construction, examining the industry, firm and project level approaches. A number of determinants of innovation within construction are identified, however whilst project based factors and the nature of construction have an impact on the direction and potential for innovation within construction as a whole, it does not explain difference between innovative and non-innovative firms. Discrepancy between innovative and non-innovative firms is explained in part by the ability and willingness of individuals within the firm, but these are argued to be underpinned by the resource envelope of the firm, and related to the presence of resources termed ‘slack’. However, the definition, functions of slack have yet to be explored within construction, presenting a gap in knowledge.

Chapter 3 examines the concept of organisational slack, or simply ‘slack’, its definition functions and relationships established within mainstream management literature, providing a comprehensive review of the concept. As can be seen existing literature forwards a number of definitions and constructs in order to understand organisational slack and distinguish it from ordinary resources. These are explored, critiqued and the
more appropriate carried forward. Following this, the presence of slack within the firm is argued to provide a number of functions in order to facilitate innovation and performance. Once again, these are explored in order to understand the benefit or harm that may be derived from organisational slack. Further to this two conflicting perspective of the presence of slack were critiqued, a positive view supporting the presence of slack, and the negative view arguing for its removal or reduction from firms. Finally, this chapter examines the number of approaches to measuring slack that may be taken by the researcher. This thesis distinguishes work based upon its method of slack measurement (objective or subjective) and the interest of the slack measurement system (amount of slack or changes in levels of slack).

Chapter 4 develops theoretical linkages between the concept of organisational slack above and the firm level determinants of innovation. Theoretical links were extrapolated in order to connect the individually examined concepts of innovation in construction, and organisational slack. Drawing upon the resource dependency of the cultural determinants of innovation within construction firms, links were made between the managerial actions and the presence and functions of slack within the firm. Although theoretical links were made, it was argued that the ability to test this relationship was fundamental defective; ultimately, performance of the firm is forwarded as a suitable proxy measure for innovation, and being reinforced by the resource-based view of the firm. This chapter concludes with hypotheses regarding the relationship between the level of slack and firm level performance (used as a proxy for innovation).

Chapter 5 outlines and demonstrates for the reader the assumptions, methodology and research design adopted for the research within this thesis. This chapter reviews literature regarding the selection of an appropriate research strategy, paradigm, and stance for the research within this thesis. Further to this, chapter 5 examines criteria necessary to establish a ‘good theory’, and contrasts these criteria against the developed theory in chapters 2-4. Following this, the research designs adopted for this research are presented. Study 1 taking an econometric approach to examining slack and the firm, using statistical techniques and adopted measures to test the slack-innovation relationship. Study 2 incorporated semi-structured interviews to explore the slack-innovation relationship to support the assumptions used to build Study 1.
Chapter 6, 7 and 8 discuss the findings and analysis from the research studies. Chapter 6 is composed of three parts, the first discusses the analysis and findings from the construction context, and the second part repeats the analysis within the manufacturing context. The findings support evidence for a relationship between slack and firm performance within both contexts. Chapter 7 is a further development of the analysis, which compares the results obtained in the manufacturing and construction contexts, then evaluates these results against existing literature. This further supports evidence for a relationship between slack and firm performance within the construction context, and the underlying innovation of the firm. Chapter 8 provides analysis of Study 2, demonstrating that the innovation is measured in practice using financial metric to assess innovation outcomes, further that slack is seen as a factor in determining innovation and firm performance.

Chapter 9 presents a discussion of the findings of the research studies in relation to existing literature discussed within the literature review. The chapter continues by examining the research projects ability to meet the specified research objectives.

Chapter 10 concludes the thesis by reflecting upon the quality of the research and its contributions to research design and practice. This chapter also provides a number of contributions as conclusion of the thesis, also discussing the limitations of the research and recommendations for further research. The chapter is concluded by a discussion on the implications for slack research following this research.
Chapter 2. Revisiting innovation in Construction

2.1 Introduction

Innovation is generally held to be a desirable objective for firms both within and outside the construction sector. By innovating, firms might reduce costs (Kissi et al. 2012), improve value added, obtain a competitive advantage (Slaughter 2000; Stewart & Fenn 2006; Bowen et al. 2010; Volberda et al. 2013) and ultimately continue to survive in the marketplace (Egбу et al. 1998; BIS 2013). Consequently, it is not surprising that innovation is considered central to the business models of many firms (Slaughter 2000).

‘Innovation’ remains a complex phenomenon, while some offer definitions of innovation as an applied idea (Rogers 2003), others insist on these ideas being successfully exploited (Stewart & Fenn 2006), and further still other suggest that innovation be limited solely to a concepts first application (Medina et al. 2005). This chapter unpacks the complexity of defining innovation - in part a consequence of the many fields in which the concept has historically been defined - to develop a definition capable of raising the issues tackled by this work.

In spite of the suggested benefits of innovation in construction, innovation is claimed to occur less readily than in other sectors. This problem has been studied many times by, for example, the seminal works of Blayse & Manley (2004) and Winch (2003) who argue respectively that the inherit characteristics of construction inhibit innovation, and that comparisons between sectors do not fairly examine the construction sector. Despite ongoing examination of innovation in construction, the knowledge contributed has had limited impact in helping either industry or academia understand why some firms are innovative and others are not, and it therefore has had little impact on practice. This chapter explores the factors that underpin the firm’s capacity to deliver innovations and its ability to engage with the act of innovation, rather than focusing on the mechanics of the innovation process that have been the focus of many prior works.

As will be seen, approaching innovation from this perspective allows research to distinguish between firms capable of innovation and those not. It is argued that this allows the resources made available to the innovation process to be studied, rather than the mechanics of those processes themselves. This chapter thus addresses a critical, but
overlooked aspect of innovation: the availability of the resources required to innovate and the propensity of a firm to use those resources to innovate.

### 2.2 The Study of Innovation

Innovation underpins the economic growth of economies and industry by being a key source of competitive advantage for firms (Damanpour & Wischnevsky 2006; Bowen et al. 2010; Dodgson & Gann 2010; Abadi & Fenn 2012). Beyond this, research councils fund work into exploring innovation as it has the potential to allow firms to meet the demands of customers (Gambatese & Hallowell 2011b); improve the profitability and productivity of firm and their overall performance (Choi et al. 2009; Gambatese & Hallowell 2011b; Abadi & Fenn 2012); improve competition within the construction sector (Blayse & Manley 2004; Erbil & Akincitürk 2010); improve economic growth and living standards (Aouad et al. 2010; Whyte & Sexton 2011); and ultimately benefit the economy as a whole (Tatum 1986; Barrett et al. 2007; Czarnitzki & Kraft 2010; Loosemore & Holliday 2012; Seaden et al. 2003). Additionally, in order to reduce the environmental impact of the construction sector and meet the required governmental standards, large scale and extensive changes are required within the construction context, which will rely heavily upon the firm’s ability to innovate (Shaw et al. 2010; Whyte & Sexton 2011; Loosemore & Holliday 2012; Hardie 2010). While environmental issues are not the focus of this work, they play a key role in the rhetoric involving construction literature (Thorpe et al. 2008). For example, government set targets to reduce CO₂ emissions by 2050 (see Whyte & Sexton 2011) will only be met through extensive innovation within the construction sector.

Construction firms continue to face the challenges of increased competition, radical technological change, increased product complexity and tougher regulations. To withstand these challenges, Shaw et al. (2010) encourage construction firms to develop or adopt new innovations. As observed in other sectors, innovations are held to provide construction firms with a competitive advantage (Kissi et al. 2012) necessary to navigate their environment. In construction, Kissi et al. (2012) argue that construction related innovations address a range of issues including: problem solving on-site; improving project performance; responding to expectations from clients; and maximising profit.
The advantages that can be derived from innovation fuel the need to understand the phenomenon more readily. It is argued that central to understanding the complexities of innovation are differentiating between the innovative and non-innovative units of analysis. Where innovation, and its outcomes (both risk and reward), is considered desirable by construction firms, i.e. firms want to be innovative. Revealing these differences is vital as innovation ties into not only the firm, but also the sector as a whole, and thus the national economy (Barrett et al. 2007).

2.3 Current state of innovation in construction

Despite the need for innovation, within the construction sector as a whole, innovation is often argued to occur less frequently than other sectors (Tatum 1986; Koskela & Vrijhoef 2001; Reichstein et al. 2005; Erbil & Akincitürk 2010; Hardie & Newell 2011). Within construction literature two prevalent lines of thought offer explanations to the lack of innovation within construction. The first, offered by Winch (2003), argues that this apparent ‘lack’ of innovation within the construction sector is the result of biased measurement, which excludes a substantial amount of innovation within the construction sector such as design. Further bias is argued to exist as a substantial section of the automotive industry considered to be ‘non-innovative’ is excluded from the comparison. Thus leading to a comparison that rarely favours the construction sector. The second explanation is summarised by Blayse & Manley (2004), in which the unique nature of construction products (e.g. project based nature, longevity, cost, maintenance, complexity) and the subsequent characteristics of the sector (e.g. fragmentation, adversarial relationships, risk aversion, diminished resources) inhibit the potential for innovation within the construction sector.

As stated within Chapter 1 it is maintained that ‘construction’ cannot continue to be defined so narrowly to include only ‘core construction firms’. ‘Construction’ as a whole is much broader than simply its core, overlapping and connecting with many other industries will ill-defined boundaries (Groāk 1994). Barrett et al. (2007) recognise the existence of parallel activities such as architectural and technical consultancy and upstream activities such as mining, quarrying and manufacturing as being part of the construction sector. Research must consider construction in its entirety, and accept the large array of firms that support and function within the construction context. Therefore, when discussing innovation must begin to look beyond a narrow definition of construction, and consider the plethora of innovative firms wider spectrum of industries.
within the economy. The narrow definition of construction results in construction being seen as ‘non-innovative’ as a whole, with its innovative activities not being identified. As stated within Chapter 1, a definitive list of firm SIC codes considered part of construction can be found in Appendix 1.

Further this, the measurement of innovation is also a significant issue. Innovation is a multifaceted and varied subject, as discussed later, innovation is a complex and dynamic construct (Damanpour et al. 1989) leading to issues in its measurement and quantification. As such, its measurement can be equally complex, with indicators having both strengths and weaknesses in its measurement (Smith 2004). As discussed in Winch (2003) there is a disjointed effort to compare innovation in construction to other sectors, generating an apparent lack of innovation within the sector. Innovation however can, and does occur frequently within construction. However, it is typically ‘hidden’ from standard measures due to its incremental nature (Barrett et al. 2007; Harris & Halkett 2007). Although considered poor at innovating, increases in measures of innovation outcomes such as profitability, productivity and customer satisfaction all indicate that innovation in construction does occur (Barrett et al. 2007).

Therefore, the arguments from Winch (2003) are considered justifiable. Regardless of the explanation behind the perceived lack of innovation within construction, innovation can and does occur within the sector as it remains as competitive market (Gambatese & Hallowell 2011a). Which is demonstrated in the progressive improvements in a range of criteria; profitability, reduced number of defects productivity and customer satisfaction (Barrett et al. 2007).

The criticism of the characteristics of construction hindering innovation has long been supported within construction literature, offering a perspective that seeks to explain the ‘lack’ of innovation in construction. These characteristics are discussed in more length in Section 2.7.1. Whilst these explanations are insightful to a degree, it is argued that they to limit the exploration and understanding of innovation within the construction sector. The focus attention on the measurement of innovation and the supposed distinction of the construction sector respectively is argued to distance construction literature from the academic advancements developed within broader management literature. What remains is the fact that innovation does occur within construction. This should be used as a starting point for further inquiry, as opposed to focusing on why
construction is different or isolated. Consequently, both innovative and non-innovative firms may be found within construction, and it is argued that understanding the differences between these firms will reveal previously unexplored practices or perspectives that underpin the innovative capacity of the firm.

Past work may provide insight into these practices and perspectives. Past studies of innovation in general have approached the concept from schools of thought and theoretical perspectives. Examples of such perspectives are the rational or behaviour view of the innovation process (Koskela & Vrijhoef 2001; Abadi & Fenn 2012), diffusion theory (Rogers 2003) and organisational innovativeness research (Wolfe 1994).

Due to these differing perspectives, researchers vary dramatically in their conceptualisation of innovation, with no single definition or interpretation dominating the debate (Leiringer 2003). Different approaches to innovation argue that its emergence is dictated by (but not limited to): the demands of the market (Elster 1983); access to resources (Schumpeter 1934); and the ability of individual (Nelson & Winter 1974). As a result, it is not possible to provide a complete historical account of all the schools of thought relating to innovation. As the context of this study is construction and the ability of the firm to deliver innovations, this study explores perspectives of innovation found within construction and where possible those related to the firm as a unit of analysis.

As stated previously, innovation is a vital component to construction firms, the sector and the economy as a whole, in spite of this importance and the extent of research into the concept, innovation remains highly complex. Many authors offer different definitions of innovation, and with the consensus being that there is no single definition of innovation (Blayse & Manley 2004; Damanpour & Wischnevsky 2006; Davies 2006). Without providing a clear definition of innovation, research cannot be critiqued, compared or progressed in any meaningful fashion. The following explores innovation and its varying interpretations to provide a definition to use as a foundation from which this concept might be explored further.

2.4 Exploring the concept of innovation

Innovation is complex, non-linear and dynamic (Leiringer 2003; Aouad et al. 2010), it is also a complex construct (Damanpour et al. 1989) with many interpretations and
application. Innovation in construction, depending on the definition, can vary from construction specific: Solar powered, rainwater collecting hot water systems (Hardie & Newell 2011) or foundation engineering (Egbu et al. 1998), to generic in integration of mobile phones (Sexton et al. 2006). Colloquial use of the term carries many meanings, often leading to confusion regarding what it is and is not considered to be. Dodgson and Gann (2010:13), for example, attempt to skirt this complexity by defining innovation as “ideas successfully applied”, but also acknowledge the frailty of this definition by questioning what constitutes an idea which is ‘successful’ or when such an idea is actually ‘applied’. On the other hand, some authors are much clearer regarding their presented definitions of innovation. For example, construction researchers Kissi et al. (2012:12) define innovation as “the generation or adoption of ideas; design concepts or delivery processes, new to the adopting organisation, which when implemented will yield a reduction in cost and/or time associated with project delivery and improve the quality of outcome”.

In order to progress this study a clear definition must be constructed or adopted in order to illustrate the perspective of the author in regards to this concept and provide a foundation of further development. The chosen definition reflects the author’s perspective of what is considered ‘innovation’ and as a result dictates the framework of the discussion of the concept.

From a review of prevailing discussions of innovation, it is contended that there are three aspects to the ambiguity of interpreting innovation: distinguishing innovation from ‘invention’; distinguishing innovation from ‘change’; and understanding whether ‘innovation’ refers to an ‘object’ or a process or combination of the two. Innovation must be understood first by these aspects, prior to its definition, and the exploration of perspectives of the concept itself. The following distinguishes innovation from other concepts.

2.4.1 Disambiguating Innovation ‘object’ from Innovation process

When discussing innovation, ambiguity can arise in establishing what ‘innovation’ actually is. Past studies have positioned innovation as the result of a process (i.e. an output or conclusion of a set of activities), the process itself (i.e. a set of activities – sequential or non-linear) or a combination of the two (Leiringer 2003). Literature may conflate whether ‘innovation’ is: a set of activities that lead to an outcome or object, or
the object itself. The discussion of the innovation process is traditionally due to an analysis of ‘innovation’ itself, where an instance of innovation is the unit of analysis, as opposed to the analysis of the firms’ propensity to deliver innovations (Damanpour & Wischnevsky 2006). This work chooses to characterise innovation as an ‘object’ as opposed to what is considered a black box process that it results from. For clarity, the latter view of innovation as a process shall hereafter be described as the “innovation process” and the subsequent object shall be termed “innovation.” With this distinction drawn, this work continues to focuses on “innovation” as single identifiable objects that occur within the firm.

2.4.2 Distinguishing Inventions from Innovations

In the exploration of definitions of ‘innovation’, a primary concern is that inventions be made distinct from innovation as confusion can otherwise result when the above view of innovation is adopted, as both inventions and innovation represent something ‘new’ (Schumpeter 1934; Winch 1998; Kaiserfeld 2006). This component of ‘newness’ can cause innovation to be misinterpreted as an invention, or vice versa, thus these concepts must be made theoretically distinct.

Schumpeter (1934), a leading author on innovation, distinguished between innovation and invention: Invention being the generation of ideas and innovation their application (Slaughter 1998; Leiringer 2003; Dodgson & Gann 2010). This distinction arises from the view that “inventions are economically irrelevant” (Schumpeter 1934:88), therefore inventions require application to contribute to the market place and become economically relevant. It is this application that distinguishes invention from innovation. This perspective is also adopted within construction literature (e.g. Winch 1998; Slaughter 1998). Slaughter (1998: 226) extended the distinction, arguing that invention is “a detailed design or model of a product or process, which is clearly distinct from the existing arts, while innovation need only be novel to the unit of adoption”. This notion of relative novelty can simply mean that an invention is new to a particular firm yet may have existed in another context for some time. Therefore it does not matter if an idea is “objectively” new in the sense of time since its first creation (Lu & Sexton 2009), innovations only have to be novel to the unit of adoption (i.e. a particular firm), whereas inventions must be novel to the existing arts and the entire world (Kaiserfeld 2006; Hardie 2010). This is why, for example, patents will only be
granted to an invention in the absence of prior art, whereas novel concepts with prior application may be termed as innovations.

2.4.3 Differentiating Innovation to Change

Innovation may also be confused with the regular changes that occur within a firm. While innovation is conventionally distinguished from invention as above, Leiringer (2003) notes that definitions of innovation seldom explicitly distinguish between innovation and change.

Leiringer (2003) argues that, in addition to being new, an innovation must also bring about a change that has a positive effect. An example of this distinction can be seen in construction literature where (Barrett & Sexton 2006:337) define innovation as “the effective generation and implementation of a new idea, which enhances overall organizational performance”. Because of this position, and the definition above, it is clear that Leiringer (2003) must exclude those changes that do not benefit the firm (that is, the unit of adoption) from being considered innovations. This perspective however, is rejected as it forces the distinction based upon a success factor that might take months or years to provide tangible evidence to determine.

In order to separate the two concepts, rather than attempting to distinguish innovation in relation to a success criterion, this work retains Damanpour & Wischnevsky’s (2006) core distinction between innovation and change; namely the notion of “newness” or novelty. It is argued that the perception of novelty (i.e. newness) is central to distinguishing innovation from change, and not the success of an innovation or a change (Johannessen et al. 2001). Novelty relates to a relevant unit of adoption (i.e. the firm), therefore, innovations are seen to be changes that are novel to the firm, while changes or past innovations that have been developed by the unit previously are labelled as changes.

2.5 Defining of Innovation

As already stated, innovation can be interpreted and defined from many perspectives throughout general and construction literature. In this work so far, the concept of innovation is considered to relate to a ‘new idea’ or concept, which is applied within the firm, thus distinguishing innovation from invention and change. In response to the notion of something being ‘new’ Johannessen et al. (2001) raise three questions that
must be resolved to provide a complete definition of innovation. The researcher must consider: what is new; how new; and new to whom?

- What is new? – This concerns how innovation is operationalised, as previously stated within this research, innovation is seen as an ‘object’ that is the result of a black box set of activities.
- How new? – This concerns the extent to which the innovation deviates from what already exists. While some authors argue the requirement of a significant advancement in practice to be described as an innovation, other such as (Slaughter 2000) dictate innovations as being “non-trivial”
- New to whom? – Related to the domain in which an innovation is applied. In essence this is the unit of adoption be it firm level, project level or industry level. The distinction of this domain, or what Damanpour & Wischnevsky (2006) call the boundary of newness, dictates much about what defines an innovation. A clear definition of innovation must provide a relevant unit of adoption in order for the concept to be distinguished and explored further.

As stated, innovation remains a complex concept with multiple interpretations (Armbruster et al. 2008). This discussion seeks to establish a fully formed and debated definition of innovation as a foundation for further exploration. The number of possible definitions of innovation can lead to confusion in its discussion due to the conflicting interpretations that exist (Dodgson & Gann 2010). The following provides a list of some of the most common definitions of innovation that have been found within general and construction research. Although not exhaustive, this list illustrates the variation in approached to defining innovation. In each can be found a mixture of the elements and differences of those elements that have been discussed so far:

1. Barrett & Sexton (2006:337) definition where innovation is seen as “the effective generation and implementation of a new idea, which enhances overall organizational performance”
2. Rogers (2003:11) defines innovation as “an idea, application or a subject which is considered new by a person”

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1 Emphasis added
3. Slaughter (1988:226) “a non-trivial change and improvement in a process product or system that is novel to the institution developing the change”

4. BIS (2013:23) “the successful exploitation of knowledge and new ideas to create new or improved products, processes and organisational structures”

5. Dewar & Dutton (1986:1422) who define innovation as “[The application of] an idea, practice or material artefact perceived to be new by the relevant unit of adoption”.

6. Choi et al. (2009:1725) “Intended and planned changes within a business entity that include product, process, and management (organisational) innovations”.

7. Armbruster et al. (2008:645) “the use of new managerial and working concepts and practices.”

Whilst the selection of definitions above presents a varied array of definitions, only one definition may be adopted as an appropriate representation of the author’s perspective of what defines innovation. A definition must relate to something new, that is applied within an unspecified unit, and not to something objectively new (Lu & Sexton 2009). Although the firm has been established as the unit of analysis, within the conceptualisation of innovation this must be allowed to vary.

The definition provided in Barrett & Sexton (2006) is selected because it is considered an appropriate representation of innovation in practice that is compatible with the perspective of the researcher, whilst also answering the questions put forth by Johannessen et al. (2001). Secondly, is a definition developed within construction and one that resonates with construction practitioners from both large and small firms (Barrett & Sexton 1998; Barrett & Sexton 2006). Thus innovation is defined as “the effective generation and implementation of a new idea, which enhances overall organizational performance”².

2.5.1 Types of Innovation

The previous section has dealt with defining and distinguishing innovation from other concepts. Innovations in themselves however, can take multiple forms within the firm and must also be explored. Innovation can vary from the development of new pre-cast concrete techniques, the use of digital technology (Egbu et al. 1998) to even new forms of partnering (Harris & Halkett 2007). Authors typically use constructs to differentiate

² Emphasis added
innovations based upon common characteristics, traditionally in relation to its application or purpose. Innovations in their broadest sense are divided into types to allow the researcher more in-depth examination of the concept. This section focuses upon highlighting the different conceptual types of innovation themselves, as objects, and characteristics that are typically discussed in innovation literature. This section does not seek to debate the implications of the socio-technical framework for understanding innovation. The socio-technical perspective of innovation is concerned more closely with the diffusion of a particular innovation, and how the social system interacts with the innovation, however, this does not relate to different characterisations of innovation.

Constructs differentiating types of innovation can be found throughout general and construction literature on innovation. In a macroeconomic study of technical change Schumpeter (1934:66) originally suggested five types of innovation: the introduction of a new good; the introduction of a new method of production; the opening of a new market; the opening of a new supply source; and the carrying out of a new organisation of any industry. However, since then, construction literature has typically addressed alternative constructs.

Within construction literature, innovation research often explores product, process and service innovations (Lu & Sexton 2009), with a frequent over emphasis of those relating exclusively to construction. However, it is contended that innovation can take broader forms, and is not limited to the conventional product service and process construct. Volberda et al. (2013) recognises that innovation research, in general, over emphasises technical innovations, a perspective also seen in construction literature is that innovation must represent not only technical but also organisational and service innovations (Aouad et al. 2010).

A broader construct can be seen in Subramanian and Nilakanta (1996), where the authors split innovations into an ‘administrative’ and ‘technical’ dichotomy. In Subramanian & Nilakanta (1996), administrative innovations affect the social system of firms, consisting of the firm members and their relationships, while technical innovations affect the technical system of a firm, which produces its services or products for market. Damanpour (1991) clarifies this distinction, noting that technical innovations support what the firm does in terms of its products and services, whereas
administrative innovations influence its social factors. An example of a technical innovation for the construction context might be a novel process for assembling concrete formwork for contracting firms, or a novel computer-modelling program for architectural firms (Sexton et al. 2006; Hardie & Newell 2011). Administrative innovations are typically non-technological in nature (Volberda et al. 2013). Examples of administrative innovation include new organisational structures, new staff practices, new efficiency processes, novel contracts (Birkinshaw et al. 2008). Further to this construction specific administrative innovations include, new procurement processes, novel contracts, or organisational re-structuring.

Construction research on innovation must cast a ‘wider net’, and consider the importance of all innovations that might occur, and ensure that practices and research do not stifle or limit instances of innovation which might be of great importance. Neither Subramanian & Nilakanta (1996) nor Schumpeter’s (1934) categorisation are typically recognised in the construction literature. Construction literature predominantly favours a more narrow perspective of product, process and service innovations (Lu & Sexton 2009), which typically focuses upon technical innovations within construction firms or projects. Consequently, this perspective overlooks the important role administrative innovations might play within the firm and lessons that might be learnt from their development. Seaden et al. (2003) suggested that technologically innovative firms are also innovative elsewhere in the firm, and that innovativeness permeates within the firm. This is recognised in construction literature; Winch (2003), Reichstein et al. (2005), Barrett et al. (2007) and BIS (2013) all recognise that current approaches to innovation fail to capture the true extent of innovation within the construction context, which is hidden within problem solving and alternative organisational investment.

Nevertheless, whilst distinctions might be made between the different types of innovation that emerge, what is important is that this work recognised the importance of how broadly or narrowly innovation can be examined depending upon the chosen construct. Of note is that this work does not seek to differentiate between innovation types, but does propose that innovations within the firm are most appropriately characterised as administrative and technical innovation.
Although innovation might differ in their form and function within the firm, it is contended that they share the same underpinning factors, which are explored later in this chapter; this construct is carried forward but not examined further. This work focuses upon the factors relating to innovation as a whole, following Van de Ven (1986) who argued that the distinction of innovation types is unnecessary and fragments the understanding of the innovation process. The discrepancy between innovating and non-innovating construction firms, does not prescribe itself to importance of one type of innovation over another.

2.6 Approaches to innovation

As stated previously within this thesis, innovation remains an integral concept for the construction firms. Innovation relates to not only improvement in terms of cost, quality and efficiency on projects (Erbil & Akincitürk 2010), but also the opportunity to improve profitability of the firm (Reichstein et al. 2005), improved firm performance (Choi et al. 2009), meet environmental challenges (Hardie & Newell 2011) and ultimately firm survival (Egbu et al. 1998; Mousa et al. 2013). Innovation is chosen to be explored again not solely for its importance to individual construction firms, but also its importance for unintended spill over effects on environmental sustainability, improved living standards, and the economy as a whole (Barrett et al. 2007).

As argued above, construction literature has overemphasised construction innovations, overlooking the non-technical innovation such as organisational and marketing innovations that are not construction specific but operate within its context. The following sections discuss the common approaches to innovation within literature, examining the innovation process, market and resource based drivers of innovation, and finally the purpose of innovation itself.

2.6.1 The process of innovation

In attempts to understand innovation, many authors focus upon the process or processes by which innovations are developed (Damanpour & Wischnevsky 2006). Innovation is often considered consist of the process or activities that leads to its generation, as well as the novel concept itself (Damanpour & Wischnevsky 2006). However, within this thesis these two concepts are seen as being separable, and are made distinct. As stated earlier, innovation is considered to exist as an object, which results from a set of activities termed the innovation process. Within general management literature process,
theory research examines the nature of the innovation process; investigating how and why innovations emerge, develop and grow (Wolfe 1994).

The study of the innovation process is dominated by two schools of thought; the rational school and the behavioural school (Barrett & Sexton 2006), both of which shall be discussed here. Within the rational school, the innovation process encompasses a wide variety of activities from concept to final development of the innovation. These activities are typically set into a model of sequential stages (Wolfe 1994). An example of an innovation process can be seen below in Figure 3. This example of the innovation process moves from knowledge to the decision to adopt, or reject a novel ideal, following this ideas are implemented and finally confirmed. This is one among many models of the innovation process. As seen in Damanpour & Wischnevsky (2006) and Wolfe (1994) there are a number of different interpretations of the innovation process.

![Figure 3: A Model of Stages in the Innovation-Decision Process (Rogers, 1995)](image)

Whilst some authors seek to examine the innovation process as sequential set of activities, it must be remembered that innovation, and its related process, is considered to be a highly complex phenomenon, and most importantly non-linear (Aouad et al. 2010). As such, the rational school falls under criticisms for not accurately portraying the dynamic movement and uncertainty of the innovation process (Barrett & Sexton 2006). In turn, this lead to the behavioural school that view the innovation process more as ‘controlled chaos’ (Sexton & Barrett 2003), in that the innovation process is a
nonlinear cycle of divergent and convergent activities that may repeat over time and at different organisational levels (Van de Ven et al. 1999:16). In spite of less recognition of this perspective (Barrett & Sexton 2006), the innovation process in project-based firms such as construction firms is considered to be behavioural in nature (Abadi & Fenn 2012). Construction researchers Barrett & Sexton (2006) found evidence suggesting that innovation is cyclical and non-linear within firms. Regardless of whether innovation is technical or administrative, the processes involved in its generation remain complex (Aouad et al. 2010). Whilst linear models have dominated construction literature, it is more widely accepted that the innovation process is far from linear and in fact messy, unpredictable, and full of feedback loops and setbacks (Loosemore & Holliday 2012).

While many authors might focus upon the innovation process to understand the nature of innovation, the focus of this research is to understand the firms’ propensity of innovation. As such, focus must remain on differentiating innovative and non-innovative firms, preventing a debate on the process of innovation at any great length. While it is accepted that there is evidence supporting identifiable innovation stages, and that they occur throughout all contexts, its argued that the degree to which they occur sequentially and predictably is less concrete (Wolfe 1994). Maintaining the perspective of Abadi & Fenn (2012) it is argued that there is no precise recipe for innovation, and that the innovation process is more complex, and inherently uncertain than can be accurately portrayed in a stepwise conceptualisation (Leiringer 2003).

Therefore, it is argued that the innovation process be considered as behavioural in nature for the purposes of this thesis, and not explored any further. As such the innovation process is considered a black box process, wherein inputs are consumed by the innovation process, which outputs are considered innovations within the firm.

2.6.2 Market and resource based views of innovation
There are considered to prevailing schools of thought which offer explanations on what drives innovation which are maintained within construction literature: the market based view and the resources based view (Barrett & Sexton 2006). These perspectives argue that consumers or producers in the market respectively stimulate the emergence of innovation.
The market-based view contends that it is the market conditions that provide the context that stimulates or restricts the direction and amount of innovation generated by firms (Manley 2008). From this perspective, the principal drivers of innovation are the industry structure and the competitiveness of the environment (Lu & Sexton 2009). The market-based view of innovation is argued by the author to parallel to the Neo-classical theory of technical change presented by Elster (1983) which discusses innovation. The neo-classical theory diminishes the importance of a resource base, and the driving effect on innovation, by assuming that technology and knowledge are constant visible and available to all. Therefore, the availability of technology, resources and knowledge are universal between organisations. Innovation, results from a desire to use a combination of technologies in order to maximise profits, by exploiting the demands of the market. In essence, it is the demands of the consumers, which dictate the direction, and extent of innovation by generating this demand. For example, within the construction context, a shift of consumer demands towards a particular environmental solution would lead to innovations surrounding this solution as there is a demand-pull.

In contrast to the above, the resource based view places emphasis on the resource base of the firm as the driver of innovation, unlike the market based view where the importance of resources is diminished. The resource-based view of the firm emphasises the firms’ attempts to nurture resources that enable innovation to occur (Lu & Sexton 2009). Schumpeter (1934:66) argues that innovation, or what he refers to as “carrying out new combinations”, results from the availability of existing resources and the ability of the individual(s) or firm to generate combinations of said resources into novel constructs.

The resource-based view argues that the volatile and dynamic markets are not suitable for providing an explanation for the emergence of innovation (Barrett & Sexton 2006). Rather it is the resource profile of the firm that offers a more appropriate explanation of innovation. Although it might be argued that the market creates demand (‘market pull’) for innovation, Schumpeter (1934) argues that, by combining resources in new ways, the producer initiates change and not the consumer (‘resource-push’). Through marketing, the producer teaches the consumer to want new or different things and thereby reduces the importance of the market effect on innovation.
The resource-push view of innovation explains how firms can develop ‘new combinations’ or innovations through the utilisation of resources, offering a means to examine differences between firms’ relative to their level of innovation. Schumpeter (1934) contends that firms innovate by combining an existing base of old combinations of technology, knowledge and resources in new ways to produce innovation. A key constraint on the individual’s, and consequently the firm’s ability to innovative is, therefore, the availability of resources to them (Barrett & Sexton 2006).

The resource-based view of innovation is most appropriate for this research as it focuses on systematic differences across firms in their ability to mobilise resources for innovation (Gann & Salter 2000). The resource-push view of innovation clarifies the role of resources as a factor of production specifically in relation to innovation. With this and the above in mind, this work terms adopts available resources as the primary focus for investigation due to the extent of their influence over a producer’s propensity to innovate (when viewed from the market).

**2.6.3 Innovation generation and Adoption: The purpose of Innovation**

The potential benefits of innovation, both to the firm, the construction sector, and the economy as a whole have been cited frequently within this thesis. However, what remains important for debate, in conjunction with the market or resource drivers debated above, is the intended purpose of developing innovation that drives construction firms to innovate. Though it is maintained within the thesis that innovation is a positive and desirable objective for the firm, it is also important to understand why this is so.

In general, innovation is considered beneficial to the firm within literature. Sexton & Barrett (2003) argue that the ‘value’ neutrality of many innovation definitions reveals the dominant assumption that innovation is a beneficial action, which fails to recognise the association between innovation and risk and uncertainty. Nevertheless, within construction literature there is an overwhelmingly positive attitude towards innovation (Davies 2006). Within this thesis the adopted definition is explicit regarding its purpose to improve overall organisational performance. However, it is maintained that innovations in themselves carry with them a certain degree uncertainty and the risk of failure (Sexton & Barrett 2003; Leiringer 2003; Abadi & Fenn 2012), which is an inherent property of the novelty of the concept within the context of its application.
Therefore, this thesis upholds the perspective that innovation does not guarantee benefit for the firm, but offers the potential for the firm to derive benefit from an innovation, which would not exist without said innovation.

Yet, in the face of this uncertainty, firms continue to strive to innovate. Innovation is continually attributed to a benefits such as being able to meet the demands customers (Gambatese & Hallowell 2011b); obtain and maintain a competitive advantage for firms (Damanpour & Wischneovsky 2006; Bowen et al., 2010; Dodgson & Gann 2010; Abadi & Fenn 2012); and improve the profitability and productivity of firm and their overall performance (Choi et al., 2009; Gambatese & Hallowell 2011b; Abadi & Fenn 2012). It is argued that understanding the firm’s aspiration to develop innovations may be revealed by distinguishing between firms that predominantly generate innovations and firms that predominantly adopt innovations.

**Innovation generating (IGO) or innovation adopting organisations (IAO)**

While the thrust of this investigation is to examine the difference between innovation and non-innovative firms, differences are found between innovative firms. Innovation studies may categorise firms as innovative firms if they adopt an innovation earlier than the majority of their counterparts in the industry (Subramanian & Nilakanta 1996), distinguishing between innovators, and their imitators. This thesis briefly distinguishes between innovation generating (IGO) and innovation adopting organisations (IAO) as a means to examine innovative firms, and understand the purpose of innovation. This discrepancy might be considered a finer distinction to the comparison between innovation and non-innovative organisations. These types of organisation (i.e. firms) differ in the means by which they innovate and consequently as will be seen according to the primary purpose of producing innovations. Damanpour & Wischneovsky (2006:272) state the following:

> “The generation of innovation results in an outcome, be it a new product, service or technology, which is at least new to an organisational population. A second organization adopts this innovation by acquiring it from or by imitating the organization, that has produced it. As such, adoption basically means that the innovation is developed elsewhere, not in the adopting organization”

Examples of IGO’s within the construction context would be firms who develop new computer-aided design (CAD) software, while IAO’s would be firms integrating mobile
phones into their communication practices (Sexton et al. 2006). Illustrated below in Table 1, Damanpour & Wischnevsky (2006) distinguish organisational types, and make clearer the distinction between innovating and non-innovating organisations. Innovative firms, capable of both generating and adopting innovations are seen in cell A, while non-innovative firms, unable to deliver or adopt innovations are seen in cell D.

Table 1: Organisational type and innovation (after Damanpour & Wischnevsky 2006:271)

<table>
<thead>
<tr>
<th>Adoption of Innovation</th>
<th>Generation of Innovation</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>A. Innovative organisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>C. Innovation generating organisation</td>
<td>D. Non-innovative organisation</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 divides firms based upon their ability to generate and or adopt innovation. It is by these dimensions that generating and adopting organisations are distinguished. IGOs predominantly generate innovations (cell B) while IAOs source ideas from the environment for adoption (cell C) (Gambatese & Hallowell 2011a). The primary difference between IGOs and IAO is their approach to innovation, and how innovation is actually used within the firm. For IGOs, the critical issue is the innovation itself and its distinction from other existing products, services or technologies. On the other hand IAOs emphasise the assimilation of existing concepts into the firm, which are perceived to be new to its members. IGOs aim to match their organisations capabilities to new product and market opportunities, and see the generation of an innovation as an end in itself, such that a key goal of the organisation it to produce something new. IAOs seek to match their strategic requirements with innovations available in the market; innovation is not an end but a means to facilitate change that will contribute to organisational objectives e.g. overall firm level performance. Unlike IGOs, innovation in IAOs is a contributing factor to organisational success, but is not a critical success factor in itself. For example, IGOs might be firms on the forefront of construction technology, developing the latest advances in kinetic roads, 3D Concrete printing or solar roads (Lineshapespace 2014), while IAOs would be considered those who will take these same technologies on board when it meets their strategic requirements. For
example the adoption of 3D modelling technology, cloud sharing and modular construction that has become more prevalent in recent years (Raconteur 2015).

Innovation Generation and Adoption Process

As with the purpose of innovation differing between IAOs and IGO, as does the process by which innovation occurs. At its core, innovation generation is a creative process, while innovation adoption is a problem solving process (Duncan 1976). As with the process of innovation (see Section 2.6.1), there are differing interpretations of the generating and adopting process. Examples of these interpretations can be seen below in Figure 4. For Rogers (2003) the process for adopting innovation is considered to comprise on only two sub-processes: diffusion and adoption. While the process of generation has more stages in the recognition of need, research, development and finally commercialisation.

<table>
<thead>
<tr>
<th>Process of Innovation</th>
<th>Generation</th>
<th>Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kanter (1988)</td>
<td>Idea generation → coalition building → idea realization</td>
<td>→ implementation → routinization → transfer or diffusion</td>
</tr>
<tr>
<td>Klein and Sorra (1996)*</td>
<td>Research → development → testing → manufacturing → packaging → dissemination</td>
<td>Awareness → selection → adoption → implementation → routinization → routinization → Technology utilization and/or diffusion</td>
</tr>
<tr>
<td>Roberts (1988)</td>
<td>Recognition of opportunity → idea formulation → problem solving → prototype solution → commercial development →</td>
<td>→ Technology utilization and/or diffusion</td>
</tr>
<tr>
<td>Rogers (1995)b</td>
<td>Needs/problems → research (basic and applied) → development → commercialization →</td>
<td>→ Diffusion and adoption</td>
</tr>
<tr>
<td>Rothwell and Robertson (1973)</td>
<td>Idea generation → project definition → problem solving → design and development → production → marketing</td>
<td>→ Agenda-setting → matching → redefining/restructuring → clarifying → routinizing</td>
</tr>
<tr>
<td>Tomatzky and Fleischer (1990)c</td>
<td>Research → development → deployment</td>
<td>Adoption → implementation → routinization</td>
</tr>
<tr>
<td>Zaltman et al. (1973)</td>
<td></td>
<td>Knowledge awareness → attitudes formation → (adoption) decision → initial implementation → continued-sustained implementation</td>
</tr>
</tbody>
</table>

**Figure 4: Process of Innovation (after Damanpour and W 2006;##)**

Construction firms are argued to be typically representative of IAOs, although a minority of construction firms might generate innovations for the market, typically the
problem solving that occurs on site is adapted from existing solution, although novel to the firm applying it (Shaw et al. 2010). Further support for this position can be found within literature. Research and development (R&D) is predominantly linked with the generation of innovation (Armbruster et al. 2008), however, Groák (1994) argues that the majority of innovations used within construction are generated outside the construction sector. It is also recognised in Gann (2003) and Loosemore & Holliday (2012) that innovation within construction primarily emerges from the adopting of ideas from other industries. An example of this is the adoption of mobile phones by a construction firm in Sexton et al. (2006). Consequently, it is argued that the purpose of innovation for construction firms is not for its own sake, but rather innovation is one of a larger set of organisational goals that support the firm as a whole. The purpose of innovation for IAO’s is echoed in Erbil & Akincitürk (2010), that by innovating construction firms must improve quality, reduce costs, increase sales, in order to ultimately improve their market share and profitability.

While the purpose of this study is to examine and determine discrepancies between innovative and non-innovative firms, the above argues that construction firms are representative of IAOs. Which provides the research essential information in determining the purpose of why firms innovate, and how innovation might appear, thus enabling clearer examination of the determinants of innovation within construction firms.

However, it must be noted note that the distinction between innovator and imitators can be blurred, are often followed by imitating firms which often unintentionally or by design alter or deviate from an original innovation (Lööf & Heshmati 2006), and thus might be considered innovators themselves. As such, the distinction of IGOs from IAOs is not precise, wherein the propensity of innovation for both types of firm is likely to be similar. Furthermore, the distinction provides another complexity to the measurement of innovation, requiring the distinction between adoption and generation of innovation, as seen later prevents meaningful measures being taken. Therefore, the distinction is not carried forward as a determining factor between types firms, but one that informs the researcher about the purpose of innovation, and its outcomes within construction firms.
2.7 Levels of analysis of innovation in construction

In the above, a number of differing approaches used to understand innovation emanating from general innovation literature have been discussed. However, the context of ‘construction’ has been often characterised by authors as being different or unique in comparison to other sectors (Hillebrandt 1985; Blayse & Manley 2004; Thorpe et al. 2009). Prior authors distinguish construction based upon particular characteristics; one-of-a-kind production, site-production and temporary project organization (Koskela & Vrijhoef 2001). Although it is recognised that construction may share these characteristics with other industries, for instance mining (Koskela & Vrijhoef 2001). The unique combination of characteristics distinguished construction form other industries (Hillebrandt 1985), and has had individual attention, distinct from existing developments.

Within the construction literature, examinations of the concept of innovation typically address cross-sector analysis; sources of innovation; the difference between innovating and non-innovating firms; and project based innovation. These perspectives on innovation in construction are critiqued as follows.

2.7.1 Cross sector analysis

Construction literature discussing innovation will often perform a cross sector analysis, extracting the fundamental differences between construction and other sectors as a means to explaining differences in innovation between the sectors. The conclusions drawn from this approach predominantly focus what are termed the ‘barriers to innovation’ which relate to the nature of the construction process (e.g. duration, variability) or subsequent characteristics of the sector (e.g. highly fragmented, dominated by small firms), or the interaction between firms (e.g. temporary and adversarial) and dictating that they are unique to the construction sector.

It has been argued that construction projects, and consequently the products used and produced, require high levels of durability (commonly requiring a minimum life span in excess of 25 years), thus requiring extensive and long term testing (Blayse & Manley 2004). Miozzo & Dewick (2002) suggest that the longevity of constructed products prevents the production of technical innovations, building a dependence upon reliable tools and techniques instead of more novel solutions. Construction methods and solutions tend to evolve without innovative rethinking. The longevity of construction
principles and products compounds this issue by potentially requiring suppliers to stock outdated parts for repairs in the future, removing the incentive for manufacturers to develop new product ranges (Egbru et al. 1998; Blayse & Manley 2004). Davey et al. (2006) using a case study method argued that the construction industry suffers from high fragmentation; complex and dynamic products; unpredictable and seasonal workloads; and low profit all limiting innovation. These characteristics offer an explanation to why construction as a whole is, or perceived to be, less capable of innovation compared to other industries. Nevertheless, these arguments do not explain why one construction firm might be more innovative than another construction firm.

In addition to the above, further differences have been argued exist within the construction context that inhibit that propensity for innovation within construction, relative to other sectors. The adversarial relationships within construction prevent inter firms learning and the codification of knowledge which might later result in innovation (Harty 2008). The potential for innovation is further regressed due to the temporary couplings of firms and the variability of the projects within the sector itself. Additionally, unlike other sectors, construction is heavily dictated and influenced by government regulation, which can either dramatically encourage or restrict innovation in certain areas (Blayse & Manley 2004). For example, innovations low carbon and sustainability might be encouraged, while other developments are restricted due to building regulations.

In response to these contentions with the construction sector’s capacity for innovation, Winch (2003) suggests two possible responses: that the criticisms should be accepted and radical change sought; or that construction is different to other sectors and should not be expected to innovate in the same way or to the same extent. The second response dominates construction rhetoric and has been overemphasised in past studies of innovation in the sector. The selection of one response and consequent dismissal of the other response is rejected by the author.

Whilst it is accepted that construction is different in the products it provides, and the unique combination of industry characteristics (Hillebrandt 1985; Koskela & Vrijhoef 2001), it is argued that this does not automatically mean that innovation in construction and its related factors are totally distinct from other sectors, and that neither the behavioural process nor the resource based view of innovation are not applicable within
construction. Of course the adversarial environment, and complexities of products might limit technical innovations, what is overlooked is the ability to produce administrative innovation within the construction context.

Although the construction sector is argued by some academics to be a unique entity within the economy, exhibiting a unique combination of characteristics that distinguish it from other sector (Hillebrandt 1985), it is argued that construction firms function like other firms by bringing together factors of production within the market to be sold for a profit (Myers 2013). Similarly, whilst Davey et al. (2006) forwards a number of characteristics of the construction sector that limit innovation, these are on a sector wide scale, and do not address the differences between firms within the same context. From the perspective resource based view of innovation, when considering the capacity for innovation, construction firms are no different from other firms found within other sectors. While the limiting characteristics of construction do exist, these should not overshadow the determinants of innovation, nor prevent construction academics or practitioners from striving to improve industry level innovation.

It is argued that when discussing innovation within the construction context, the rhetoric of construction failing to innovative and the reasons behind this can overshadow other relationships. The inappropriate and rather unnecessary differentiation of construction from other sectors, with respect to innovation, has precluded the adoption of innovation lessons that are well established within broader management literature.

2.7.2 Sources of Innovation in the Construction Supply Chain

Another prevailing proposition within construction literature is that specific classifications of firms within the construction supply chain produce more or less innovations than other firms (Gann 2003).

Construction and the firms within it are often approached in a manner that considers the construction sector to exist as a single identifiable entity, with matching characteristics and functions relating to construction. However, in reality, within the construction sector there are a number of sub categories of firm types. These firm types differ from one another in the products or services they provide and the market in which they operate. As such, and alternative approach to innovation examines the differences between firms concerning the nature of their work, and then uses this to differentiate between firms and examine their propensity for innovation.
By drawing focus away from cross industry comparison to a focus solely upon firms within the construction sector, this provides an opportunity to remove the over emphasised barriers to innovation that the nature of the construction process brings, as all the examined firms operate in a relatively similar market. Thus, research may instead focus solely upon the differing firm types within construction.

Although some variability might be seen as to how much impact the characteristics of construction affect one firm to the next in relation to innovation, and the nature of the product they produce might differ, for the most part the external environment is argued to be consistent for construction firms. This argument is supported by Hardie & Newell (2011), who found consistency among practitioners assessment of their environment. Due to this consistently between construction firms environment it is argued that the characteristics and nature of construction do not provide an adequate explanation for why some firms are more innovative than others; which is integral to understanding the determinants of innovation within construction. The characteristics of construction are limited to suggesting why construction might be seen as having a lower rate of technical innovation compared to other sectors, but cannot explain why firms within the same context innovate or fail to do so. As discussed previously these comparisons also fail to take into account the administrative innovations that occur within construction.

Subsequently, within the construction context discrepancies between innovating and non-innovating firms could be argued to occur according to its size and or type (i.e. specialisation) of the construction firms in question. However, informed by examination of construction sector, Slaughter (2000) argues that the firms which can produce innovations are more widely spread throughout the supply chain than previously thought (Figure 5). Figure 4 illustrates some of the connections that can exist within construction between different firm types in the value chain. Innovation is practiced across the entire construction ‘value chain’. Construction contractors, manufacturers and suppliers were traditionally considered to be the key innovators within construction (Slaughter 2000; Slaughter 1998). However, it has also been revealed that structural engineers and architects have also seen to innovate, especially during early design development (Slaughter 2000). Further supported by evidence in Reichstein et al. (2008), demonstrating that firms of all types innovate. These revelations about the propensity for innovation across construction is also restricted to technical innovations,
and overlooks contributions in the form of administrative innovations that might developed within consultancy and management firms.

**Figure 5 - Value-added Chain in Construction as Sources of Innovation (after Slaughter 2000: 4)**

The belief that one area or division of construction holds supremacy over innovation is also applied to the size of the firm. Conventionally smaller firms are considered, poor or unable to innovate compared to their larger counterparts. This however, has been demonstrated by Hardie and Newell (2011) and Barrett and Sexton (2006) to be a fallacy, by examining Small-Medium Enterprises (SMEs) within the construction sector and their ability to innovate. Moreover, Reichstein *et al.* (2008) found that whilst larger firms were more capable of delivering process innovations, they were no more likely than smaller firms to achieve product innovations. This however, once again did not address administrative innovations.

In light of the above, it is argued that construction firms, regardless of size or type, are capable of innovation. Although once divided into sub categories (see Figure 4) and assessed against different types of innovation, one type may excel in certain aspect, this is thought to cloud the issue of innovation, removing the complexities that enabled innovation to emerge, to focus on a somewhat arbitrary distinguishing factor. However, this is not argued to relate to the nature of a firms work. Within any competitive market there must be innovation (Gambatese & Hallowell 2011a), and as a result some firms which are more innovative than other firms. Whilst the inherit characteristics of construction are important in differentiating between sectors, they plague the entire sector and the firms within it; both innovative and non-innovative. Although research from Hardie and Newell (2010) stresses the attention provided by practitioners to government regulation for example, this exists outside of the influence of the common construction firm, and fails to explain why construction firms are innovative and others are not. Likewise, whilst subdivisions of construction firms might reveal something
about the differences between firm types, the emphasis is placed upon the nature of their craft, as opposed to how the firm operates.

Although firms might differ in the nature of their work output (i.e. type), as innovation can occur through the construction supply chain and is not limited to a particular area or firm type. Therefore, isolating types of construction firms in such a way is not considered to facilitate any great understanding of the firms’ propensity for innovation. As concluded within the cross-sector approach above, firms regardless of output are constrained by the resources available to them. Innovation is considered a firm level issue, and the ability of the firm to innovate within its environment is dependent upon the characteristics of the firm itself as opposed to the environment or here the nature of the firms work. The firm’s potential for innovation is not related to the nature of their work but the resources envelope of the firm Therefore a greater exploration of firm level determinants of innovation is required.

2.7.3 Project based perspective of innovation in construction

A key issue within innovation research in a construction context is that construction firms are predominantly considered project orientated (Gann & Salter 2000). Innovation in construction is considered ‘project-based’, with an attitude towards problem solving which is intrinsic to construction (Shaw et al. 2010). Work cycles and most of the resources within the firm are diverted towards performing work on a series of external projects, which for the most part firms are not in control of (Gann & Salter 2000). As a result, much of the research on innovation, at a level below that of analysing the sector as a whole, is focused upon the project-based nature of work and its relationship with innovation.

Project level innovation is here considered a component in the two-moment model of Construction Innovation by Winch (1998). This model asserts that there are two processes by which innovation occurs; the first is through “top-down” process of adoption where strategy and formal approaches are applied (Shaw 2010), the second by “bottom-up” process of informal learning, which represents project level innovation. The latter is considered indicative of innovation in construction (Shaw et al. 2010). This model can be seen in Figure 6 below. It is argued that this model has led to an over emphasis on the codification of problem solving on site, and a focus towards understanding project level innovation. As opposed a balanced perspective with the
firm, which maintains both processes with the firm as the focal point for innovation. While it is agreed that innovation does occur via a “bottom-up” process, the firm that must codify and apply this new development for it to be considered innovation (Winch 1998; Sexton & Barret 2003). Therefore, rendering the firm and is capacity to engage with these development as the subject of innovation, i.e. where innovation occurs.

![Figure 6: Two moment Model of Construction Innovation (Winch 1998:273)](image)

Additionally, although construction projects may be thought of as being broken down into a similar set of process stages, each individual project is regarded as unique (Wegelius-Lehtonen 2001; Erbil & Akincitürk 2010) and thus unsuitable for the study of innovation. While consistent elements might be found within construction projects, due the variations in; project size, length, cost, location, associated contractors, client and design. Each building, road or bridge is consequently considered a prototype, because every site is different, so every design is different. This is also true for the team assembled to deliver the project, which is traditionally only assembled for a single project (Wegelius-Lehtonen 2001). Although innovation might occur on one site (Shaw et al. 2010), differences in projects can limit the codification of knowledge and the reapplication of innovation to later situations (Barrett & Sexton 2006). The unique nature of construction projects makes it difficult for construction firms to reap the advantages of economies of scale or scope found in mass production industries (Reichstein et al. 2008).

Despite the multitude of barriers that are argued to prevent innovation at the project level, such as the longevity of construction products (Blayse & Manley 2004).
majority of innovation that occurs within the construction context is argued to occur on site (Shaw et al. 2010). As such, investment into such innovation would not appear as formal research and development expenditure (R&D), and explain why Reichstein et al. (2005) argues that R&D fails to explain innovation in construction. However, whilst ‘informal’ on site innovation might occur (Shaw et al. 2010) there is a significant investment by construction firms in formal long-term development and innovation (BIS 2013). Indicating that the project is not a suitable lens for the analysis of innovation in comparison to the firm that captures this long-term investment.

It is argued that projects are an unsuitable context from which to study innovation. Most notably due to the fact that developments from other industries based upon the firm level cannot be easily applied to a project perspective in construction. Thus limiting the development of knowledge to within the construction context. Nevertheless, project-based innovation (i.e. innovation that occurs during projects) however, remains an integral part of innovation. (Gann & Salter 2000) distinguish between the project and business process of the firm, the former is temporary and unique, while the latter is repetitive and ongoing. They go on to argue that projects are one-off and although project-based firms (such as construction) may relate to the sum of all its projects. A particular project might not be representative of the firm. In construction, the project-based innovation is argued to relate to the ‘bottom-up’ learning considered a part of the firm view of innovation (Koskela & Vrijhoef 2001).

As stated previously the unit of analysis for this project is the firm. While firms may be heavily project based, for the most part the activities performed by the firm are repetitive across projects, and the boundary of firm is more easily defined. Thus offering a consistent context from which innovation might be assessed. Attempting to do so with projects is argued to be heavily problematic, as it may be unclear where and why innovation emerges.

2.7.4 Differentiating innovative and non-innovative firms in construction

The above have focused upon sector level analysis, project level analysis, and firm differences, based upon the nature of the work that is carried out. The final, and considered the most appropriate approach to examining innovation, is the differentiation between innovating and non-innovating construction firms. Innovative firms include all firms able to generate innovations, adopt innovations or both, while non-innovative
firms are unable to generate or adopt innovations (recall Table 1). This approach seeks to examine how and why firms are able to innovate, when other fail to do so. This approach examines firm level factors that exist within innovative firms, but are absent or restricted within less innovative firms. It is argued that there is a continual bias towards exploring project based innovation, to the detriment of the firm as a unit of analysis (Reichstein et al. 2008).

Two prominent firm level factors in differentiating innovative and non-innovative firms are identified within construction literature; the first the cultural and behavioural aspects of the firm, the second being the existence of leaders or champions of innovation within the firm. The former addresses the collective cultural aspects of the firm relating to its ability and willingness to innovate, while the latter focuses upon the actions and impact of unique individuals within the firm.

Culture

It is held within broader management literature (Delbecq & Mills 1985; Ekvall & Ryhammar 1998) and also in construction literature (e.g. Egbu et al. 1998; Hartmann 2006b) that the propensity of a firm to innovate is contingent upon two component parts ability and willingness of the firm to innovate. Here, ability represents the resources for potential use, while willingness is considered to represent the behaviours of firm. Essential to their understanding is that these factors are considered interdependent, and cannot function independently of one another. A lack of willingness, derived from a non-innovative culture within the firm, is considered to prevent the utilisation of the abilities within the firm. Likewise, without the necessary ability to innovate (consisting of intellectual and physical resources), an innovative culture (the collection of individual behaviours within the firm) would be fruitless. For the purpose of this thesis culture is seen as a pattern of underlying assumptions, values and beliefs shared by individuals (Hartmann 2006: 161).

The ability and willingness of the firm to innovate encapsulates a number of cultural and behavioural aspects of the firm, by which the innovation process is encouraged to deliver innovations. The ability and willingness relate to the culture of the firm as a whole, (i.e. collective attitudes and factors of production within it), and not to an individual innovative process. Together ability and willingness dictate internally the
firm’s propensity for innovation, by determining if the innovation process is restricted or not.

**Ability**

The *ability* of the firm to innovate is derived from its collective physical and mental (i.e. knowledge) resources available to be allocated to innovative activities (Hartmann, 2006a), and is therefore more quantifiable than the willingness of the firm. In a literal sense, *ability* is the collective representation of the resource competences of the firm; not only financial but also material, human and intellectual. A firm’s *ability* to innovate is therefore associated with the resources available to it; or, more specifically, the availability of unallocated resources and resources that can be diverted to innovation activities without drawing resources from existing activities (Delbecq & Mills 1985). Thus may be considered as the inputs to the innovation process.

Resources are required for the firm to be able to engage with, fund and support innovative activities, whatever their form, in order to deliver innovations. Without the intellectual resources, ideas or solutions will not be generated, without financial support, the innovative activities formal (such as R&D) or informal cannot occur, and without adequate human resources, the work cannot be carried out, not without disruption to the existing practices within the firm (Delbecq & Mills 1985). Thus, the ability of the firm to innovative is considered heavily *resource-dependent*. Resources within the firms are considered to be not only financial but also human an intellectual also (Hartmann 2006b). Emphasis of the importance of resources in determining the firm’s ability to innovation is considered to echo the resource based view of innovation discussed within Section 2.6.2. More so when recognising that innovation is most often results from an unplanned and opportunistic action, thus requiring there to be an existing amount of resources available to fund innovative activities should the need arise.

**Willingness**

The second component of firm culture is *willingness*. *Willingness* within the firm refers to the energies that allocate resources within the firm in relation to innovation, and is driven predominantly through the motivation of individuals and the creation and maintenance of an innovative culture within the firm (Hartmann, 2006a). Within construction literature, larger attention is paid to willingness, or the cultural aspects of
the firm. So much so that Blayse & Manley (2004) when discussing ‘organisational resources’ as a key influence on innovation, in fact focus upon culture, and leaders within the firm, but fail to address the presence of resources themselves.

When discussing willingness or cultural aspects of the firm, construction literature often cites Egbu et al. (1998) who identified common cultural traits of an innovative firm. These traits are considered indicative of a culture of a firm that is willing and capable of innovation. This study was conducted by comparing innovative and non-innovative firms, of various sizes and types. These traits are:

- A culture where people are open-minded, willing to accept change, flexible, and free from dogma.
- Flexibility in lines of communication and organisational structures that allow top-down, bottom-up and lateral communication;
- A risk-tolerant culture where it is accepted that lessons can be learned through mistakes;
- A ‘knowledge-friendly culture’ where people are not inhibited about sharing knowledge and do not fear that sharing knowledge will cost them ‘power and influence’ or even their jobs;
- A culture where people genuinely feel valued and where people feel some sort of ‘ownership’ or involvement with the innovation; and
- A culture where people feel some job security.

In the above it can be seen that openness to change and risk are essential components to a firm being innovative, which is unsurprising considering the inherent risk that has been argued to be associate with innovation (Leiringer 2003; Abadi & Fenn 2012). This of course is an integral issue for construction firm, which are often criticised as being risk adverse (Seaden et al. 2003; Blayse & Manley 2004). While the above list indicates a number of traits within innovative firms, merely presenting them does not allow for an understanding of how these traits might be achieved.

In order to generate and maintain these cultural traits, it must be better understood what mechanisms allow and/or encourage these traits to be expressed. Hartmann (2006a) argues that in order to alter firm culture towards one that induces innovation, firms must employ managerial actions to encourage values and beliefs that are concurrent to an
innovative culture. Table 2 below demonstrates the suggested managerial actions available to managers, grouped according to the mechanisms that underlie the actions are communication; recognition; participation; and symbolism (Hartmann 2006a).

**Table 2: Managerial actions to mobilise mechanisms inducing commitment and motivation after Hartmann (2006: 162)**

<table>
<thead>
<tr>
<th>Mechanisms</th>
<th>Communication</th>
<th>Recognition</th>
<th>Participation</th>
<th>Symbolism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilisation</td>
<td>Enabling information permeability</td>
<td>Enabling intrinsic rewards</td>
<td>Enabling incremental choices</td>
<td>Showing consistent behaviour</td>
</tr>
<tr>
<td></td>
<td>Enabling dialogue</td>
<td>Giving extrinsic rewards</td>
<td>Enabling personal responsibility</td>
<td>Enabling understanding of work impact</td>
</tr>
<tr>
<td>Managerial actions</td>
<td>Open work spaces</td>
<td>Goal Setting</td>
<td>Work autonomy</td>
<td>Providing time and financial resources</td>
</tr>
<tr>
<td></td>
<td>Public spaces</td>
<td>Feedback</td>
<td>Task identity</td>
<td>Enforcing the realisation of new ideas generated</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
<td>Pay rises</td>
<td>Job enrichment</td>
<td>Overcoming volition barriers</td>
</tr>
<tr>
<td></td>
<td>Hotlines</td>
<td>Fringe benefits</td>
<td>Job enlargement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information days</td>
<td>Flexible and pleasant working conditions</td>
<td>Quality circle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Excursions</td>
<td></td>
<td>Suggestion schemes</td>
<td></td>
</tr>
</tbody>
</table>

From the table above it can be seen that there are a number of mechanisms by which the cultural traits within the firm can be encouraged and maintained towards innovation. The above table demonstrates that in order to enact particular mechanisms for cultural change, there are related mobilisations and underpinning managerial actions. It is argued that the managerial actions reveal a resource dependency which associates willingness with the ability of the firm. Much of the managerial actions listed above such as workshops, hotlines, excursions, pay rises, fringe benefits and work autonomy all require support of both financial and human resources in order to be realised. For example, without adequate resources in order to fund pay rises for individuals, the intended cultural traits will not be demonstrated within the firm.

As stated previously, ability is representative of the resources available within the firm, which coincides with the resource-based view of innovation also established previously. By associating willingness with ability it is possible to draw the cultural aspect of the firm into the resource based view of innovation, by being able to indicate how willingness and an innovative culture is derived from the presence of resources. This further solidifies the fact that resources available to the firm are a significant factor in determining the firms’ propensity for innovation.
This is important as it indicates that while culture and the associated behaviours are vital there is an underlying resource dependency that also must be satisfied in order for firms to innovate. It is argued that the resource dependency is upon the excess resources within the firm, not previously allocated to current activities, termed ‘slack’ (Sexton & Barrett 2003). Excess resources, or slack, within the firm can be used to enact the managerial actions above without disruption to resources required for conventional activities (Delbecq & Mills 1985), as such are vital to delivering innovation.

Leaders and Champions

In association with the cultural aspects above, leadership within the firm has been considered an instrumental key factor in determining the propensity of innovation within construction firms (Dulaimi 1995; Nam & Tatum 1997). The influence of leaders has been demonstrated across both small and larger construction firms (Nam & Tatum 1997), where they are seen to provide direction and support to other organisational members in support of innovative activities and consequently deliver innovations.

Leaders are argued to capable of helping other seek solutions to problems, overcoming the negative perspectives of innovation. Leaders make resources available, provide autonomy and provide support (Kissi et al. 2012). It is put forth that, in essence, leaders enact the managerial actions within the firm necessary to cultivate willingness to innovate and utilise the firm’s ability to innovate. As such, much like the managerial actions above, leaders of innovative activities become stagnated without sufficient freedoms and access to resources, and can thus be clearly related to the presence of ‘slack’ identified above. Nam & Tatum (1997:267) go so far as to state that: “one prerequisite for innovation is slack resources – either in form of time or funds”. Nam & Tatum (1997) identified that successfully innovative firms provided leaders with ‘slack’ resources for innovation. Although not explicit about what ‘slack’ resources are, what is identified is that resources are integral to innovation and the function of leaders within the firm.

2.7.5 Summary

Existing research has focused upon sector or project level issues, which overshadow or cloud comparisons between sectors. Subsequently this has forced energy into addressing the ‘unique’ components of construction in order to deliver a level of innovation within construction, which is more akin with other sectors. Instead, this thesis seeks to identify
the elements that are in fact universal and underpin the firm’s propensity for innovation, regardless of sector.

Although existing construction research has sought to identify key components that offer explanations of why firms differ in their propensity to innovation, to this point it is argued that the concept of slack for the most part has been overlooked. Although references do exist, construction literature does not examine the concept closely, nor explore it with the construction context. Research demonstrates that leadership and culture are key to developing innovation within construction firm (Dulaimi 1995); however, here it is argued that these factors are resource dependent, and dependent upon ‘slack’ (Nam & Tatum 1997).

According to the resource based view of the firm, firms differ in their resource profiles (Wernerfelt 1984); i.e. the amount and type of resource and internal capabilities that the firm can draw from in order to support its activities. It is argued that the concept of slack offers researcher a lens by which firms might be differentiated from one another in relation to their level of slack resources and consequently their propensity for innovation. Thus, allowing focus upon the firm itself, as opposed to the nature of construction at an industry or project level, this is argued to cloud the underlying principles of innovation within construction and other contexts.

It is argued that the mechanisms, and the underlying managerial actions demonstrated by Hartmann (2006a) offer the necessary resource dependent relationship to enable theoretical links to be extrapolated between ‘slack’ and the innovative organisational culture. Slack, being a critical determinant in developing an innovative culture, and enabling leaders to facilitate innovative activities (Jong & Hartog 2007).

2.7.6 Focusing upon firm level differences

Researchers within construction management research have exposed that within innovative construction firms there exist a number of common cultural attitudes and behaviours (O’Reilly 1989; Egbu et al. 1998; Hartmann 2006b), and it is argued that a firm’s ability to innovate hinges on not only the innovative behaviour of their employees, but the resources available to the firm. As yet cultural and behavioural aspects of the firm are the only viable explanation for the differences between innovative and non-innovative construction firms. Yet this it is contended that cultural and behavioural factors are themselves dependent on available resources. These
available resources for innovation are termed ‘slack’ following Nam & Tatum (1997), (Sexton & Barrett 2003) and (Jong & Hartog 2007). ‘Slack’ is further argued to be a relevant explanation as to why firms differ in their propensity for innovation within the same context. Although it is maintained that a firms propensity of innovation across different sector differs due to contextual issues, beneath this exists a dependency upon resources that differentiate innovative and non-innovative firms, which are common and measurable. Excess resources, termed ‘slack’ offer the researcher another level of analysis of determinants that are non-firm specific, but determinant of innovation regardless of type, and importantly measureable. Resources therefore deserve attention, meriting a return to resource based view of innovation, in order to discover the patterned variations, we need to delve deeper into these aspects in order to mature the study of innovation in construction.

It is argued that a greater understanding of innovation may be developed by examining the concept of ‘slack’ resources, and determining how it interacts with the firm and its relationship with innovation. Within general management literature, organisational slack (or ‘slack’) has been identified as being a positive determinant of innovation (Damanpour 1991). Slack is argued to allow the organisation “to afford to purchase innovations, absorb failure, bear the costs of instituting innovations, and explore new ideas in advance of an actual need” (Rosner 1968:15), all factor considered to resonate with the cultural traits of innovative firms (recall Section 2.7.4). However, in spite of referencing to the concept of ‘slack’, and its importance as a determinant of innovation, within construction literature an in-depth exploration of the concept and if function within the firm does not exist within the construction context.

2.8 A Gap in the Knowledge of Innovation in Construction

As identified above, it has been argued that certain resources, termed ‘slack’, are a necessary antecedent of innovation, which relates not only to the ability of the firm to innovate, but also underpins the willingness of the firm and the actions of leaders within the firm.

However, what remains unclear is how the ability and willingness of the firm to innovate is constrained by the resource envelope of the firm, and what differentiates slack resources from conventional firm resources. Although identified as supporting innovation, which is generally held to be beneficial to the firm (Davies 2006), Nam &
Tatum (1997) also identify that slack represents extra costs to the firm and may distort its competitive position i.e. decrease profits. Therefore, it is unclear to what extent slack is beneficial or detrimental to innovation and the firm.

It is put forth that the concept of ‘slack’ represents a gap in knowledge in construction literature, which largely exists as an unexplored, unknown determinant of innovation within the construction context, or at best not fully understood. Further, because of that fact the impact of slack has not yet fully explored within the construction literature. As such, the concept of slack has not achieved a level of importance within innovation discourse in the construction context, where the concept is commonly cited, considered or commonly measured.

2.8.1 Positioning ‘slack’ as an determinant of innovation

Despite its lack of exploration, construction literature has positioned the level of slack resources as an antecedent to innovation in construction (Manley 2008). Within construction literature, a number of authors have made reference to the importance of organisational slack: Nam & Tatum (1997:267) explicitly stated that firms require “a certain amount of slack resources for innovation”. Later references by (Barrett & Sexton 2006) arguing small construction firms are argued to lack the sufficient amount of slack resources to invest in innovation in comparison to their larger counterparts. More recent construction literature even identified, through a case study analysis, that the maintenance of organisational slack was good practice (Jeong et al. 2010). Jeong et al. (2010) identified that finance, staff and time slack are key elements in transferring good practice, absence of this ‘slack’ significantly hindered this process. Manley (2008) goes so far as to recognise the well-documented relationship between slack and innovation within general management literature. However, within the same work Manley (2008) incorrectly proposes that slack is well documented within the construction industry. In the face of sparse referencing, the vast majority of research on innovation overlooks the importance of slack within the firm and its relationship with innovation. Also, the literature cited within Manley (2008) comes from general management, and does not capture the construction sector at all.

Furthermore, construction literature fails to explicitly investigate organisational slack as a concept and its interaction with the firm within the construction context. As previously stated this in part might also be due to an over emphasis of innovation at the
Revisiting Innovation in Construction

project and sector level within construction literature (Reichstein et al. 2005), which is detrimental to the use of the firm as a viable unit of analysis. Although Jeong et al. (2010) briefly identified the importance of slack of within construction firms, within the study conducted however, slack was only a component part and not the focus of the study. A key issues of innovation identified in Section 2.7.3 is the transfer of knowledge by firms across projects. Senaratne & Sexton (2011) also identified that slack is integral to knowledge transfer, survival and long term effectiveness. Yet again despite the concept being aligned as important, it once again was overlooked.

As a result of the above, it is argued that the requirement of positioning slack as a determinant of innovation in construction has been completed with existing slack literature, and to a lesser extent positioned within construction literature as a viable determinant of innovation in construction. Slack has been seen to underpin the action of leaders and champions (Nam & Tatum 1997; Jong & Hartog 2007), its maintenance identified as good practice (Jeong et al. 2010) and recognised as a key component to innovation, currently lacking in small construction firms (Sexton & Barrett 2003; Manley 2008). In spite of all of this, the concept of slack has not been fully developed, explored or measured within construction literature as a means of improving the propensity for innovation within construction firms.

Construction Innovation literature is argued to neglect the distinction between context variables that construction firms are capable of influencing and those they are not (Hartmann 2006a), here slack is argued to be a variable that the firm can dictate to some degree in order to improve its innovative position. Bresnen & Marshall (2001) argued that the construction views itself as distinct from other sectors, and as a result is either indifferent or hostile to imported ideas, or too readily accepting of approaches without sufficient critique. In this case, slack exists as a concept forwarded as applicable in construction, however, prior to adoption the concept must be fully explored and critiqued. Therefore, it is considered necessary to explore the concept of slack in greater depth than previously seen it construction literature, which will be conducted in the following chapter. In doing so a greater understanding of how and why slack is associated with innovation may be developed. Furthermore, providing an understanding of the potential impacts of differing levels of slack on innovation. Although a greater exploration of its definition will be conducted, for the time being slack is considered as “excess resources within the firm”
As a result of the assertion regarding slack as a gap in knowledge within the construction context and the lack of conceptualisation of what slack is two questions arise: What is slack and how does it function within the firm? How does the amount of slack determine firm level innovation?

2.9 Chapter Summary

In this chapter innovation, its distinction from other concepts, definition, approaches and levels of analysis within construction, and the positioning slack as a gap in knowledge in construction literature were discussed.

For the purpose of this thesis, innovation is viewed as beneficial to the firm and the economy as a whole. Innovation enables the firm to meet the demands of customers (Gambatese & Hallowell 2011b), obtain and maintain a competitive advantage for firms (Dodgson & Gann 2010; Damanpour & Wischnevsky 2006; Bowen et al. 2010; Abadi & Fenn 2012), improve the profitability and productivity of firm and their overall performance (Choi et al. 2009; Gambatese & Hallowell 2011b; Abadi & Fenn 2012).

Innovation was distinguished from invention as being novel to relevant a unit of analysis, as opposed to objectively novel in terms of discovery (Lu & Sexton 2009) and requiring application to make it relevant (Slaughter 2000), and from ordinary change as being something new and non-trivial, and not based on its success (Johannessen et al. 2001). Ultimately innovation was defined as Barrett & Sexton (2006:337) definition where innovation is seen as “the effective generation and implementation of a new idea, which enhances overall organizational performance” Barrett & Sexton (2006:337).

The Innovation process is deemed to exist as a black box within the firm, wherein inputs into the process result in innovation ‘objects’. Whilst the innovation process is not total chaos, it is not entirely structured either. The innovation process is considered far from linear, and in fact messy, unpredictable, full of feedback loops and setbacks (Loosemore & Holliday 2012). Construction firms are typified as innovation adopting organisations (IAO) (Gann 2003; Loosemore & Holliday 2012), which seek to innovate in order to support further organisational goals, such as firm performance (Damanpour & Wischnevsky 2006).

A number of determinants of innovation within construction are identified. Whilst project based factors, and the nature of construction, have an impact on the direction
and potential for innovation within construction as a whole, they do not explain differences between innovative and non-innovative firms. Discrepancy between innovative and non-innovative firms is explained in part by culture and behaviour (i.e. *Ability* and *Willingness*), and leadership, but these are argued to be underpinned by the resource envelope of the firm, and related to the presence of resources termed ‘slack’. However, the definition, functions of slack have yet to be explored within construction, presenting a gap in knowledge. Despite references stating that there is a lack of slack within construction firms inhibiting innovation (Barrett & Sexton 2006; Manley 2008; Hardie & Newell 2011), and its maintenance being identified as good practice (Jeong *et al.* 2010), frequent consideration of the concept is lacking within construction literature. Innovation literature is argued to neglect the distinction between context variables that construction firms are capable of influencing and those it is not (Hartmann 2006a). Here slack is argued to be a variable that the firm can dictate to some degree in order to improve its innovative position, but one that is neglected. It therefore is proposed that the concept of slack be fully explored and addressed by examining existing literature on the concept within general management literature.
Chapter 3. Exploring Organisational Slack

3.1 Introduction

It is has been proposed that the concept of ‘organisational slack’ provides not only insight into the differences between high and low innovating construction firms, but also represents a gap in knowledge within construction literature. Organisational slack, defined as “the pool of resources in an organisation in excess of the minimum necessary to produce a given level of organisational output” (Nohria and Gulati 1997: 604). As seen within construction management literature (Sexton & Barrett 2003) organisational slack is thought to explain the discrepancies between the rates of innovation of construction firms, however, is yet to be explored and tested within the construction context. In order to innovate, and consequently distinguish themselves from the competition, firms engage with innovative practices which place demands on a range of resources both tangible (financial) and intangible (intellectual), which are also required for existing activities within the firm. Organisational slack allows for the availability of these resources, and the authority to allocate and consume them in order to innovate.

Although a definition is put forth by Sexton & Barrett (2003) within construction literature, the concept of organisational slack has previously been unexplored within construction research or the context of construction, except for infrequent references to the concept’s existence (Nam & Tatum 1997; Jeong et al. 2010; Hardie & Newell 2011).

Within general management literature, organisational slack has been explored to a much greater extent, with a number of interpretations. Consequently, as with innovation in the previous chapter, there are different conceptualisations, interpretations and approaches to the measurement and testing of organisational slack. This chapter moves away from construction literature to broader management literature in order to explore and define ‘slack’. Following this, the conceptual functions provided by organisational slack are explored, which are considered to lead to increased innovation and performance within firms, which are assumed to also function within construction firms. The relationships between the level of slack and the benefit derived by the firm are then explored. Prior research on slack has demonstrated results showing not only positive and negative slack-benefit (Daniel et al. 2004), but also non-linear relationships both inverse-U shaped relationships (\(\cap\)) (Nohria and Gulati 1996; Tan and Peng 2003; Tan 2003) and
U-shaped relationships (∪) (Chiu & Liaw 2009). This chapter draws almost exclusively from previous organisational slack research within broader management literature, in order to develop the understanding of the concept of organisational slack in its own right due to a lack of its exploration within construction related literature.

3.2 Introduction to the concept of organisational slack

As shall be seen in this chapter, the concept of organisational slack is complex phenomenon, which can be broken down into multiple interdependent functions within the firm, which can be seen as beneficial or detrimental to the firm. Organisational slack, herein referred to as ‘slack’, is rooted around a basic principle. Firms and the organisations within them require a certain “cushion” of resources to protect the firm against both the internal and external variability that can manifest itself within the real world. Variability can come from shifts in demand in the external market, or internal changes to the firm itself and friction between current activities and other activities such as those relating to innovation (Delbecq & Mills 1985). Without this cushion of resources, the firm becomes susceptible these variations, which in turn prevents the firm from functioning properly.

This basic concept is most easily described by the Bourgeois’ bicycle chain metaphor (1981: 30-31) that relates the presence of slack within the firm to the ‘slack’ in a bicycle chain between two connected cogs (Figure 6). The presence of slack in the chain allows for the distance between the cogs to be adjusted under stress. If the slack were to be completely removed from the chain, it becomes more susceptible to changes in stress, to a point where any increase stress will cause the chain to rupture. Bourgeois (1981) argues that the same can be said for an organisation: external changes (shifts in the market) or internal forces (conflict, political behaviour) place stress on the internal mechanisms of the firm. If too little slack is present within the firm, the mechanisms within the firm will break down resulting in disruption to workflow, lowering performance or preventing innovation.
Authors have posited that organisational slack benefits the firm beyond simply preventing disruption to workflow, but is also associated with enabling creativity and innovation (Geiger & Makri 2006; Chen & Huang 2010), risk absorption (Moses 1992), conflict resolution and inducement of individuals (Bourgeois & Singh 1983). It is contended that organisational slack is a vital element to the functionality of the firm, consisting of not only financial resources, but - in fact - all resources to some degree. To explore these functions with clarity, however, it is necessary to define both what is meant by the ‘firm’ and what is meant by ‘organisational slack’ in this work.

3.3 Defining the firm as the unit of analysis for the study of slack

As seen earlier the firm is defined as “an Organisation [functioning as a legal entity] that brings together different factors of production, such as labour, land and capital, to produce a product or service which is hoped to be sold for a profit” (Myers 2013:97). Thus, it is considered to exist as a single legal entity operating within the market, which is made up of different resources. The organisation, which makes up the firm, is held to follow the understanding of slack authors Cyert & March (1963). The organisation is argued to be a coalition of individuals, some of which are organised into sub-coalitions, of which one dominates the activities of the firm (Cyert & March 1963; Sharfman et al. 1988). This perspective establishes the internal friction caused by interactions within the macro-organisation (Bourgeois 1981), and hence the firm. This friction consequently forms a basis to which slack is used within the firm to ease this friction, as excess payments made to maintain the coalition of the firm (Cyert & March 1963).

For the most part, within slack literature the firm and the organisation are not conceptually separate, and considered by the author synonymous in the context of
organisational slack. Similar to the definition above the firm is defined by slack researchers as “a bundle of resources” (Penrose 1959), which is considered to parallel the factors of production that make up the firm in the Myers (2013) definition.

For this thesis slack, and the organisation, are considered to operate within the boundaries of a single legal entity, ‘the firm’ as defined by Myers (2013). Slack operates within the firm, and originates from firm activities and movement of resources within the firm. Therefore, discussions regarding the ‘organisation’ may also apply to the firm, which exists as a macro organisation, within which exists sub-coalitions or sub-organisations (Cyert & March 1963).

### 3.4 Defining and Conceptualising Organisational Slack

Clearly defining organisational slack is vital in providing and developing the concept of slack for the previously unexplored construction context. A definition is also required to frame the measurement of slack for empirical testing in order to ascertain if and how slack might influence the firm in this case in relation to the level innovation. By exploring the origins and development of the concept in other sectors, a definition suitable for construction, and a thorough understanding of the concept, can be built. This process is presented below.

#### 3.4.1 Origins

Bourgeois (1981) suggest that the origins of organisational slack might be attributed to the inducement-contribution ratio presented by Barnard (1938). However, the term ‘slack’ was first coined much later by (March & Simon 1958), when describing excess “payments” made to an employee above the minimum required for that person to continue to work for their current employer (Bourgeois 1981). In spite of a description of slack being formulated, Cyert and March (1963:36) did not provide a formal definition of slack until five years later. The researcher defined slack as:

“...the disparity between the resources available to the organisation and the payments required to maintain the coalition” (Cyert and March 1963: 36).

This was the first of many definitions of organisational slack. Bourgeois (1981) presents a summary of these definitions, in which the concept is seen to develop from excess payment (in the economic sense of surplus rent) to individuals to expand to include: surplus resources (Moch & Pondy 1977); discretionary allocation of resources
Exploring Organisational Slack

by managerial action (Dimick & Murray 1978); and buffering (March 1979) (as cited in Bourgeois (1981)). Bourgeois (1981) synthesised these perspectives, viz.:

“Organisational slack is that cushion of actual or potential resources which allows an organisation to adapt successfully to internal pressures for adjustment or to external pressures for change in policy, as well as to initiate changes in strategy with respect to the external environment”. (Bourgeois 1981: 30)

Despite its age, this definition is referenced throughout more recent slack literature due to its clarity and explanation of slack. Slack authors cite this definition as a means of clearly defining slack prior to further developments (Marino & Lange 1983; Sharfman et al. 1988), comparing different definitions (Stan et al. 2014), a presentation of their own augmented definition (Greenley & Oktemgil 1998; Sadorsky 2006), or a precursor to empirical investigation (Tan & Peng 2003).

Although Bourgeois’ definition remains widely used, more recent studies have sought to broaden both the definition and concept of slack. Moreover, the Bourgeois (1981) definition explains more what slack does, e.g. in terms of providing a cushion, as opposed to what slack is i.e. differentiating slack from ‘ordinary’ firm resources. In order to do this we must look to the developments of the concept of slack over the past 30 years.

3.4.2 Developments of the concept

Since its inception, the concept of organisational slack has since been extended by Sharfman et al. (1988) who adhere two amendments to the concept. The first is that, for organisational resources to be considered as ‘slack,’ they must be both visible and employable to managers. This is a vital component of a definition as it distinguishes between the excess resources within budgets given to managers, and other excess resources, which are inaccessible to these same managers. If resources become inaccessible or are not visible to managers, they shift outside their sphere of influence, and thus no longer considered to be slack as they no longer interact with activities in the firm. Additionally this distinguishes time or resources wasted by poor scheduling (i.e. not used in a ‘slack’ manner) from purposeful scheduling extensions and stock management (i.e. used in a ‘slack’ manner).
The second amendment differentiates between the types of resources within a firm. To this point Bourgeois (1981) and Bourgeois & Singh (1983) for the most part considered slack relative to the financial resources that can be extracted or recovered from a firm’s activities and expenditure. The resources within the firm that are encapsulated by slack are expanded upon by Sharfman et al. (1988) to consider resources in their own right as opposed to the ability to convert them to financial resources. The authors argued that different resources provide managers with differing levels of flexibility and discretion with which these resources might be redeployed within the firm. Highly discretionary resources (such as cash), can be employed or converted within firm across a very broad range of activities. Lower discretionary resources however, are not as mobile, divisible or applicable to such a range of activities. For example, skilled labour cannot be effectively reapplied outside its skill set/expertise, nor can its time be so easily divided without disruption or reducing its effectiveness (Sharfman et al. 1988; DeMarco 2001).

Later developments, and explorations of slack have seen the resource base of slack expanded upon to include a larger variety of resources within the firm skilled and unskilled labour and plant (Sharfman et al. 1988); spare capacity (Nohria & Gulati 1996; Voss et al. 2008; Salge & Vera 2013); human resources (Mishina et al. 2004); and creative work force density (Chen & Huang 2010). This broader conceptualisation of slack and the resources it describes requires the definition of slack to move from a purely financial perspective to one that encompasses resources in their own right.

The definition of slack subsequently was expanded upon to address the changes in its conceptualisation, and additional resources. Although first defined as “excess payments”, Nohria and Gulati (1996, 1997) expanded upon this concept of excess as to not exclude any form of excess resource. Nohria and Gulati (1997) define organisational slack as

“The pool of resources in an organisation that is in excess of the minimum necessary to produce a given level of organisational output” (Nohria and Gulati 1997:604)

Although brief, this definition clarifies what organisational slack is; existing as excess resources within the firm. This definition is further distinct as it removes any value judgement as to slack’s interaction with the firm (Nohria & Gulati 1997), i.e. not defining that slack is either beneficial or harmful to the firm. It is argued that this
definition be adopted within this work. As it is not only the most recent development but also one that allows slack to be characterised as a larger variety of resource types, not restricted to only financial resources. While not explicit within the definition it is maintained that resources must not only visible but also employable by individuals within the firm, if they are to be considered ‘slack resources’ (Sharfman et al. 1988). As with innovation, the definition of slack seeks to define what differentiates slack from other resources within the firm, much like innovation is differentiated from change and invention. This definition does not seek to detail the functions the presence of slack can afford as these are not definitive, nor do they alter what slack is. Following these developments in defining slack it is necessary to examine the construct of slack types.

### 3.5 Types of slack within the firm

The slack available to firms has a wide variety of characteristics. Past authors have typically conceptualised slack in relation to a set of constructs which differentiate between types of resources. Example of these constructs have been seen earlier in Bourgeois’ (1981) definition of actual or potential resources, and again in Sharfman et al. (1988) when considering high and low discretionary resources.

To provide direction to the work, and influence the selection of measures that might empirically test the impact of slack within firms, the four most prominent constructs are explored below. This is complemented by Stan et al. (2014) non-dichotomous typology, which is considered particularly insightful in demonstrating the commonalities and differences between constructs of slack types, as well as being supportive of empirical analysis. Table 3 below illustrates examples of measures used represent these constructs.

3.5.1 Available, Recoverable and Potential

In Bourgeois & Singh (1986), the authors provide insight into the dimensions “actual and potential” slack, which appeared in the earlier definition provided by Bourgeois (1981:30) but were never explored. In Bourgeois & Singh (1986), the authors discuss and measure three types of slack: available, recoverable and potential. Where the ‘actual’ resources referred to by Bourgeois (1981) are made up of available and recoverable resources. This typology differentiates between slack types according to how easily resources can be recovered and converted to cash resources.
Bourgeois & Singh (1986) consider ‘available’ slack to be those financial resources that have not been consumed by the firm (e.g. excess cash/liquidity) and may be readily reallocated. ‘Recoverable’ slack comprises financial resources that have already been consumed to some degree but which are can be recovered for allocation to other tasks if needed (e.g. excessive operating overheads). ‘Potential’ slack comprises that which the firm might be able to generate from its environment (e.g. by raising additional debt or equity capital). Unlike the others, potential slack is just that – potential - and therefore cannot be guaranteed or easily extracted (Bourgeois & Singh 1986). This slack construct is commonly used within slack literature, as can be seen in Appendix 2, slack researchers use a variety of measures for these slack types.

This early conceptualisation is part of the foundations on which slack as a concept is based. This typology however, is not without its flaws. Because available, recoverable and potential slack are all related to the recovery of financial assets, this typology does not consider fixed assets such as machinery or inventory, nor does it consider human resources beyond the ability of the firm to convert these tangible resources into cash. By only focusing on the recovery of financial resources, this typology is rather limited. Additionally in consideration of the later developments of Sharfman et al. (1988) expressed earlier, potential resources considered within this typology must be excluded. Potential resources do not exist within the firm, they are firstly not visible to individuals or managers within the firm, nor are they employable; ergo they do not fall within the realms of slack.

3.5.2 Absorbed and Unabsorbed
In an alternative construct, Singh (1986) distinguished slack according to their levels of absorption into the activities of the firm, classifying them as either ‘unabsorbed slack’ or ‘absorbed slack’. Unabsorbed slack is defined as excess uncommitted liquid assets within the firm, which are used to indicate the firm’s ability to meet current obligations with readily available resources (Wefald et al. 2010). Absorbed slack is defined as resources embedded in the firm as excess costs that difficult to redeploy (Chen & Huang 2010), but that may be recovered through organisational redesign (Stan et al. 2014). Absorbed slack can be represented in salaries, overhead expenses and other administrative expenses (Wefald et al. 2010).
Much like available slack above, unabsorbed slack can be easily redeployed by the organisation for alternative purposes, representing a fast solution in response to environmental changes that may confront the firm (Tan & Peng 2003). On the other hand absorbed slack cannot be easily redeployed by the firm, as it is its resources are more specialised and therefore less applicable in other instances (Love & Nohria, 2005).

argues that absorbed slack is closely related to recoverable slack, and unabsorbed slack is closely related to available slack. In fact, Wefald et al. (2010) go so far as to consider available and unabsorbed slack synonymous. This perspective can be seen in Stan et al. (2014) whose typology does not distinguish between available/unabsorbed and recoverable/absorbed slacks. Although these constructs are often discussed in isolation of one another, it is maintained that these constructs are not fully distinct. Further evidence of the parallels of the two construct can be seen in Appendix 2 which illustrates how different authors measure different constructs of slack. What can be seen is that the measures for available/unabsorbed and recoverable/absorbed slacks are often the same. For example Lee (2011:10) views the current ratio as a representative measure of both available and unabsorbed slack. This amalgamation of the two constructs, or alternatively lack of distinction is maintained by the author.

3.5.3 High and low discretion

As seen earlier, Sharfman et al. (1998) differentiated between slack types according to their level of discretion of resources. The level of discretion is deemed by Sharfman et al. (1988) to be the ability of the firm to allocate otherwise excess resources (i.e. slack) to productive uses should the opportunity or need arise. Highly discretionay resources (e.g. cash) can be used by managers in a variety of situations, whereas low-discretion resources (e.g. dedicated production capacity) have limited flexibility or can only be used in a few specific situations. This distinction was defined as follows:

“High discretion slack is defined as including cash, cash equivalents, credit lines, raw materials inventory, low skilled labour, and highly flexible machine capacity. Low discretion slack ranges from processed inventory (work in process to finished goods) to skilled labour and low flexibility machine capacity” (Sharfman et al. 1998: 602)
In identifying this dichotomy, Sharfman et al. (1988) extended the conceptualisation of slack beyond financial resources to include labour, plant and goods in their own right. This is a divergence from what has been seen earlier where slack is only considered in terms of finance or the ability to finance to be extracted from slack. This typology was the first to allow managers and theorists to consider a wider variety of resources alongside the financial investment they represent. By placing other types of resources alongside cash in this way, the manager’s discretion when matching slack to needs can be considered in a more realistic way.

Mishina et al. (2004) consider that the discretion construct put forth by Sharfman et al. (1988) parallels the concept of resource stickiness developed by Penrose (1959). ‘Stickiness’ (or the level of discretion) is a function of a resources divisibility and fungibility. Fungibility describes the extent to which a given resource can be applied to multiple uses. Divisibility relates to how easy the amount of a given resource may vary in relation to demand. To that end cash is seen as both a liquid and a highly discretionary resource, whereas labour, which is not as divisible or fungible, is considered sticky and discretionary.

The construct of resource discretion is considered comparable but not synonymous with the previous constructs above. Although some highly discretionary resources might be comparable to unabsorbed slack, others are not. Taking from the notion of resource stickiness above, the level of absorption is considered to be comparable to the fundability of the resource; however the additional dimension of divisibility distinguishes this construct from those seen earlier.

3.5.4 Financial and Human resource slack

In addition to the above typologies of slack, two other forms of slack are prominent within slack literature: Human resource and financial slack (Stan et al. 2014), the former most notably championed by Mishina et al. (2004).

In a similar vein seen above by Sharfman et al. (1988), Mishina et al. (2004) differentiated between slack resources based upon the “stickiness” of said resources. However, as opposed to the above, the constructs here are considered constructs used epitomised what were liquid and sticky resources – human and financial resources, which are considered antithesis of one another.
Financial slack refers to the level of liquid assets, commonly cash resources within the firm (Voss et al. 2008). As such, financial slack is not considered distinct from available slack, but rather a specific representation of only the most liquid financial resources that exist within the firm. Human Resource slack is considered much more “sticky” than financial slack (Mousa & Chowdhury 2014a), and is representative of the human resources within the firm relative to an industry level (Stan et al. 2014). Human Resource slack (or HR slack) is used to represent the possible space capacity that might exist within the firm (Bourgeois 1981), but also the knowledge and skills embedded within the firm (Mousa & Chowdhury 2014a).

Table 3: Typical measures of slack constructs

<table>
<thead>
<tr>
<th>Author</th>
<th>Slack Typology</th>
<th>Measure(s)</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Resource</td>
<td>Firm employees/firm sales</td>
<td>Publicly owned manufacturing firms from Ewing Marion Kauffman Foundation database</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>Working capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed</td>
<td>Working Capital, SG&amp;A/Sales</td>
<td>Swedish Small to Medium Enterprise (SME) firms</td>
<td></td>
</tr>
<tr>
<td>Unabsorbed</td>
<td>Current Ratio, SG&amp;A/Sales</td>
<td>Taiwanese high technology electronics and IT firms</td>
<td></td>
</tr>
<tr>
<td>Available, Recoverable, Potential</td>
<td>Debt/Equity ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-discretion</td>
<td>Current ratio.</td>
<td>Taiwanese publicly listed high-technology firms</td>
<td></td>
</tr>
<tr>
<td>Low-discretion</td>
<td>equity/debt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.5.5 Developing an alternative typology

As discussed above, despite efforts to differentiate constructs of slack, similarities between different researchers’ interpretations can be seen. Stan et al. (2014) took the commonly held constructs of slack types and presented an illustration of how these constructs are related, which can be seen in Figure 8 below. This typology, as discussed and maintained previously, does not distinguish between absorbed and recoverable slack, nor unabsorbed and available slack. Furthermore, as proposed above, this typology illustrates a relationship between the level of discretion and the level of absorption of resources to some degree.
Despite demonstrating the first illustrative appraisal of differing slack constructs, this typology is considered by the author to have major faults, and is subsequently rejected. Primarily the author, as detailed earlier, has rejected the conceptualisation of potential slack, on the basis that it is not visible nor readily employable to the firm (Sharfman et al. 1988) therefore should be removed from any construct of slack types. Secondly this typology is made on only a single variable, not distinguishing how the vertical placement of constructs differentiates them. Thirdly, while it is accepted that financial slack is closely related, if not comparable with aspects of unabsorbed slack (and potential slack were the construct not rejected). It is contended that HR slack is not analogous with unabsorbed slack, nor is it only partially related absorbed slack. HR slack is considered to represent the epitome of low discretion slack. HR slack represents excess human resources, which can vary in level of skill and expertise but remain indivisible, and thus must represent the antithesis of financial/high discretionary slack.

For these reasons, the above typology is rejected, and an alternative typology is constructed (see Figure 8).

The topology constructed within this thesis illustrates the comparability of the constructs of slack types based upon the perspectives and interpretations communicated above. The development of Figure 9 seeks to demonstrate the complexity and confusion of discussing differing slack constructs that are often highly comparable if not in some cases equivalent to one another. In Figure 9 below, it is maintained that the constructs presented in Bourgeois & Singh (1983) and Singh (1986), are synonymous with one another, and that potential slack is rejected. Additionally, unlike the typology presented
Exploring Organisational Slack

in Stan et al. (2014), this typology categorises slack constructs according to the two dimensions of stickiness described in Mishina et al. (2004); divisibility and fungibility.

In Figure 8, it can be seen that high discretionary slack and unabsorbed slack are comparable to one another but not equivalent, as each construct captures slightly different resources from within the firm. Furthermore, HR slack is considered here only partially associated with absorbed slack, on the basis that increases in the number of employees with the firm leads to increased costs also. However, HR slack is distinct from the conceptualisation of unabsorbed slack and is not considered related these uncommitted liquid resources. This typology maintains the connection between financial slack and unabsorbed slack seen in Stan et al. (2014).

Figure 9: Re-developed typology of slack constructs

The author is aware that the typology presented within Figure 8 is not without its weaknesses. Firstly, there are likely to be examples of excess resources that to one firm might be considered absorbed and to another unabsorbed slack, similarly human resources might be more easily divisible in one context and not another. Therefore, the typology above is not an absolute representation of resources within the firm, but a guide for practitioners and academics to understand the differing interpretations of slack. Second, through High and Low discretionary slack, and absorbed and unabsorbed slack, are clearly definitively separated from one another, this is only to aid visual interpretation. In practice resources are more likely to exist along a continuum between extremes, and at some point fall between categories.
Due to the complexity and comparability of differing constructs not all of them can be carried forward in this thesis, as this would continue to confuse readers and present a lack of consistency throughout. In that vein, two constructs of slack resources are continued within this thesis; Absorbed & Unabsorbed Slack and Financial & Human Resource Slack. The discretionary construct established by Sharfman et al. (1988) is also not carried forward. Firstly, this construct is not as well established or extensively adopted within contemporary literature. Secondly, the discretion of resources is not considered significantly distinct from other constructs of absorption. Once again as recoverable and available slack are synonymous with absorbed and unabsorbed slack, the latter construct is adopted. Human Resource (HR) slack and Financial slack are also carried through this thesis to offer an alternative construct to Absorbed and Unabsorbed Slack. HR and Financial Slack are considered distinctive as they represent distinct, un-ambiguous resources within the firm, as opposed to a range of possible resource within the firm that may be captured by the constructs of Absorbed and Unabsorbed Slack.

3.6 Manifestations of slack within the firm

Following the development of slack constructs, it is vital that the role slack plays within the firm be explored. The role of organisational slack in the firm can be considered in terms of the functions it facilitates or the internal capabilities it provides within the firm. These include not only the excess payment to individuals (inducement) described above, but expands to include slack functioning as a means of conflict resolution, and a strategic facilitator for innovation. While the majority of these functions are considered beneficial, others are detrimental to the firm. The functions afforded by the presence of slack resources within the firm are summarised in Table 4 below, taken from Bowen (2002).

Table 4 also illustrates how slack might be allocated or operationalised by managers to induce these functions. For example, by providing higher than expected wages through issued rewards or ‘perks’ managers demonstrate the role of slack resources as inducement for individuals to perform desired tasks. The following individually discusses the functions and strategies that the presence of slack resources might facilitate.

<table>
<thead>
<tr>
<th>Functions of Slack</th>
<th>Key Authors</th>
<th>Operation</th>
<th>Unit of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inducement</td>
<td>Barnard (1938)</td>
<td>Excess Dividends</td>
<td>Individual</td>
</tr>
<tr>
<td></td>
<td>March and Simon (1958)</td>
<td>High Wages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cyert and March (1963)</td>
<td>Income and Prestige</td>
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</tbody>
</table>
When first defining slack, Cyert and March (1963) associated slack as the condition where inducements to individuals exceed that required to retain the employee’s contribution. For example, a firm may offer an employee income and prestige that exceeds statutory minimum wages and working conditions. As seen previously, Cyert and March (1963) accordingly defined slack as “payments to members of the coalition in excess of what is required to maintain the organisation” (1963: 42).

In providing an inducement, firms ensure that workers remain within the firm maintaining ‘the coalition’. Additionally inducement might be used to encourage individuals to engage with prescribed activities such as those relating to experimentation, risk taking and innovation (George 2005). The ability to provide inducement to individuals comes from the internal pool of resources within the firm i.e. slack (Pitelis 2007). As detailed earlier following Bourgeois (1981) this function of slack is rooted in the concept of an ‘inducement-contribution’ ratio (I/C) put forth by Barnard (1938), where he sought to examine the act of attracting members to an

### Table

<table>
<thead>
<tr>
<th>Conflict resolution</th>
<th>Executive ‘perks’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyert and March (1963)</td>
<td>Pursuit of pet projects.</td>
</tr>
<tr>
<td>Astley (1978)</td>
<td>Lowered ROI hurdle</td>
</tr>
<tr>
<td></td>
<td>Increased/decreased financial authority</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Political Behaviour</th>
<th>New resource infusion and subsequent distribution, political conflicts between managers, coalition formation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyert and March (1963)</td>
<td>Organisational or top management team</td>
</tr>
<tr>
<td>Astley (1978)</td>
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<tr>
<th>Workflow buffer</th>
<th>Change in inventory</th>
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<tr>
<td>Thompson (1967)</td>
<td>Change in administrative intensity</td>
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<td>Pondy (1967)</td>
<td>Reduced performance levels</td>
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<td>Galbraith (1973)</td>
<td>Longer delivery times</td>
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<tr>
<td>Sharfman et al. (1988)</td>
<td>Hire more labour</td>
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<td></td>
<td>Buy more equipment</td>
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<thead>
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<tr>
<td>Hambrick and Snow (1977)</td>
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<td>New processes</td>
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<td>Sharfman and Gulati (1996)</td>
<td>R&amp;D and market research</td>
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<tr>
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<tr>
<td>March and Simon (1958)</td>
<td>Number of alternatives generated or considered</td>
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<tr>
<td>Sharfman and Gulati (1996)</td>
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* Additional literature added in italics

#### 3.6.1 Inducement

When first defining slack, Cyert and March (1963) associated slack as the condition where inducements to individuals exceed that required to retain the employee’s contribution. For example, a firm may offer an employee income and prestige that exceeds statutory minimum wages and working conditions. As seen previously, Cyert and March (1963) accordingly defined slack as “payments to members of the coalition in excess of what is required to maintain the organisation” (1963: 42).

In providing an inducement, firms ensure that workers remain within the firm maintaining ‘the coalition’. Additionally inducement might be used to encourage individuals to engage with prescribed activities such as those relating to experimentation, risk taking and innovation (George 2005). The ability to provide inducement to individuals comes from the internal pool of resources within the firm i.e. slack (Pitelis 2007). As detailed earlier following Bourgeois (1981) this function of slack is rooted in the concept of an ‘inducement-contribution’ ratio (I/C) put forth by Barnard (1938), where he sought to examine the act of attracting members to an
organisation and sustaining their membership. Wherein I/C ratio is the difference between inducements provided to individuals and the contribution they make to the firm.

The level of inducement represents the tangible and intangible ‘perks’ (or simply surplus rent) provided to employees to maintain their membership of the firm. Firms engage with inducement to encourage or discourage certain actions or behaviours that are seen to be beneficial or harmful to the firm. Bourgeois (1981) suggests that this function operates on the individual level, and can be measured by examining the individual as a unit of analysis.

3.6.2 Conflict resolution

Conflict resolution regards the presence of slack as a solution to goal conflict, which is not entirely alleviated by contracts (Pitelis 2007). Slack authors argue that slack is able to reduce this goal conflict within the firm by eliminating the tension between subunits that would otherwise arise from a scarcity of resources (Cyert & March 1963; Bowen 2002). As Moch & Pondy (1977:356) remark that through the provision of additional resources. “Slack allows choice opportunities to be distributed generally to all employees. With sufficient slack, there will be a solution for every problem.”

Cyert and March (1963) suggest that firms contain an identifiable ‘dominant coalition’ whose members represent a subunit within the firm. Each subunit recognises their own organisational issues with a degree of “local rationality” ultimately leading to goal conflict between these subunits. For example different departments within a firm may have goals in relation to costs, marketing, sales, quality control, production, design and so forth, which may not be compatible with categorically-similar goals of other subunits. As a result, it is essential that the firm maintains a certain degree of slack, in order to facilitate the resolution of goal conflict between factions (Love & Nohria 2005; Pitelis 2007), alleviate the tensions that might occur within the firm, and maintain the coalition as in the above.

Bourgeois (1981) suggests that this function might be measured by looking towards the allocation of resources towards non-essential projects, which might give an indication of slack being utilised to satisfy sub-unit goals. Whilst this might be useful, it is recognised that the perspective of subunit goals does not necessarily indicate the existence of slack within the firm (Bourgeois 1981).
3.6.3 Workflow buffer

As stated earlier Bourgeois (1981) and Greenley & Oktemgil (1998) have previously described slack as a cushion or buffer within the firm, wherein slack has the potential to protect the technical core of an organisation from external variations, turbulence and internal inertia. Slack protects core activities from any disruption, and allows existing routines to be maintained. External variations include fluctuations in market demand, taxes, legislation, economic decline and growth. Internal inertia can occur from goal conflict and political behaviour among subunits within organisations. Thompson (1967) was among the first to conceptualise slack as a ‘buffer’ within the firm.

Having a slack buffer afforded by excess resources offers managers the opportunity to use their discretion to deploy resources to tasks outside of the demands of their core function or react to shifts in demand. Consider a firm with excess human resources and consequently spare capacity in its total output. By having additional staff, managers might only dictate enough work to individuals to employ 80% of their time to existing activities, therefore 20% spare capacity has not been dictated by their managers. This 20% then acts as a buffer against work disruptions, additional capacity demands, or even underestimates of work demands. Without this buffer, i.e. working continually at 100%, it is possible that individuals would become overwhelmed by any disruptions as they would not have the capacity to accommodate them being unable to increase their workload, the presence of slack resources is considered essential to preventing overwork and burnout within the firm as a result of these shift in demand (Love & Nohria 2005). The presence of additional resources, both human and financial, prevents individuals working excessive hours in the face demand shifts, reducing employee turnover (Wefald et al. 2010).

In addition to accommodating variations in workflow itself, without this spare capacity afforded by slack individuals would be unable to adjust to changes, search for alternative practices, or engage with innovative activities without disrupting their current practices. Without sufficient time to engage with activities associated with innovation a firm will be unable to innovate.

Bowen (2002) observed evidence of the workflow buffer when he investigated UK based public limited companies. The observed firms maintained slack resources to ensure that they could proactively seek out and respond to opportunities within the
market in response to new legislation. Furthermore, the firms sought to fully understand what the new legislation required and the slack ensured that they were able to implement any changes. Nohria & Gulati (1997) were also able to capture this function of slack through a subjective questionnaire which asked the extent to which output might be affected by a 10% shift in individual’s responsibility. Slack as a workflow buffer can be measured at the organisational level. In practice the importance of slack as workflow buffers has been demonstrated within both 3M (Brand 1998) and Google (Mousa & Chowdhury 2014), with managers arguing that some of the best innovations resulted from unstructured work time within the firm (Mousa & Chowdhury 2014).

3.6.4 Innovation: Stimulating creative behaviour

Slack is frequently argued to stimulate the creative behaviour and consequently innovative ability of firms not only via other functions (i.e. workflow buffer) but also directly. The majority of slack research which does not focus upon performance improvement instead focuses upon innovation. When considering slack simply as a resource in excess of what is required for standard operation within the firm, the presence of slack allows a firm to interact with and compete in its environment more boldly. Simply put, the presence of slack enables the firm to invest in experimentation and new strategies by introducing new products and services, entering new markets or developing new processes (Bourgeois 1981).

The presence of slack within the firm enables ‘slack search’: that is, the pursuit of projects that do not appear profitable in their own right, but have significant potential to improve organisational performance from the perception of other corporate drivers (Nohria and Gulati 1996). Thus, by having more slack, firms have a greater pool of resources from which to fund innovative activities (Cyert & March 1963). The presence of financial slack offers the firm safety net that enables these firms to pursue new ideas and projects with longer investment horizons and less certain outcomes (Kim et al. 2008).

Cyert and March (1963) initially considered, all other things being equal, that unsuccessful firms are more likely to innovate than successful firms because failure induces search behaviour and consequently a solution or ‘innovation’ (Bourgeois, 1981). Opponents of slack such as Jensen & Meckling (1976) argue that the threat of failure and restricted access to resources drive individuals to behave more creatively to
meet targets, whereas the presence of slack breeds complacency. However, in spite of this perspective Cyert and March (1963) could not find evidence of this mechanism and found themselves unable to predict innovation using it (Cyert and March, 1992:188). In response to this discovery, Cyert & March (1963) assert that slack is bred from success and provides resources for innovations that would, in the face of resource scarcity, not be created. Moreover, the innovations that occur within firms are predominantly not problem-orientated (as suggested by (Cyert & March 1963) but are, in fact, subunit goal orientated. Cyert and March (1963) term this principle “slack innovation” and as a result, stress that firms capable of delivering significant innovations are also those with substantial slack. Such positions have since been reinforced, with Mousa & Chowdhury (2014) arguing that financial and human resources are essential to innovation, and that firms with increased organisational resources are more likely to engage in essential activities like R&D, which lead to innovation.

In essence the presence of slack, allows firms to divert attention away from “firefighting” (Voss et al. 2008), instead allowing attention to be paid to expansive and risky concepts and innovation (Mousa & Chowdhury 2014). In the face of resource scarcity, organisations are likely to rely upon existing products, and introduce minimal, low-risk improvements and not truly innovate (Voss et al. 2008). Authors such as Nohria & Gulati (1997), Geiger & Makri (2006) and Chen & Huang (2010) have been able to accurately demonstrate relationships between the level of slack within the firm and the ability of the firm to innovate. These researcher demonstrate that moderate and higher levels of slack in fact improve the rate of innovation in the firm.

3.6.5 Satisficing
Satisficing is where firms searching for a solution adopt the best available or suitable solution from a limited search as opposed to an optimal solution from an exhaustive search. The level of satisficing within the firm is argued to increase with higher levels of slack. Satisficing or what is also known as sub-optimal behaviour occurs largely due to the bounded rationality (limitations of the cognitive ability) of either the organisation or the individual (Bourgeois, 1981).

Satisficing can be considered both beneficial and harmful to the firm. Benefits may be derived from allowing satisficing to occur within the firm, allowing the firm to operate in non-ideal real world circumstances where it cannot perfectly match its environment.
Moreover, reducing the time, energies and resources required to perform an exhaustive search (Cyert & March 1963). However, satisficing might also be considered harmful to the firm, as it prevents the firm from maximising its potential by allowing imperfect matching to occur, and allows sub-optimal solutions to be adopted (Jensen & Meckling 1976; George 2005).

The association of slack with satisficing was first hypothesised by Cyert and March (1963) who argue that the threshold for a workable solution is influenced by the presence of slack. They contend that slack reduces the number of criteria necessary to deem a solution acceptable, which in essence allows for a ‘non-perfect’ solution to be chosen; thus reducing the drain on resources within the firm in search of a maximal solution.

3.6.6 Political behaviour

Despite arguments that greater levels of slack can reduce conflict within the firm, it has also been posited in opposition to this that slack encourages the political behaviour in the firm that can lead to goal conflict (Bourgeois 1981). It is argued that slack provides greater opportunities for managers to engage in political behaviour in order to capture a greater share of the spare resources (Nohria & Gulati 1997).

Although slack can alleviate conflict from political activity as seen above, some authors contend that it can, in fact, breed political behaviour rather than reduce it. Excess slack provides managers with opportunities to engage in political behaviours in an effort to capture these additional resources (Singh, 1986). Contrasting the previous discussions, this function of slack is considered to be damaging to the firm. Although to some degree excess resources alleviate sub-unit conflict, it also encourages political behaviour. Therefore, it is likely that a balance must be struck in order to prevent damage to the firm.

This complex and conflicted relationship between organisational slack and political behaviour raises questions regarding the relationship between organisational slack and firm outcomes and whether or not the presence of slack is beneficial or harmful to the firm. Whilst proponents claim slack to be beneficial, authors such as Nohria and Gulati (1996) recognise and warn that slack may have a negative impact on firm outcomes. The issue of conflicting impacts of slack is explored at greater length in the following chapters.
3.6.7 Summary

As can be seen in the above, the presence of slack in the firm affords a number of interdependent functions. Although generally considered beneficial to the firm, these benefits must also be balanced with the detrimental effects of the functions. A schism can be seen between slack authors such as Tan & Peng (2003) support the existence of organisational slack, whereas opponents to the concept such as Jensen (1986) deem the presence of slack as being harmful to the firm. This theoretical conflict creates a need to examine the relationship between organisational slack and firm outcomes.

3.7 Interaction between slack and the firm

The relationship between slack and the benefit derived from its presence is complex, with promoters and opponents of slack advocating its influence with equal vigour. As discussed in the above satisficing induced by the presence of slack might be seen to benefit or harm the firm. Similarly slack might alleviate conflict within the firm, but also increase the political behaviour.

Advocates of slack support the belief that this presence of unallocated resources affords several functions (recall Table 4) that positively benefit the firm. They also argue that a greater presence of slack within the firm affords, through an improved ability to perform these beneficial functions, greater benefit to the firm. Opponents, on the other hand, contend that slack should be eliminated from the firm because its presence damages the firm’s potential, for example by increasing political behaviour. Whether one or both of these views is correct was questioned by Daniel et al. (2004) who, in a meta-analysis of 66 studies of organisational slack found that previous slack research has demonstrated both positive and negative relationships between slack and the benefit to the firm. To form a position for this study, the following critiques these competing views.

3.7.1 Positive correlation argument

To recap, advocates of slack argue that, as well as buffering the technical core from environmental turbulence (Tan & Peng 2003), slack provides excess resources that enable the firm to take advantage of opportunities (Mishina et al. 2004; Lin et al. 2009); legitimises experimentation (Nohria & Gulati 1997); allows for inducement and rewards (Bourgeois 1981); and provides a cushion against turbulence in the firm’s environment (Sharfman et al. 1988; Tan 2003). As an example of these benefits, uncommitted staff
time (derived from excess human resources) affords workers the autonomy and flexibility they require to engage with problem detection, learning and problem solving (Singh 1986; Salge & Vera 2013), which are considered factors that benefit the firm. It is held by slack authors that increase in level of slack within the firm improves its benefit to the firm. Authors who adopt this perspective argue that benefit to the firm is positively correlated with the amount of slack present. In short, more slack is better. This position can be confirmed not only by considering increases in slack resources and the benefit derived by the firm, but the consequences of reducing the amount of slack in a firm. If the positive position holds, then a reduction in the magnitude of slack present in a firm should result in a reduction of the benefit the firm accrues from its presence.

Although it is recognised that slack represent an additional cost to the firm, as slack resources are an excess, and consequently can harm the firm. Tan and Peng (2003) point out that; proponents of the positive view argue that the benefits derived from the presence of slack must outweigh their financial burden to the firm. This is further supported by Sharfman et al., (1988) who argues that slack resources are considered to be vital for long term survival and long term effectiveness of the firm, in spite of the excess short term costs.

To understand the how much slack to have within a firm when slack resources are viewed from a positive correlation position, it is necessary to also consider the consequences of reducing the amount of slack within the firm. For the purpose of this discussion, and in line with most established works exploring the reduction of slack resources (typified by Love and Nohria (2005) and Mellahi and Wilkinson (2010), human resources (specifically: workforce size) will provide a proxy for slack.

Lawson (2001) argues that firms that completely eliminate human resource slack only do so because they fail to recognise the benefits to the firm that arise from the presence of this slack. Unintended consequences result from an excessive reduction of human resource slack. Indeed, there is mounting evidence that removing resources from the firm is detrimental to the firm, being; an ineffective and inefficient practice (O’Neill et al. 1998) and damage the learning capacity of the firm (Fisher & White 2000). A reduction in slack therefore brings about a reduction in benefit, confirming the positive correlation view.
Love and Nohria (2005) also recognised that downsizing may unintentionally discard the tacit knowledge held by ‘downsized’ individuals, noting that organisations have rehired previously- downsized employees to regain this expertise. In noting that reducing of the workforce without reducing the work to be performed, Fisher and White (2000) concluded remaining workforce is afforded less time to reflect and learn from experiences as they are provided with their predecessors work load. Again, a reduction in slack reduces the benefit to the firm.

Downsizing can also cause overload, burnout, inefficiency, conflict and low morale among individuals in the firm (Cameron et al. 1993). Downsizing causes firms to: become less flexible (Fisher & White 2000); exhibit diminished innovation (Lawson 2001) have reduced creativity (Amabile & Conti 2011); and exhibit reduced risk taking (Cameron et al. 1993). In extreme cases, Lawson (2001) argues that fatal accidents can be caused by systems and people that are overstressed due to a lack of slack; for instance in power plants and hospitals.

Although, as reviewed above, most prior analyses of slack reduction have been focused on Human Resource Slack, it is posited that similar unintended consequences are associated with the reduction of Financial Resource Slack, leading to effects such as restricted experimentation due to lack of funding and increased political behaviour due to internal resource scarcity.

Proponents of slack maintain that in spite of its excess costs to the firm, the benefits afforded to the firm by the presence of slack outweigh its detrimental effects. Slack provides resources to encourage and fund innovation, cushion workflow against disruption, enable autonomy, flexibility and resources necessary to capitalise on opportunities. In addition to all this slack prevents individuals within the firm from being overworks, succumbing to burnout, reductions in moral, and maintains the creativity, learning and risk taking. Irrespective of whether considering the increase or reduction of slack within the firm it is held that more slack benefits the firm.

3.7.2 Negative correlation argument

The above discussion has associated an increase in benefit to the firm resulting from an increased presence of organisational slack within it. In contention is an opposing perspective that argues a negative correlation between the amount of slack present within the firm and the benefit to the firm that it generates. Love and Nohria (2005)
highlight this conflict, commenting that a rhetoric of describing firms as ‘fat’, which is
often forwarded to advance the perception that slack is harmful to the firm, and that its
removal will improve the benefit derived by firm.

From the above review of the functions afforded by the presence of slack within the
firm (recall Section 3.6), slack has been seen to facilitate political behaviour and
satisficing, both of which dampen the potential of the firm and thus, the benefit derived
from the presence of slack.

In addition to the preceding discussion, a body of work opposes the existence slack, or
at least high levels of slack within the firm. Following what is described as neoclassical
economics perspective, opponents of slack assert that its existence is wasteful and costly
to the firm, and that its optimum level is zero (Love and Nohria 2005; Chiu and Liaw
2009). This view contends that slack should be reduced if not eliminated from the firm
in the pursuit of efficiency (Sharfman et al., 1988). Increased amounts of slack is argued
to be detrimental to the firm as result of increased ill-discipline, the funding of risky
projects (Jensen 1986) and other sub-optimal behaviours (such as empire building)
made possible by the presence of these excess resources (Nohria and Gulati 1997). Tan
and Peng (2003) argued note that “agency theorists” who also oppose the presence of
slack, challenge the existence of slack on the basis that it benefits the managers within
the firm as opposed to the firm itself. Managers may, for example, divert resources to
build personal empires, power and prestige, drawing funds away from legitimate
activities of the firm as they do so (Nohria and Gulati 1997).

As stated earlier slack exists as a cost to the firm, which proponents argue is superseded
by the benefits that might be derived from slacks presence. Opponents such as
Leibenstein (1969) however argue that the cost of slack results a discrepancy between
the actual output of the firm and potential/maximum output that a firm, termed the “X-
inefficiency”. When it is present, firms operate below their potential due to the
inefficiencies and excess costs that result from the presence of slack that, with this view,
is held to unnecessarily burden the firm. Finally the 'cushion' that is afforded by excess
resources suggested by Bourgeois (1981) is said to diminish exploration and increase
risk aversion which, rather than enabling more innovation, in fact prevents it (Voss et
al. 2008) as firms seek to maintain rather than exploit their cushion of resources.
Below Figures 9a & Figure 9b illustrate these conflicting perspectives of slack. Figure 9a illustrates the positive view where higher levels of slack result in greater benefit derived by the firm. Figure 9b illustrates the opposing view, where increases in the level of slack result in less benefit derived by the firm due to the excess costs and detriments that slack imposes.

![Figure 9a: Positive view of slack](image1)
![Figure 9b: Negative view of slack](image2)

**Figure 10: Opposing views on the impact of organisational slack on the firm (a) Positive (b) Negative.**

### 3.7.3 Resolving conflicting but concurrent arguments

Both of the above arguments are potentially valid. The presence of slack can be both - and potentially concurrently - beneficial and harmful to the firm. Clearly, any burden of excess costs on a firm cannot be continually increased if the firm is to remain viable. Eventually a point at which that burden can no longer be borne must be reached. This raises the notion that a firm may seek to possess an *optimal* amount of slack. Given that with the positive correlation argument, an increase in slack will increase the benefit to the firm, but that a firm may become insolvent or otherwise non-viable if too much slack is present, the question of ‘how much’ slack should be present within the firm must be explored.

Authors such as Nohria & Gulati (1996), Tan (2003), Tan & Peng (2003), George (2005), Bradley, Wiklund, *et al.* (2011), Lee (2011) and Stan *et al.* (2014) have also debated these conflicting perspectives of slack and sought to resolve their opposing views. They found that both perspective had merit and could not be treaded separately and required a certain degree of compromise. Recognising this conflict of perspective, Bourgeois (1981) was the first to hypothesise a compromise between the two seemingly
opposing perspectives. It was posited that the benefit derived from slack must exist in a curvilinear relationship (see Figure 11a), wherein increases in slack result in increased in benefit (i.e. follow the positive correlation argument) up to a maximal slack magnitude (with associated benefit amount), after which further increases in slack damage the firm by reducing benefit (negative correlation argument). Since this proposal it has also be posited that the curvilinear relationship is U-shaped, wherein the moderate levels of slack reduced the benefit to the firm, whereas higher and lower levels of slack are actually beneficial (Figure 11b). The U-shaped relationship argues that higher and lower levels of slack afford the greatest benefit to the firm. At lower levels additional benefit is derived from being more efficient than competitors, and having less overhead cost. Firms with high levels slack on the other hand are capable of pursuing and surviving more complex and riskier strategies allowing for greater benefit. While firms with moderate levels of slack are faced with additional costs preventing efficiency and lack the adequate resources to pursue risky strategies, therefore fail to derive additional benefit for slack within the firm (Chiu & Liaw 2009).

![Figure 11: Alternative resolutions of conflicting slack perspectives (a) inverse-U shaped (b) U-shaped](image)

The proposal of the curvilinear relationship integrates the positive correlation argument and the negative correlation argument by accommodating these seemingly polar perspectives in the same model as two periods of the same function. The development of this relationship has been pivotal to the approaches and understanding of slack within research since its inception in Bourgeois (1981).

If, as suggested by slack authors Bourgeois (1981), Nohria & Gulati (1997), Tan (2003), Tan & Peng (2003), Bradley et al. (2011) Lee (2011) and Stan et al. (2014) that the curvilinear relationship has an inverse-U shape (♂) (Figure 11a), the first period
Exploring Organisational Slack

illustrates the positive correlation argument while the second period (reached after passing after a maximal point of optimality) illustrates the negative correlation argument. This relationship balances the improvements with the detriments derived by the firm at different levels of slack. At lower levels the benefits outweigh the detriments, whereas at higher levels the detriments outweigh the benefits. Such a relationship between slack and benefit might explain why empirical evidence has been found supporting both a positive and a negative correlation: they both exist in the same relationship. If the relationship is found to have a U-shaped relationship (∪) (Figure 11b), however, then the periods of the function associated with either argument would be swapped. Although empirical support for this slack relationship was initially inconclusive (Cheng and Kesner, 1997; Tan, 2003), a growing number of studies have provided empirical evidence suggesting the curvilinear relationship.

It is vital to understand and test the shape of the slack-benefit relationship within firms, as this will dictate how a firm might improve the benefit it achieves. If a certain type of resource exhibits an inverse-U shaped relationship (∩), then the firm would seek to find and maintain the equilibrium point, to derive the greatest benefit. Alternatively slack which exhibits a U-shaped relationship (∪) with the firm must be maintained at higher or lower levels to derive greater benefit. Therefore, when addressing the level of slack within the firm, it is not simply a question of whether more or less slack is required; but what types of slack, and what level depending on the relationship. At present it is unclear if differing levels of slack have any impact on the benefit derived by construction firms, let alone the shape of this relationship.

Predominantly slack research has demonstrated an inverse-U shaped relationship between slack and the benefit to the firm in a variety of contexts: George (2005) found that in privately held firms slack and firm performance share an inverse-U shaped relationship; Nohria & Gulati (1997) found that the relationship between perception of slack and level of innovation is inverse-U shaped in multi-national corporations; Geiger & Cashen (2002) provides further support for the inverse-U relationship (∩) between slack and innovation, demonstrating this relationship for both available and recoverable slack in fortune 500 firms; and finally Tan & Peng (2003) demonstrated and inverse-U shaped relationship between slack and performance of state owned enterprises in china. However, there is also growing support for the U-shaped relationship (∪) (Figure 11b);
Mousa & Reed (2013) found evidence for both U-shaped (∪) and inverse-U shape (∩) when examining slack against the initial public offering of high tech firms; similarly Lin et al. (2009) found support for both curvilinear relationships when investigating firm internationalisation; finally Chiu & Liaw (2009) demonstrated a U-shaped relationship between recoverable slack and firm performance.

If the curvilinear slack-benefit function (i.e. benefit = f(slack) or, for simplicity, b=f(s)) has an inverse-U shape, then the firm should locate and maintain what is termed by the author as a “slack equilibrium”, at which point the firm gained maximum benefit from its slack. If b=f(s) has a non-inverted U shape, then the point of inflection dividing the two function periods will be associated with a minimal amount of benefit. As either increasing or decreasing the slack present in the form to move away from that point would increase the benefit accrued, it would not be possible to find a single, optimal magnitude of slack.

Clearly, establishing the shape of the b=f(s) function is a matter of concern that will be examined in the following chapters. Before that can be done, however, the practicality of quantifying both benefit and slack (to elicit the b=f(s) function) must be established.

3.8 Approaches to Measuring Slack Resources

Having established the magnitude of slack within a firm as a key determinant of the benefit accumulated to that firm, and having established that an increase in the magnitude of slack can either benefit or harm the firm, it must next be understood how this magnitude of slack might be measured. To test the proposition that slack impacts the firm’s ability to innovate in more detail it is clearly necessary to explore how the presence of slack resources may be measured and quantified.

This section critiques past empirical studies of slack to characterise the measurement principles and metrics used. From this, a theoretical foundation for measurement of slack is assembled, upon which propositions for measuring the magnitude of slack present in construction firms will be formed and discussed later in Chapter 5 (Methodology).

3.8.1 Over and Underestimating levels of slack

Historical studies of slack illustrate the difficulty and complexity of obtaining accurate and absolute measurements of resources within the firm. As discussed previously, slack
exists as excess resources within the firm, however, the firm contains a variety of resource types (for example: liquid vs. non-liquid assets; tangible vs. intangible assets). Each resource type may be arranged on or viewed with the constructs of slack critiqued in Section 3.5 (e.g. absorbed and unabsorbed). It is argued to extract and measure excess resources, distinct from ordinary resources, across a range of resource types presents a highly complex task. Therefore, it is difficult to obtain an exact measure of slack within the firm.

A further issue compounding measurement is the potential concurrency of slack resource measures with each other and with the non-slack portions of each measured resource. Slack measures risk capturing not only the slack (i.e. the excess resources) within a particular resource type but also some or its entire non-slack portion. Additionally, as with the constructs of slack seen in Section 3.5, types of slack can unintentionally be characterised by the similar metrics resulting in overlap the resource being measured twice or more, therefore the disambiguation of metrics is critical when measuring slack.

Figure 12: The complexities of capturing organisational slack within the firm

Figure 11 above illustrates some of the complexities that can exist when attempting to measure slack within the firm. In the figure, there exist three types of firm resource, the blue section indicates resources committed to existing activities, and the white section the amount of slack for that resource. The measure of slack is indicated by the red lines and the amount of resources they capture within them. For type 1, the measure is sound, capturing predominantly slack for this measure type. However, for Type 2 this measure
Exploring Organisational Slack
captures not only slack resources but also non-slack resources also. Finally for Type 3, the measure does not capture any resources despite their being a large proportion of slack for that resource type. While the measure of slack is suitable in resource Type 1, it is not for Types 2 and 3. Although the above figure is only hypothetical, the researcher must be careful when selecting approaches to measuring slack. Ensuring that excess resources (i.e. slack), and not committed resources are captured.

Recounting Table 4 in Section 3.6, aside from articulating the functions demonstrated by the presence of slack within the firm, Bourgeois (1981) also theoretically considered how these functions might be measured and some of the issues that might arise during its measurement, this is summarised in Table 5 below. Bourgeois (1981) argued that there are many issues when facing the measurement of slack within the firm, the organisation or a subunit. In terms of inducement, i.e. excess payments, this may be considered perceptual and based upon the lens of the observer, additionally individuals are likely to feel threatened that their slack might be removed should it be revealed. Furthermore, with conflict resolution, slack provided for the organisation does not equal sub-unit slack, and vice versa. These positions illustrate some of the complexities that must be considered when approaching the measurement of slack.

### Table 5: Issues measuring slack adapted from Bourgeois (1981:32 and 35)

<table>
<thead>
<tr>
<th>Function of slack</th>
<th>Measure</th>
<th>Time frame</th>
<th>Problems</th>
</tr>
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<tbody>
<tr>
<td>Inducement</td>
<td>£</td>
<td>static (one point in time)</td>
<td>Perceptual Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Threatening Individual (vs. Organisation) phenomenon)</td>
</tr>
<tr>
<td>Conflict Resolution</td>
<td>£ or Δ</td>
<td>relative compared to previous period</td>
<td>Sensitive data</td>
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<td>Subunit slack ≠ Organisational slack</td>
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<td>Accuracy in Capturing Innovation</td>
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<td>Satisficing</td>
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<td>What constitutes maximising behaviour?</td>
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<td>Differentiating optimal solution from sub-optimal</td>
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As noted by Daniel et al. (2004) it is not entirely possible to capture the level of slack due to its pluralistic nature of its deployment. Regardless of how slack is measured it is not possible to capture slack resources in their entirety, and the measures may also capture resources that are not slack (Love and Nohria, 2005). As a result slack research for the most part does not measure the entire resource profile of the firm in order to measure its level of slack, which would be vastly time consuming and impractical. Research instead used measures that act as proxies to the existence of slack, be it through the use of questionnaires (Tan & Peng 2003) or the measurement of resources using accounting measures (Love & Nohria 2005). However, these are limited as they cannot capture slack in its entirety. It is a limitation of research into slack that must be illustrated clearly. In order to combat limitations there are a number of different approaches to measuring slack within firms.

### 3.8.2 Empirical slack research

According to Marino and Lange (1983) the differing approaches to studying organisational slack and its measurement can be placed in a 2 x 2 matrix, differentiating the approaches taken Figure 12. The matrix splits research according to two dimensions:

The vertical dimension concerns the method by which data is collected in the study, and differentiates between objective or subjective data collection. Objective measures extract data externally most commonly from financial reports, in order to measure the level of slack, whereas subjective studies engage with questionnaires and interviews in order to extract individuals’ perception of their environment in relation to slack.

The horizontal dimension is concerned with the ‘interest’ of the slack measurement system, differentiating between studies of slack over time and studies of slack at a particular instant. Relative measures gauge the change ($\Delta$) in the level of slack over time within the firm in relation to past instances, measuring both increases and decreases in relative to organisational outcomes as time passes (Marino & Lange 1983).

The absolute measurement system identifies the levels of resources with a firm and differentiates them according to who has the most or the least amounts of slack (Marino & Lange 1983) within the context in question. These are then assessed against firm
outcomes to determine if more, less or intermediate levels of slack provide the best benefit to the firm.

<table>
<thead>
<tr>
<th>Method of Slack measurement</th>
<th>Relative Change in slack</th>
<th>Absolute amount of slack</th>
</tr>
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</table>

*Theoretical paper on this approach to measuring slack

Figure 13: Typology of Operational Definitions of Organisational Slack (Adapted from Marino and Lange (1983))

Figure 12 above has been extended to include a selection of the works used within this literature review as representations of more recent developments of slack research since the work by Marino & Lange (1983). The studies have been placed according to the dimensions set out in Marino & Lange (1983). It can be seen that existing slack research is dominated by approaches measuring the absolute level of slack, with no studies taking a relative-subjective having being conducted or referenced to. Furthermore, Objective-Absolute studies are seen to also far outweigh other approaches in terms of numbers. The attributes of approaches represented by the four quadrants seen above are discussed in more detail in the following sections.

**Relative-objective studies (Quadrant 1)**

Relative-objective studies assess the changing (i.e. relative) levels of slack *within an individual firm* using objective measures of in slack rather than the total quantity of slack in order to understand how this affects the firm. Bourgeois (1981) considered this study form the most appropriate approach to conducting slack research, as it is easier to gauge the changes in resource levels within the firm than it is to extract slack from measured resource levels. In what are here termed ‘relative’ studies, researchers such as Geiger & Makri (2006) gather data on multiple firms across multiple years. Changes in

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3 Study Method 2
4 Study Method 1
the levels of slack resources within these firms is then measured over these years and examined against other measured variables. Relative-objective studies are less common than other study types, but have been used by authors with various contexts such as Lant & Nessubrar (1985), Lin et al. (2009) and Mellahi & Wilkinson (2010).

Authors engaging with objective measures commonly adopt accounting measures to represent the level of resources and consequently slack within the firm. For example Voss et al. (2008) use cash reserves to measure financial slack, while Bradley et al. (2011) use the Equity/Debt ratio to measure potential slack within the firm, more examples can be seen in Appendix 2 which provides a table of slack measures from prior studies.

The advantage of this study is that the researcher can see how relationships develop over time, and how a change in the amount of slack affects the firm in the long term. However, this approach is also limiting as it requires the researcher to obtain a broader spectrum of data, and requiring the handling of missing data.

**Absolute-objective studies (Quadrant 2)**

Absolute-objective studies are similar to relative-objective studies in that they gather objective data. However, they differ in that they characterise the differences in slack *between* firms, rather than monitoring the changing level of slack within a single firm.

As seen in Figure 12, many such studies have adopted this approach to investigate slack. Absolute-objective studies employ to different types of data collection: cross sectional studies and panel studies. The former, cross-sectional study, gathers a large number of firms in single year. The latter, panel studies are akin to the relative studies where they gather data across multiple years. However, unlike relative studies each ‘firm year’ is independent of one another and examined as if it were another firm. In doing so panel studies allow the researcher to narrow the scope of the study while still maintaining a large enough sample. An example of a panel study is found in Tan (2003) who collected from only 900 firms but over 4 years, providing 3,598 (due to missing data) observations or ‘firm-years.’

Apart from this difference (and subsequent differences in the statistical techniques adopted), these two types of study are very similar. As with relative-objective studies, absolute-objective studies tend to draw data from annual financial reports and other
econometric measures (such as those found in commercial databases). As seen in Appendix 2, across the different absolute-objective studies large variety of measures provide proxies for slack, including: sales, general and administrative expenses (SG&A) (Geiger & Makri 2006; Wefald et al. 2010; Bradley, et al. 2011); working capital (Singh 1986; Mishina et al. 2004; Mousa & Reed 2013); and retained earnings (Chen & Huang 2010; Tan 2003; Tan & Peng 2003). These measures are used as proxies for the characterisations of resources within the firm. For example Love & Nohria (2005) used SG&A as a proxy of absorbed slack, because it provides the best indication of resources channelled into overheads and staff expenditure. Whereas Bradley et al. (2011) uses working capital as a measure of unabsorbed slack.

Whilst this is the most popular approach to slack research it must be remembered that the measures of slack must be relevant to the firms being assessed (Love & Nohria 2005), and when measured only provide a snapshot of the firm (Mishina et al. 2004). Whilst financial and accounting measures can be used to correlate a measure of slack against some dependant variable, these measures are limited. It is not possible to obtain a true measure of slack as measures cannot differentiate slack from common resources. In response researchers often adjust their measures of slack against industry averages in order to determine firms with higher or lower levels of resources (Mishina et al. 2004; Love & Nohria 2005; Chiu & Liaw 2009).

Relative-subjective studies (Quadrant 3)

At the time of writing, slack has not yet been studied from a relative-subjective perspective. It is therefore only possible to speculate on the content of such a study and how such an approach would measure slack.

As with relative-objective studies this approach would require the measurement of slack over a number of years, however must do so utilising subjective as opposed to objective measure of slack. It is likely that the framing affects that bias the subjective perception of an individual’s environment would be too difficult to control in a study spanning multiple years. This risk of poor reliability coupled with the high cost of repeating subjective (i.e. survey-based) studies across multiple years may explain the absence of evidence of this study form being performed in the slack literature.
These practical constraints on the implementation of this theoretical study approach are argued to prevent its exploration, despite it being a gap in knowledge in the slack literature.

**Absolute-subjective (aka Perceptive studies) (Quadrant 4)**

Absolute-subjective studies measure slack using subjective perceptions of the individuals’ environment. They reply upon individuals’ ability to perceive their environment in relation to slack resources and/or particular firm outcomes. Although not as common as absolute objective studies, the use of subjective approaches has contributed significantly to the examination of slack, most notably demonstrating the first curvilinear relationship between slack and innovation (Nohria & Gulati 1997).

Commonly researchers use questionnaire surveys to posit questions which relate to the abundance of variance forms of slack within the firm. For example Tan & Peng (2003) assessed managers’ perception of unused capacity and the financial standing of their firm, relating to the absorbed and unabsorbed slack respectively. Although commonly incorporating questionnaire surveys, Bowen (2002) was able to use semi structured interviews to discuss issues relating environmental innovation within the firm, and found respondents discussing their amount of slack.

Nohria & Gulati (1996, 1997) advanced the evaluation of slack following on from Bourgeois’ (1981:31) prompt that focused on the simple inducement-contribution ratio to ask managers to perform judgements how on changes within their work environment might impact their output tasks. Responses to this new question format revealed the extent of unused capacity within the firm.

"Assume that due to some sudden development, 10% of the time of all people working in your department has to be spent on work totally unconnected with the tasks and responsibilities of your department. How seriously will your output be affected over the next year?" (Nohria & Gulati 1997:607)

The use of approaches such as this allows the author to extrapolate those within a high slack and a low slack environment based upon their responses. If the hypothetical changes cause little to no impact it is argued that there is a high level of slack, if the impact is large or disproportionate to the change this indicates lower levels of slack (Nohria & Gulati 1997). Absolute-subjective measurements of slack have two
Exploring Organisational Slack

limitations. First, they require participants to reliably assess their environment and how much it will be affected by change (Richard et al. 2009). Second, participants might not be inclined to reveal how much slack they think exists due to fear of it being removed (Bourgeois, 1981), further compounding survey reliability.

Summary

The above has discussed the limitations of slack research, and the four approaches to conducting slack research. The measurement of slack is problematic, as the common measures of resources cannot distinguish between ordinary and slack resources. In spite of this, a number of approaches categorised following Marino & Lange (1983) and be used to examine slack within the firm.

Absolute objective studies were seen to be the most popular historically, whilst there to date have been no examinations of slack using a relative subjective approach. Each approach is considered to have its merits and drawbacks intrinsically attached its approach. The suitability of a particular approach however is dependent upon what the researcher wishes to uncover and the research questions posed.

3.8.3 Limitations of Slack research in the Construction Context

The above has discussed the approaches to researching slack that have previously been conducted within a variety of contexts. This research has been used as a theoretical foundation to understand how slack impacts the firm and the benefit (or harm) that the firm might derive from its presence. In spite of the extensive exploration of slack literature, no such research has been conducted within the construction context to test such a relationship. As a result, a key limitation to exploring slack within the construction context (due to the unique nature of construction (Hillebrandt 1985)) that the functions of slack might not function within the construction context.

Hillebrandt (1985) has argued that while construction shares many features with other industries, its combination of the features that make construction unique. While the principals of slack might be theoretically applicable in any environment, the uniqueness of construction could prevent slack functioning as theoretically predicted, or prevent the theoretically relationships being measured. The construction sector is typically highly fragmented, made up of small independent firms without access to extensive resources (Blayse & Manley 2004). In fact, it has been proposed that within construction there is a definitive lack of slack (Hardie & Newell 2011; Barrett & Sexton 2006). The
combination of these limitations might make it impossible to statistically infer relationships between variables. It is therefore necessary that the researcher consider the unique properties of construction when developing a research design, and consider the applicability of slack measures within a construction environment to lessen these variations.

3.9 Examining slack in construction firms

Thus far, this chapter has sought to explore the concept of organisational slack in its fullest extent. This chapter has not only debated the concept’s definition, but also explored the constructs of slack types within the firm, the manifestation of functions afforded by the presence of slack, the positive or negative relationship between slack and the firm, and finally the common approaches to measuring organisational slack in literature. However, the literature used within this chapter relies almost exclusively upon research from a broader management context.

Explicit references within construction literature to the concept of slack are distinctly lacking. More so, there is a lack of exploration and measurement of the concept within the construction context. Although the concept of organisational slack can be traced back as far as Barnard (1938), and has been explored more extensively in general management literature, it remains predominantly overlooked within construction research. Within slack literature, the construction industry is also under represented. Despite slack research examining a wide variety of industry/firm types including: domestic airlines (Cheng & Kesner 1997), high technology and low technology industries (George 2005), Chinese State owned enterprises (Tan & Peng 2003) and Multi-national corporations (Nohria & Gulati 1997). Slack research has also more recently been applied to new interesting context such as; public hospitals (Salge & Vera 2013), and on-profit theatres (Voss et al. 2008). Within this broad range of contexts only a single study was found to include construction firms as only 0.46% of the sample (Bradley et al. (2011). Therefore, there is no existing foundation from which to launch an exploration of the concept of slack within the construction context.

As stated in Section 2.8 of the previous chapter, references to slack’s relationship with innovation in the construction context have been put forth. These references generally argue that smaller construction firms lack the necessary slack resources to innovate (Hardie & Newell 2011). However, these references do not provide detailed linkages
between innovation and slack as its determinant. Therefore, in order for slack to be suitably advanced as a determinant of innovation or a relevant concept within construction, more detailed linkages must be extrapolated between the concepts. This in turn will allow a synthesis between the concept of slack and its functions, and the accepted determinants and underpinnings of innovation in the construction context.

3.10 Chapter Summary

In this chapter the concept of organisational slack, or simply ‘slack’, was examined, discussing the definition, developments, functions and approaches to its measurement. Slack is defined within this thesis as “The pool of resources in an organisation that is in excess of the minimum necessary to produce a given level of organisational output” (Nohria and Gulati 1997:604). Distinguishing between resources which are ordinary and slack based upon their commitment. Through the developments of Sharfman et al. (1988), slack is considered to represent excess resources within the firm in their own right, and not the ability to convert those excess resources back to cash.

This thesis carries forward both the Absorbed and Unabsorbed Slack construction (Singh 1986) and the Human Resources and Financial Slack construct (Mishina et al. 2004; Voss et al. 2008). Rejecting the conceptualisation of potential slack, on the basis that it is not visible nor readily employable to the firm (Sharfman et al. 1988).

Following Bowen (2002) and Bourgeois (1981), the presence of slack within the firm is argued to provide inducement, conflict resolution, work flow buffering, stimulation of creative behaviour, satisficing and increased political behaviour. It is established that two conflicting perspectives exist, arguing that slack benefits or harms the firm respectively. Both perspective were argued to have merit and could not be rejected, a number of authors (Nohria & Gulati 1996; Tan 2003; Tan & Peng 2003; Bradley, Wiklund, et al. 2011; George 2005; Lee 2011; Stan et al. 2014) have also debated these conflicting perspectives of slack and sought to resolve their opposing views. It is posited that the benefit derived from slack must exist in a curvilinear relationship.

Two perspectives of this curvilinear relationship are maintained; the first speculated that the curvilinear relationship in inverse U-shaped (∩) wherein increases in slack result in increased in benefit, up to a maximal slack magnitude, after which further increases in slack damage the firm by reducing benefit (negative correlation argument); the second
posited that the curvilinear relationship is U-shaped (∪), wherein the moderate levels of slack reduced the benefit to the firm, whereas higher and lower levels of slack are actually beneficial. These relationships can be seen in Figure 10 (page 81). Within this thesis both relationships are maintained.

In order to test the slack-benefit relationship within construction firms, it was also necessary to understand the approaches by which slack might be measured. There are a number of approaches to measuring slack that may be taken by the researcher. However, as noted by Daniel et al. (2004) it is not entirely possible to capture the level of slack within the firm due to its pluralistic nature of its deployment. Measures of slack instead act as proxies to the existence of slack be it through the use of questionnaires (Tan & Peng 2003) or the measurement of resources using accounting measures (Love & Nohria 2005).

Although a vast amount of information was examined regarding slack and its interaction within the firm, in isolation this is not sufficient evidence to support a relationship between slack and innovation within construction firms. Therefore, additional linkages must be made to associate slack with the firm level determinants of innovation discussed in the previous chapter.
Chapter 4. Relating Innovation in Construction Firms to Organisational Slack

4.1 Introduction

Two core concepts have been discussed thus far: innovation (both in general and in construction); and organisational slack (its functions, relationships and measurement). These concepts have been approached largely independently of one another. The following synthesis seeks to develop additional conceptual links between firm level innovation and organisational slack beyond those currently seen in slack literature. It also seeks to examine how the relationship between the two concepts might be measured.

As stated previously, it is maintained that slack currently represents a gap in knowledge within the context of the construction industry. Slack literature that encompasses the construction firms to any significant extent does not exist, nor does any construction related literature that extensively discusses the concept of organisational slack. That is, there is no slack research on construction, and no construction research on slack. Past studies that do reference slack within the construction context stress that a lack of slack prevents small to medium sized construction firms from innovating readily (Barrett & Sexton 2006; Hardie & Newell 2011). However, these references lack extensive theoretical development of the concept of slack and empirical support for their claims.

Without further exploring the concept, it is not known if slack functions within construction firms at all or, if it does function in construction firms, whether it does so in the same way as in other contexts. Moreover, if slack is found to function within construction firms, it is not known if its effect on construction firm innovation, or performance is beneficial, detrimental or a combination of both. Finally, it is not known whether there is a genuine lack of slack within construction firms compared to other industries.

The following discussion connects the concepts introduced independently in previous chapters. To bridge conceptual gaps between the concept of slack and existing perspectives on firm innovation within the construction context, key theories of the firm are first reviewed to determine which can explain the interaction of slack and
innovation. Following this, the most appropriate theory is selected to support and enable
the connection between theories of innovation in construction firms and the concept of
slack. Connections are then extrapolated between the established drivers of innovation
within construction firms and the established functions afforded by the presence of
slack within the firm to strengthen the theoretical association between slack and
innovation within construction firms. Whilst a slack-innovation relationship is
proposed, innovation is identified as being immeasurable within the construction
context at least, providing an obstacle to the research. Common measures of innovation,
Patents and R&D expenditures are argued to fail to capture innovation in construction.
Patents are argued to relate to invention, not innovation, and further focus
predominantly on technological development. R&D expenditure is argued to be unable
to explain innovation within construction (Reichstein et al. 2008), and further is a
determinant of innovation and therefore does not guarantee its development. Firm
performance is positioned as a proxy measure for firm innovation to examine the impact
of slack on the firm, allowing for an examination of the effect of slack on the firm,
allowing the researcher to infer the impact of slack on firm level innovation. This
chapter concludes by developing hypotheses regarding the shape of the slack-
performance relationship in construction firms, which will used in order to determine if
slack in beneficial, or detrimental to the performance of the firm, and ultimately firm
level innovation.

4.2 Theoretical Positioning: Summary
The preceding chapters examined innovation and organisational slack independently of
one another. To prompt the reader the following discussion briefly recaps the definitions
and theoretical positions adopted by the author with regards to innovation and slack.

4.2.1 Innovation
Remembering to Chapter 2, innovation as a process is described as the “innovation
process” and the subsequent object resulting from this process shall is termed
“innovation” for this thesis. Academics often accept that the construction sector does
not produce technical innovations as readily as other sectors (Thorpe et al. 2009; Sexton
et al. 2006; Reichstein et al. 2005). Additionally construction literature often fails to
address the propensity or importance of administrative innovations. However, it is
argued here that innovation does and must occur within the sector, as construction firms
operate in a competitive market (Gambatese & Hallowell 2011). A competitive market forces construction firms within the sector to innovate in order to remain competitive. Therefore, whilst it is important to understand what factors impact the construction sector as a whole, it is equally important to have a complete understanding of the determinants of firm level innovation.

It is argued that the definition of innovation in this research must not be limited to certain types or areas of innovation, allowing a better understanding of what underpins the propensity for firm level innovation to be achieved. In Chapter 1 innovation was defined as “the effective generation [or adoption], and implementation of a new idea, which enhances overall organizational performance” (Barrett & Sexton, 2006:337). This definition was adopted to capture not only technical, construction related innovations but also the administrative and managerial innovations that are commonly overlooked by discussions on innovation, as it refers only to ideas.

This definition was also implemented to connect the concept of innovation with its purpose, to improve organisational performance improvement. Innovations are argued to be necessary for firms to increase performance and market share, meet stakeholder requirements and ultimately survive. Whilst all firms strive to achieve this, novel ideas implemented into the firm do not guarantee that this will occur. Consequently, innovation is perused as a means to improve performance.

Several characteristics of the construction sector were identified by other academics as explanations for the lack of innovation within the sector, such as but not limited to: high fragmentation (BIS 2013); adversarial relationships (Blayse & Manley 2004); and project variability (Wegelius-Lehtonen 2001). It is argued that these characterisations do little to explain the discrepancy between innovative and non-innovative construction firms, and only explain why construction firms might differ from other sectors. Past studies of innovation within construction have failed to address the relationship between the availability of resources within the construction firm and the firm’s capacity to generate innovations.

Emphasis so far has been placed upon the differences between sectors or the project level interactions of firms, to the detriment of understanding the construction firm itself (Reichstein et al. 2008). This thesis focuses upon the firm as the unit of analysis,
exploring its propensity to innovate, as opposed to project or industry analysis. In doing so, it is argued that this removes the market, environmental and governmental factors which overshadow the examination of innovation, preventing the examination of firm level factors within construction. The propensity to innovate of construction firms is the result of a combination of the ability and willingness of the firm to innovate (Hartmann 2006); both of which are argued in this thesis to be underpinned by a dependency upon the firm’s resources.

The thesis identifies a distinction might be drawn between firms that predominantly generate (IGOs) and those that adopt innovations (IAOs), however, it is argued that although this distinction might be made it is not carried forward within the thesis. It is argued that the distinction between innovator and imitators is blurred, were innovators are often followed closely by imitating firms which often unintentionally or by design alter or deviate from an original innovation (Lööf & Heshmati 2006), and thus might be considered innovators themselves. Furthermore quantifying the generation or adoption of an innovation is potentially complex, who many innovation must be generated to be an IGO instead of an IAO? Therefore, the thesis maintains that innovation is an ‘object’ and that the innovation process is what produces an innovation, and is not what does not distinguishes IGOs from IAOs. Consequently, the thesis continues to discuss innovation, and innovative firms as a whole, be they IGO or IAO.

Despite the firm’s internal resources and capabilities determining their propensity to innovate (Hartmann 2006), most research into innovation continues to study the firm’s external environment. Hardie & Newell (2011) found this perspective to be shared by practitioners, who view the firm’s external environment as more important to innovation than the firm’s own resources. Emphasising this lack of awareness of resource dependency, further studies identified that a lack of innovation within small to medium sized construction firms is the result of a lack of unallocated or otherwise available resources; namely “slack” (Sexton & Barrett 2006a; Hardie & Newell 2011).

Although the concept of slack has been identified within construction literature (Sexton & Barrett 2003a; Sexton & Barrett 2003b; Manley 2008; Nam & Tatum 1997), further literature conceptualising and examining the impact of slack on construction firms could not be found, beyond that stating that the maintenance of slack was good practice (Jeong et al. 2010).
Consequently, as a result of the above assertion regarding slack within construction and the lack of conceptualisation of what slack is in that sector, two questions arise: What is slack and how does it function within the construction firm? How does the amount of slack determine firm level innovation in construction?

4.2.2 Organisational Slack

In response to the above questions, the concept of organisational slack and its relationship with the firm was examined with reference to firms in general to ascertain how it might influence the firm’s ability to innovate. The concept of organisational slack – or simply ‘slack’ – addresses the impact of uncommitted or spare resources within the firm upon the firm’s innovation, growth and performance. The wider literature surrounding the concept of slack was found to be far more expansive than that relating to construction; incorporating multiple definitions, typologies and perspectives. From its review, organisational slack was ultimately defined in this thesis as “the pool of resources in an organisation that is in excess of the minimum necessary to produce a given level of organisational output” (Nohria and Gulati, 1996: 1246). Slack was considered to not only represent financial resources but also a range of resource types within the firm including human and intellectual resources.

Examination of the slack literature found the concept of ‘slack’ to be associated with, but not limited to, innovation (Mousa & Chowdhury 2014a; Nohria & Gulati 1997), performance (Stan et al. 2014; George 2005), growth (Bradley, Wiklund, et al. 2011; Mishina et al. 2004) and internationalisation (Lin et al. 2009). The majority of research concerning slack focused on innovation and performance. The presence of slack within the firm is argued to facilitate and motivate both innovation (Penrose 1959) and superior firm level performance (Bourgeois 1981; Daniel et al. 2004) through four mechanisms, namely:

1) Inducement: Provision of rewards (e.g. wages or prestige) above the minimum necessary to ensure the individuals employment.

2) Workflow buffering and risk absorption: Free time or excess resources that protect the firm against external/internal variability or allows for extraneous activities.
3) Conflict resolution: Resolution of issues or disputes arising from issues regarding distribution of resources through the availability of additional resources for allocation.

4) Pool of resources: Resources used to fund innovative activities financially and intellectually.

These functions were seen to affect the firm’s ability to both innovate and perform within the market by: protecting core and innovative activities during environment shifts (Bourgeois 1981); pursuing innovative strategies (Nohria & Gulati 1997); and growing the firm (Bradley et al. 2011). The functions afforded by slack allow the firm to compete in its market and ultimately survive. Authors have argued that both firm level innovation (Nohria & Gulati 1997; Chen & Huang 2010) and firm level performance (Tan & Peng 2003; Lee 2011) are influenced by the presence of slack through the same functions listed above. For example, workflow buffering (generated by excess human resources or excess capacity) not only prevents disruption of current activities, also it enables free time that may be dedicated to innovative pursuits.

Although empirical studies have demonstrated a positive relationship between slack and desirable firm outcomes (innovation or performance) (Wefald et al. 2010; Daniel et al. 2004), opponents to the presence of slack remain. These opponents argue for its removal from the firm. Following what is described as a “neoclassical economics perspective,” opponents of slack assert that its existence is wasteful and costly to the firm and that its optimum level is therefore zero (Chiu and Liaw, 2009; Love and Nohria, 2005). The presence of slack in the firm is argued to encourage ill-discipline, the funding of risky projects (Jensen, 1986), sub-optimal behaviours and empire building (Nohria & Gulati 1997); all of which are detrimental to both firm performance and innovation.

Having established that both a positive and a negative relationship with the level of slack, and firm benefit, both perspectives could not be maintained without further developments. To resolve these conflicting perspectives, a curvilinear relationship was proposed first by (Bourgeois 1981) and later maintained and supported with empirical research by authors such as Tan (2003), Herold et al. (2006) and Nohria & Gulati (1996). This thesis maintains the possibility of both an inverse-U shaped relationship (∩) (Bourgeois 1981) and a U-shaped relationship (∪) (Chiu & Liaw 2009) between the
level of slack present in a firm and the benefit derived by the firm via either improved innovation or improved performance. Due to the lack of evidence within the construction context, and both relationships being previously established in research, assertions cannot be made regarding the shape of the relationship slack shares with the firm. These relationships are illustrated in Figure 14. In the figure below the X-axis represents the level of slack within the firm, while the Y-axis represents the benefit derived by the firm (as either higher rates of innovation or improved performance). The blue and green dashed lines represent the positive and negative perspectives respectively, which are resolved by the curvilinear relationship in red.

Figure 14: Alternative perspective of the curvilinear relationship between slack and benefit to the firm: Inverse U-shaped (a); and U-shaped (b).

As illustrated by Figure 13(a), the inverse U-shaped relationship (\(\cap\)) suggests that, compared with the absence of slack, initial increases in the amount of slack present in a firm improves the benefit of its presence to the firm by making the resources required for innovation and performance improvements more available. However, after reaching a maximum these benefits are overwhelmed by inefficiencies caused by idle resources, empire building and suboptimal behaviour (Stan et al. 2014; Nohria & Gulati 1997; Jensen & Meckling 1976). These negative consequences of excess resources outweigh the benefits of slack within the firm, causing further increases of slack to diminish benefit derived by the firm. In this scenario, firms face the challenge of determining the optimal amount of slack that maximises its benefit.

The counter to this relationship is the contrasting U-shaped relationship (\(\cup\)) between slack and firm benefit and as illustrated by Figure 13(b). This relationship argues that either high or low levels of slack provide the greatest benefit to the firm, while
Relating Innovation in Construction Firms to Organisational Slack

Moderate or intermediate levels do not provide sufficient benefits to offset the excess cost (i.e. inefficiency) of the slack. In this scenario, firms can derive additional benefit from low levels of slack, by being more efficient than competitors, having lower overhead costs, further maintaining a more streamline position than the competition allowing the firm to seize opportunities within the market more readily. Firms with high levels of slack can pursue and survive more complex and riskier strategies yielding greater benefit (such as increased profits). Firms with only moderate levels of slack, however, find that that slack merely yields additional costs, preventing efficiency and failing to make adequate resources available to pursue risky strategies. These firms therefore fail to derive additional benefit from greater amounts of slack (Chiu & Liaw 2009).

Both relationships have been demonstrated within slack literature. Prior work has predominately demonstrated an inverse U-shaped relationship (see, for example, Nohria & Gulati 1996; Tan & Peng 2003; Tan 2003; Chen & Huang 2010) and has characterised relationships between the presence of slack and firm benefit in the form of both innovation and performance. However, evidence also exists supporting the inverse-U shaped relationship (∪) (Mousa & Reed 2013; Lin et al. 2009; Chiu & Liaw 2009) in relation to the same firm benefits; innovation and financial performance. Due to a lack of evidence regarding which curvilinear relationship exists within construction, both perspectives were maintained as possible explanations for the impact of the level of slack present within a construction firm on beneficial firm outcomes; namely innovation and performance.

4.3 Relating Slack to Innovation in Construction Firms

Theoretical links associating the presence of slack to firm level innovation do not exist within the construction literature. Blayse & Manley (2004), for example, overlook the importance of tangible resources within the firm and the importance of resources as a determinant of innovation within the firm, instead focusing on more intangible concepts such as innovation ‘champions’ and ‘culture’. Slack represents a current gap in knowledge within the construction context, one that is vital to understanding the discrepancy between innovative and non-innovative construction firms, and possibly the lack of innovation within the sector as a whole. However, in order to position slack as a viable explanation for firms’ propensity for innovation within construction, links
between established perspectives of innovation within construction literature and the presence of slack must be extrapolated. Doing so would bridge the research gap and indicating how slack might function within the unexplored construction context. Nevertheless without theoretical or empirical research it is not possible to justify a position towards the impact of slack on construction firm benefit; be it positive, negative or curvilinear (∩ or ∪). In order to support the application of concept of organisational slack within a construction context, this section extrapolates links to bridge this current research gap between existing research in construction literature on innovation and slack research from general management literature.

Whilst relationships have been established between slack and innovation in firms generally (Nohria & Gulati 1997; Herold et al. 2006), this evidence exists externally from the construction context. Within construction literature, inferences are made to the level of slack affecting the firm’s ability to innovate but these statements are never carried forward nor established. Among construction researchers, Nam & Tatum (1997) argue that the effectiveness of innovation leaders and champions is mediated by the presence of slack, and Jeong et al. (2010) identify that slack is a vital component to good practice transfer, however neither explore in depth the definitions, constructs or functions of slack in this context.

As slack has not yet been explored within the construction context, it is unclear how slack interacts with the construction firm to provide benefit such as improved innovation or improved performance. The direction or shape of this relationship (∪ or ∩) is also unclear. Moreover, it is not clear if slack can function at all in the construction sector due to the unique characteristics, such as the project-based nature of the products, high fragmentation high risk, are often argued to distinguish construction from other sectors (Hillebrandt 1985). This thesis contends that a relationship between slack and the benefit derived by the firm does exist within construction firms.

The above position is primarily supported by the extensive prior work within the general management literature, but also by indications within construction research regarding the resource-dependent nature of innovation in construction firms. For example, Lu & Sexton (2009:124) note that innovation may fail due to: an inadequate supply of resources; full resource allocation to current activities; or the incorrect resourcing of innovative activities. This research contends that the statement by Lu &
Sexton (2009) signifies the resource dependency of innovation and, more specifically, its requirement for excess resources – that is, slack – beyond those required for current activities. To search for evidence of this relationship between slack and innovation, how resources are used within the construction firm must also be studied. A theoretical framework must be assembled using an established theory of the firm to predict how slack might stimulate increased benefit derived by construction firms, in the form of both firm innovation and performance.

4.4 Theories of the Firm

To advance the transposition of the concept of slack in the construction context, it is first necessary to examine the theories of the firm from which theories of slack function are derived. Once identified, the most appropriate theory of the firm will offer a framework within which this study can associate the presence of slack with the determinants of innovation within construction firms.

Three of theories of the firm were examined: the Behavioural Theory of the Firm (Cyert & March 1992); the Theory of Growth of the Firm (Penrose 1959); and the Resource Based View of the Firm (Wernerfelt 1984). Each theory was selected because it recognises the existence of organisational slack within the firm and provides insight into the internal mechanisms of the firm relating to resources and innovation.

4.4.1 Behavioural Theory of the Firm

The following discusses the work of Cyert & March (1963) in their seminal book “A Behavioural Theory of the Firm.”. Pitelis (2007) states that there exist a number of behavioural theories in modern literature: the following, however, discusses the original contribution from the above source. The Behavioural Theory of the Firm (BTF) is considered one of the most influential management books of all time (Argote & Greve 2007) and is credited with the first reference of the term ‘slack’ (Bourgeois 1981).

The BTF emerged from Cyert and March’s frustration at the inability of neoclassical economic theories of the firm to explain actual decision making within such organisations due to their assumption of rational actors (Bowen 2007). The BTF examines the internal mechanisms of the firm which drive the firm to engage with the market (Pitelis 2007). Cyert and March (1992) explicitly examined this internal operation to understand the firm’s economic decisions regarding factors such as output
price and quantity produced (Bowen 2007) rather than examining external market factors per prior economic models (Pitelis 2007). To do this, they defined the firm as “a coalition of individuals, some of them organised into sub-coalitions” (Cyert & March 1992:31), which is argued by (Bowen 2007) to generate an adaptive political coalition.

Whilst the concept of slack is considered to have been born from the BTF (Bourgeois 1981; Daniel et al. 2004; Kim et al. 2008), the BTF also engages with addition core features which relate to the presence of slack: bounded rationality; satisficing decision making; and unresolved conflict (Bowen 2007; Pitelis 2007; Cyert & March 1963). Elements of the concept of slack with the BTF have been used to explain phenomena such as political behaviour (Bourgeois & Singh, 1983) and, critically for this work, innovation (Nohria & Gulati 1996; Geiger & Cashen 2002).

The BTF argued that the existing economic “consensus” on the theory of the firm had two major defects (Cyert & March 1963:8). The first was that its cognitive and motivational assumptions appeared unrealistic. (Cyert & March 1963) argued that the firm’s assumed driver of profit maximisation is either one of many goals of the firm or not present at all. They argued that firms have multiple, possibly conflicting goals due to the conflicting needs of sub-coalitions within them (Bourgeois 1981; Bowen 2007; Greve 2014). The second defect was the assumption that firms operate with perfect knowledge of their market. Cyert and March challenged this, arguing that firms have “perfect knowledge only up to a [certain extent]” (1963:8), leading to the assumption of bounded rationality within the firm. By considering the behaviour of intra-firm actors in terms of bounded rationality, Cyert and March limited the assumption of profit maximisation from firm operations and placed greater emphasis on behavioural aspect of the firm (Argote & Greve 2007).

Within the BTF, slack is seen as excess payments to members of the firm that are required to alleviate intra-firm conflict and maintain the coalition: that is, the firm itself (Pitelis 2007). Excess payments can be viewed as additional resource expended by the firm over and above that required to produce its outputs with full efficiency. Examples of excess include additional financial costs within the firm or additional inventory alleviating resource scarcity. The availability of excess payments, however, does not mean that internal conflict can be eliminated from the firm (Pitelis 2007).
Firms can generate slack through success within the market. This is done by transforming retained profits and returning them to the coalition as excess payments beyond the minimum required to maintain the aforementioned coalition (Cyert & March 1963). Firms that secure sufficient slack are considered more capable of surviving within a variable external environment. Slack plays both a stabilising role and an adaptive role in the firm; acting as both a means of maintaining the coalition of the firm and as a cushion to bear and adapt to less favourable environmental changes (Cyert & March 1963:43-44). Moreover, slack plays an integral part in alleviating resource scarcity, enabling innovation (Pitelis 2007): “slack provides a source of funds for innovations that would not be approved in the case of scarcity but that have strong subgroup support” (Cyert & March 1963:189). The BTF identifies that firms generally seek to innovate continually. Slack is used to explain how and why firms continually develop innovations even when they are not faced with problems that require solving. Innovations such as this are produced within non-pressurised activities – termed slack search (Argote & Greve 2007) – as the process, like slack itself, is not a requirement by the firm, but an excess to regular firm activities. Through slack search individuals continually innovate in order to improve current activities and meet subunit goals.

Despite the BTF providing the foundations from which the concept of organisational slack was born, the BTF has had limited adoption among authors performing empirical slack research. Whilst not rejecting the principles of the BTF, these researchers predominantly mobilise other theories of the firm such as the Resource Based View (Lee 2011) or the Theory of Growth of the Firm (Bradley, Shepherd et al. 2011). Alternatively, they may take a perspective of ‘organisational theorists’ (Tan & Peng 2003) which focus upon slack as a concept, recognising both its costs and benefits to the firm.

4.4.2 Theory of Growth of the Firm
The Theory of Growth of the Firm (TGF) was developed by Penrose (1959). The theory explores why firms differ in their rate of growth and what conditions impact a firm’s ability to grow. Much like the BTF, the TGF analyses the firm internally: “the emphasis is on the internal resources of the firm” (Penrose 1959:5). For Penrose, the market is not of interest; rather the interaction between human and non-human resources within the
firm – understood as the nature of the firm (Pitelis 2007) – and how they relate to each other in supporting or limiting the growth of the firm matters (Penrose 1959).

Like the BTF, Penrose (1959) argues against the typical assumption that firms seek short term profit maximisation. The TGF considers that issues of uncertainty, bounded rationality and multiple managerial objectives make the maximisation of short-term profits infeasible. Instead, firms pursue the maximisation of long-term profits (Pitelis 2007). This perspective is also seen in Sharfman et al. (1988) who argue that slack theorists seek to sacrifice short term profit maximisation for long term profits. This is unlike the BTF, which focuses upon the negotiation of multiple firm objectives and satisficing, focuses upon increased long term profits as growth of the firm. Also in contrast to the BTF, the TGF does not consider the firm to be an unambiguous, clear-cut entity. Penrose (1959) argues that the firm is not an observable physical entity, separable from other objects but is somewhat difficult to define, due to what are considered arbitrary and overlapping boundaries. The TGF defines the firm as both an administrative organisation and a collection of productive resources used for the production and sale of goods at a profit (Penrose 1959:32). Ultimately, the TGF views the firm as “a bundle of resources” – tangible and intangible, human and non-human (Buckley & Casson 2007).

According to the TGF, slack exists within all firms to a certain degree. Slack is generated first, by the indivisibility of resources and, second, by intra-firm learning which reduces the required resources for current activities. Resources which are not easily divisible, such as labour or some materials requiring bulk order (e.g. bricks), inevitably lead to a remainder of excess resources within the firm. Intra-firm learning causes firms to improve the efficiency with which activities can be performed, reducing time and resources demand and thereby generating slack by opening a gap between resources supplied for and demanded by current activities (Penrose 1959; Pitelis 2007).

Within the TGF, organisational slack plays a larger role than in the BTF. Slack was seen to enable innovation within the BTF by providing a pool of resources from which innovative activities could be funded (Cyert & March 1992). In the TGF, however, slack not only enables endogenous growth (defined as an increased output for given factors of production (Penrose 1959:11)) and innovation through excess financial funds like that seen in the BTF, but slack is also used to motivate innovation and growth from
within the firm (Pitelis 2007). This coincides more closely within the functions of slack discussed by Bourgeois (1981), who argued that slack is often used as an inducement (e.g. perks or higher pay) to motive individuals to engage with for certain activities. Unlike the BTF above, in the TGF the issue of unresolved intra-firm conflict does not exist (Penrose 1959) and, consequently, slack is not seen to alleviate issues with regards to said conflict.

That being said, due to the shared conceptualisation of slack, as excess resources within the firm, in the BTF, the TGF has been adopted within organisational slack literature. Bradley et al. (2011) explore the importance of organisational slack in relation to firm growth across multiple sectors. Bradley et al. (2011) found that slack has a duel effect on the firm, stimulating growth through market expansion, but also stifling the entrepreneurial culture of the firm.

### 4.4.3 Resource Based View of the Firm

The Resource Based View of the Firm (RBV), although considered to be highly influenced by the work of Penrose (Peteraf 1993; Pitelis 2007), has its own independent origins in Wernerfelt (1984). The RBV seeks to understand why some firms manage to achieve competitive advantage in an industry while others fail to do so (Bowen 2007). This is done by assessing the firm’s resource profile rather than assessing its products (Wernerfelt 1984). By examining its resource profile, a firm can identify “optimal product-market activities” (Wernerfelt 1984:171). As with the BTF, the RBV has several variants (Bowen 2007); the following discusses the core concepts and propositions of the RBV.

The RBV challenges the presumption that resources within the market are homogenous (i.e. uniform) and freely mobile across firms (Bowen 2007), instead proposing that firms differ in both their resources which may be fixed to the firm and their capabilities. The RBV argues that some of the resources and internal capabilities of the firm are heterogeneous and immobile across firms: that is, they are distinct and non-transferable between firms. Firms use this heterogeneity to distinguish themselves from one another, thereby generating competitive advantage (Peteraf 1993; Mahoney 1995). The RBV relates firm resources to a sustained competitive advantage and superior economic performance (Bowen 2007). The RBV maintains the definition of the firm from the
Relating Innovation in Construction Firms to Organisational Slack

TGF, wherein firms are defined as a bundle of productive resources (Bowen 2007; Penrose 1959; Wernerfelt 1984).

The RBV defines the firm as a unique bundle of resources and capabilities (Kostopoulos 2002; Penrose 1959; Bowen 2007). Resources within the firm are classified as tangible (e.g. machinery and capital) or intangible (e.g. employee knowledge, experience and skills, reputation, organisational procedures). The capabilities of the firm refer to the firm’s capacity to deploy and co-ordinate its resources in combination to generate a desired result and therefore relate to intrinsically intangible firm-specific processes (Kostopoulos 2002).

As with both the BTF and the TGF, the RBV sees slack as a key driver in a firm’s capacity to generate innovations. The greater the amount of slack, the greater the potential to innovate in response to opportunities in the market or to grow the firm (Lin et al. 2009). As seen in the TGF, slack is considered to be generated through the indivisibility of resources and intra-firm learning (Pitelis 2007). In addition to this however, the RBV considers slack to be generated similarly as to the BTF through economic rent returned to the firm, in other words “returns in excess of a resource owner’s alternative use cost” (Mahoney 1995:91), i.e. profits.

Internal firm resources are considered to be both the tangible and intangible assets which are tied to the firm (Wernerfelt 1984). Resources are seen to vary within the firm and may conventionally be classified under headings such as: financial, physical, human, organisational, technological, and intangible (Mahoney 1995). However, it is recognised that these resource classifications may be subdivided as far as necessary for analysis. A firm can create a competitive advantage by matching its unique (or otherwise distinctive or superior) resources against opportunities presented by its environment. For example, a house builder with sufficient and appropriate resources might identify an opportunity for developing highly efficient and environmentally friendly houses. By matching existing knowledge, capabilities, financial resources and materials the firm generates a competitive advantage by distinguishing its houses from the competition. This advantage however deteriorates over time as competing firms are able to replicate or imitate these resources.
Heterogeneous, firm-specific resources and capabilities are the foundation of the RBV (Mahoney 1995). Those with marginal or comparable (i.e. homogeneous) resources can only breakeven; whereas those with superior (or heterogeneous) resources are able secure Ricardian rents (Peteraf 1993). Such rents are earned from resources that are fixed to the firm or otherwise in limited supply (Amit & Schoemaker 1993).

To obtain a competitive advantage and secure rent, according to the RBV, the firm must create a resource position that is not only different to but also not imitable by competitors. To create a unique resource position, firms recombine their existing resources in novel ways unforeseen by competitors (Bradley et al. 2011). These combinations, because they are novel to the firm, are recognised as innovations.

It is unsurprising that a theory that explores the resources of the firm has been utilised within slack research. (Bradley, Shepherd, et al. 2011) adopt the RBV when assessing a firm’s ability to cope with dynamic environments and environments with resource scarcity. Although (Bradley et al. 2011) measure financial slack across firms that are not unique, they argue that financial slack plays an important role in firm performance, enabling the firm to capitalise on opportunities in its environment. In presenting this conceptualisation, they add to the explanatory power of resource-based arguments.

4.4.4 Selecting an appropriate theory

The RBV considers that resources and internal capabilities (the energies that govern the combination and distribution of resources within the firm) underlie and determine a firm’s propensity for innovation (Kostopoulos 2002). It is therefore the most appropriate theory to mobilise as a framework for this thesis as it specifically considers the utilisation of resources. Innovation is the result of resource (both tangible and intangible) consumption energised by a firm’s capability to generate a unique combination of resources that results in competitive advantage. Whilst the capabilities of the firm are considered inherent and intangible in the RBV, the presence of resources within the firm is readily measured and evaluated and can be directly related to the concept of slack.

The RBV stipulates that the availability of uncommitted resources increases the firm’s capacity to support innovation. With this view, innovation relates heavily to the presence of slack that, when present in higher quantities, allows for more numerous
combinations of resources yet, when present at lower extents, prevents these combinations from being established. Lee (2011) explicitly states that the RBV considers slack a potential source of competitive advantage. Accordingly, the RBV argues that firm financial performance (generated through a sustained competitive advantage, and indicated by Ricardian rents), and firm innovation, are both determined by the resources within the firm. This thesis argues from this that the availability of resources within the firm, relates to both firm level innovation and firm level performance. Whilst innovation and performance are maintained as being distinct they are argued in this work to share common determinants, relating to excess resources (i.e. slack). Slack literature supports this perspective arguing and demonstrating curvilinear relationships (∩ or ∪) exists between both slack and innovation (Tan 2003; Chiu & Liaw 2009) and between slack and performance (Nohria & Gulati 1997).

4.4.5 Summary
Each of the theories of the firm discussed above is equally significant. Although other authors have attempted to synthesise the BTF and the TGF (see Pitelis 2007), such an approach is not seen as practical here as neither the BTF nor the TGF are considered a suitable theoretical framework of the firm because they offer insufficient insight into the use of resources within the firm to generate innovation and performance (i.e. the benefit to the firm of resource consumption).

Despite the BTF providing the original conceptualisation of slack with the firm, the ability of the theory to understand the economic decisions of the firm (Bowen 2007) is not congruent with the purpose of this work. Although the BTF provides a framework for understanding the decisions of the firm whilst addressing the existence and emergence of innovation, it does not address innovation as an output. As the focus of this study is on innovation in the firm and it does not seek to understand the growth of the firm, the TGF is also unsuitable.

For the TGF the main goal of the firm is growth in firm output, while according to the BTF there are multiple firm objectives. These objectives of the firm are argued to be ill-suited to the development of this thesis, as they do not match the developed relationship between firm level innovation and financial performance.
Consequently, this leaves the RBV as the remaining theory of the firm from those considered. The RBV is considered the most suitable basis for an investigation of slack due to its focus on resources and how their combinations result in innovation and economic rents to the firm (illustrated in Figure 14 below). The RBV of the firm can also be used to position the resource-based view of innovation discussed in chapter 2. As seen below innovations, once applied, support the firm’s ability to obtain superior rents from the market. These innovations come from unique combinations of resources, which are novel to the firm in question. However, superior rents are also generated outside innovation through combinations of resources unique to the market, which are used for production of goods and services sold at a profit. This shows that superior rents (i.e. firm performance in the market), is supported by both the development of innovation, and independently by the resources existing within the firm. Additionally, the RBV has been previously mobilised in the construction literature as an explanation of emergence of innovation and of innovation drivers (Barrett & Sexton 1988).

Figure 15: RBV generation of rent via innovation

4.5 Resource based view and dynamic capabilities

As discussed in Section 4.4.3, the firm may be conceptualised as a bundle of tangible and intangible resources and capabilities (Wernerfelt 1984; Kostopoulos 2002). While the RBV deals with the importance of selecting and utilising heterogeneous resources (Barney 2001a), the dynamic capability view addresses the capacity to deploy said resources (Makadok 2001). The dynamic capability view is a development of the RBV of the firm (Pitelis 2007; Green et al. 2008), this view asserts that firms generate rent through the effective deployment of resources (Makadok 2001), thus offering an alternative mechanism to understand rent collection distinct from the RBV.
The notion of dynamic capabilities relates to a firm’s ability to reconfigure its resources in response to changing environments (Green et al. 2008). Capabilities are distinct from resources in that they relate to the capacity to deploy, coordinate and energise resources in order to affect a desirable outcome (Kostopoulos 2002). There are two key features that distinguish capabilities from other resources: First, a capability is firm specific, embedded in the organisations, while ordinary resources are not, second the purpose of a capability is to enhance the productivity of other resources. The concept of dynamic capabilities emphasises management capabilities that cut across all functions, including R&D, product and process development, manufacturing, human resources and organisational learning (Lawson & Samson 2001). Dynamic capabilities therefore, are an element that helps support the firms capacity to innovate, as the process which embody dynamic capabilities energise the resources used to create innovation. It has been argued that the dynamic capabilities are what distinguish high and low innovating firms, and not the imitable resources on which the RBV is based (Lawson & Samson 2001). Firms with sufficient dynamic capabilities are able to respond to environmental shifts more quickly than competitors, and able to compete within the market place with more rapid and flexible innovation (Teece & Pisano 1994).

However, it is argued that resources, namely slack, provide the inputs for innovation at the firm level, and the capabilities of the firm represent the firms capacity to coordinate these inputs and generate innovative outputs (Kostopoulos 2002). Therefore, resources are a precursor to the utilisation and formation of dynamic capabilities. Furthermore, the development, maintenance and exercise of dynamic capabilities are highly resource-intensive activities (Salge & Vera 2013). The tangible and intangible resources of the firm determine, as a precursor to the capabilities of the firm, if innovation is possible. Further to this, dynamic capabilities are considered 'soft' assets. The values, culture, and organisational experience, that are encompassed by capabilities cannot be bought, but must be built (Teece & Pisano 1994). As such, are firm specific, and therefore, cannot be effectively captured and compared. Whilst the understanding of dynamic capabilities aid the interpretability of firm differences with regards to innovation and competitive advantage (Lawson & Samson 2001), it is not suitable for this study. The RBV is maintained as the framework for understanding differences between firms, and the function of organisational slack.
Further to this argument, as has been repeated throughout this thesis Organisational slack has not been explored and tested within the construction context. Therefore, whilst the dynamic capability view might be considered an evolution of the RBV, the developments concerning the Dynamic Capabilities are limited in their applicability to the construction context due to a lack of a solid foundation from its previous iteration, i.e. the RBV.

4.6 Connecting Innovation in Construction Firms to Slack

Having adopted the RBV as the theoretical foundation with the greatest potential to explain the drivers of slack within construction firms, focus must return to the concept of slack. The RBV must now be used to relate established concepts of innovation within the construction literature to the functions of slack identified in the slack literature. In the following discussion, emphasis is placed upon the generation of innovations, which has been identified within the construction literature as being a vital component of the performance, growth and overall survival of firms within the construction industry (Stewart & Fenn 2006).

The purpose of the following is not to fully demonstrate slack as a determinant of innovation, as that discussion was developed in chapter 2, but to extrapolate links between existing construction literature and the concept of slack. By developing links between organisational slack and existing concepts within the construction context, the theory surrounding organisational slack can more easily be transposed to the novel context; construction.

4.6.1 Ability and Willingness to Innovate and the RBV

It is maintained from construction literature discussed in chapter 2, that firm level innovation may be determined by the ability and willingness of the firm to innovate (Jong & Hartog 2007), which is further reinforced by leaders and champions within the firm (Nam & Tatum 1997; Newton 2009). The following briefly re-examines these components of innovation, and extrapolates theoretical links between these determinants and slack using the RBV as a framework.

As identified by Hartmann (2006), the firm’s (including construction firms) propensity for innovation is dictated by the ability of the firm and the willingness of the firm to innovate. Ability relates to the availability of resources with the firm and willingness
represents the forces that energise the allocation of these resources (Hartmann 2006). It is argued that the *ability* and *willingness* of the firm to innovate, resembles the interaction within the RBV between the resources bound to the firm and the capabilities that co-ordinate their application (Gann & Salter 2000). The *ability* of the firm to innovate is dependent on the resource profile of the firm including those tangible (e.g. physical) and intangible (e.g. intellectual) resources that might be used to generate innovation. The *willingness* of the firm to innovate is dependent on a firm’s unique internal capability to deploy resources (Makadok 2001). Like the internal capabilities of the firm, *willingness* (and the culture it represents) gives energy to the resources of the firm. But, without the resources themselves also being held, the firm cannot generate innovation (Kostopoulos 2002). *Willingness* and *ability* are therefore interdependent. Without the necessary *ability* to achieve a particular innovation, *willingness* to innovate becomes fruitless; likewise, unparalleled *ability* is ineffectual if the firm lacks the *willingness* to innovate.

### 4.6.2 Connecting Ability and Willingness to Slack

In addition to the association of ability and willingness with the RBV seen above, it is argued that the varied functions slack within the firm (Lin *et al.* 2009) are closely related to the managerial actions identified by Hartmann (2006) as underpinning the firm’s willingness to innovate. Thus, supporting the transposition of the concept of slack to the construction context, using existing developments regarding the determinants of firm level innovation. The following discussion connects such managerial actions to the requirement for excess resources (i.e. slack) within the firm. It is argued within this thesis that slack must be present within the firm for managerial actions conducive to innovation to be initiated. The theoretical association between these managerial actions and the presence of slack in the firm validates the transferability and application of slack to the construction context. The managerial actions which underpin firm level innovation in Hartmann (2006) are discussed as follows:

1. **Communication**: To improve communication within the firm, managerial actions such as excursions, information days and workshops can be enacted (Hartmann 2006). Such activities require workers to spend time away from their current firm activities and can be a financial burden to the firm. In addition to
supporting the managerial communication actions themselves, managers must be able to use spare financial slack to fund said activities and human or time slack must be present for workers to engage with the excursions and information days. Without slack, actions to improve communication would disrupt ongoing activities within the firm and prevent any meaningful change.

2: **Recognition** is a reinforcement mechanism used to motivate workers towards achieving a certain goal. It is employed by implementing rewards for following what managers dictate as being norms (Hartmann 2006); in this case related to innovation. It is suggested that individuals who receive rewards, such as pay rises, fringe benefits, flexible and pleasant working conditions, and so forth, are more likely to engage in extra-role behaviours (i.e. acting outside ordinary activities) such as innovation (Hartmann 2006). The provision of rewards is considered synonymous with the ‘inducement function’ afforded by the presence of slack. Slack enables payment to workers in excess of the minimum necessary (Bourgeois 1981). Whilst not only maintaining the coalition of the firm (Cyert & March 1992), the availability of excess payments can also motivate individuals within the firm towards innovation (Penrose 1959; Pitelis 2007).

3: **Participation** represents individuals’ willingness to make choices and decisions, and their freedom to do so. Individuals who feel responsible for their own choices are more committed to them (Hartmann 2006). This mechanism is essential for developing an innovative culture where “people are open-minded … risk-tolerant … and knowledge-friendly” (Egbu et al. 1998: 609). The key component of such a culture is worker autonomy, which allows individuals the freedom to engage with innovative activities through self-direction. However, if managers are to build such autonomy within their firm, excess human resources must be present to generate spare capacity or slack time so that individuals can engage with extra-role firm activities (Bourgeois 1981). Such excess can be related to the workflow buffering function of slack, specifically represented as excess human resources in general (Bourgeois 1981). Workflow buffering has also been related to time resources in construction firms by Barrett & Sexton (2006) who noted that construction SMEs argue that they are often too busy trying to survive and do not have the spare time to innovate.
4: **Symbolism** relates to the clarity, visibility and direction of managerial messages (Hartmann 2006) and must therefore be utilised alongside the other mechanisms discussed above. Managers must show consistent behaviour and send clear messages to individuals through their provision of resources. Within construction firms, Nam & Tatum (1997) argue that externally-communicated messages promoting innovation must be tangibly supported within the firm through the provision of required time and financial resources. Likewise, Hartmann (2006) states that, for managers to enact symbolism within the firm, they must provide adequate time and financial resources to support innovative activities. These time and financial resources are considered synonymous with slack, which represents a pool of excess resources within the firm from which managers can draw to fund activities (Nohria & Gulati 1997). Without the presence of slack within the firm, managers would be unable to provide clear messages, and unable to enact support for those messages due to a lack of necessary resources. The act of engaging with symbolism is, therefore reliant upon the presence of slack within the firm (Cyert & March 1992).

The above discussion links between established mechanisms for enacting managerial actions to support a culture that supports innovation with the presence of slack within the firm. This discussion demonstrates that regardless of the managerial action in questions, excess resources (i.e. slack) beyond those needed for current activities are necessary to for it to be enacted. Symbolism requires resources to support managerial messages, communication requires space outside existing activities to be enacted, resources are required for managers to recognise and reward efforts, and finally additional resources are required to allow individuals to engage within innovative activities without disrupting current activities. Therefore, at higher levels of slack these managerial actions should be more easily enacted and stifled at lower levels.

These links lend support to the resource dependent view of innovation established in Chapter 1 and the resource based view of the firm discussed previously in this chapter.

**4.6.3 Leadership**

Another key component of innovation identified within chapter 1 in construction literature is leadership (Dulaimi 1995; Nam & Tatum 1997). Nam & Tatum (1997) who found that leaders provide direction and support to other organisational members in
support of innovative activities, and demonstrated the influence of leaders in innovating construction firms. Leadership is distinguished from the above due to the distinction from others within the firm, leaders are individuals whose absence are recognised in research as being pivotal to the development of innovations,

In spite of their importance, much like the managerial actions above, leaders of innovative activities become stagnated without sufficient freedoms and access to resources. This clearly provides support for the presence of slack as a driver for innovation. Nam & Tatum (1997:267) go so far as to state “one prerequisite for innovation is slack resources – either in the form of time or funds”. This follows the functions of workflow buffering (excess time) and discretionary funding (excess funding) afforded by slack (Bourgeois & Singh 1983). Nam & Tatum (1997) established that successful innovations to some extent were the result of slack being provided to leaders and champions to enable innovation. However, Nam & Tatum (1997) failed to provide a more in-depth association between the level of slack and the ability of managers to operate within the firm.

In response to the above, it is argued that organisational slack enables leaders of innovation activities the freedom to act, and dedicate funds and time to such activities. Without such resources, leaders and champions become restricted and unable to operate effectively, thus becoming insignificant as innovation is prevented. The above tells us that slack is associate not only with the cultural aspects of the firm and their reinforcement, but also has been identified within construction literature as playing a mediating role for individuals within the firm to engage or encourage innovation. Further to this, it provides evidence that slack functions within the construction context, and interacts within the firm to deliver innovations.

4.6.4 Summary
The above links the determinants of innovation, identified within construction literature as the ability and willingness of the firm to innovate, to the presence of slack within the firm. At higher levels of slack it is argued that the willingness and ability of the firm to innovate will increase, however lower levels of slack prevents managerial action to be substantively supported, and further restricts the ability of the firm.
Leadership within the firm, identified as a driver for innovation within construction literature, was identified as being restricted by the level of slack in the firm. Moreover, the above identified that a balance between the benefit and cost of slack must be met. Ultimately, Nam & Tatum (1997) are argued to support the construct of slack as a viable factor in determining the firms’ propensity for innovation within construction. This lends further support to the transposition of the concept of slack to the construction context; identifying existing dependency within concepts previously established within the construction context, in this case leadership.

The section above extrapolates links between existing construction literature and the concept of slack. Enabling the reader to associate established constructs and determinates of innovation with the presence of slack within the firm. While it does not provide a complete discussion on slack as a determinant of innovation, this was covered at length in chapter 3 previously. This section does identify that the ability and willingness of the firm to innovate, resembles the interaction within the RBV between resources and the capabilities that co-ordinate their application (Gann & Salter 2000).

4.7 Failing to Measure Innovation: The slack-innovation relationship

Slack has been positioned as an enabler of innovation in construction firms. Further, within the general management literature slack has been demonstrated to exhibit a curvilinear relationship with the benefit accrued by the firm from its presence; namely: its role in enabling innovation. This curvilinear relationship is maintained as either inverse U-shaped or U-shaped (∩ or ∪). In order to test a possible relationship between slack and innovation in within construction firms, both concepts (slack and innovation) must be capable of quantifiable and accurate measurement.

It is forwarded that ‘innovation’ is a complex construct (Damanpour et al. 1989) and that inherently difficult to quantify, which can prevent meaningful research from being accomplished. It is further argued that the common indicators of innovation, patent count and Research and Development (R&D) expenditure, are fundamentally flawed, incapable and inappropriate for measuring innovation in construction (BIS 2013) (or, indeed, elsewhere) despite their use in the slack, general and construction literature for this purpose.
The measurement of innovation implies commensurability on some level, enabling innovation to be quantified (Smith 2004). However, by definition innovations are unique (Damanpour 1987), representing some novelty of an idea or practice. Although an innovation may also lead to outcomes that are intrinsically measurable – improved fuel efficiency, fast assembly times. These are not necessarily applicable across all forms of innovation. Remembering chapter 1, innovations are not considered purely technological in nature, nor are they considered specific to construction despite being studied within a construction context for this thesis. The adopted definition recognises all innovations that emerge the construction context, be they administrative or technical, incremental or radical. Because of this, certain measures of innovation used in prior research are not capable of fully capturing the true extent of innovation in construction, or in any context. Internal organisational innovations do not appear as patents, and much of the innovation in construction cannot be captured in R&D expenditure, but are considered equally as relevant to the firm as a product innovation that might have a patent.

A patent is a public contract between an inventor and a government that grants the applicant a time-limited monopoly right for the use of a technical innovation. Patents are considered an easily quantifiable indicator of innovation due to the creation of the associated original concepts. Furthermore, patent systems systematically record important information and the data is freely available (Smith 2004). Nevertheless, it is argued that this assumption underrepresents the development and application of innovation. Knott (2012) contended that only 50% of firms engaged in R&D actually file patents. Moreover, among those firms that do protect their innovations by patents, not all firms patent all of their innovations.

Patents also have a number of other weaknesses, most critically patents describe inventions rather than innovations (see Section 2.4.2) (Smith 2004). The award of a patent does not guarantee that the embodied concept will be applied and therefore, cannot be considered an innovation (Schumpeter 1934). Secondly, patents do not consider the economic or commercial significance of one patent to the next; many patents will exist that have little or no economic impact. An extension of this is that firms might not seek to commercialise a patent, but use this as a means of preventing a competitor from using a novel idea (Smith 2004). Finally, the diffusion of innovation is
also not recognised by patents as an innovation indicator. Patents are unable to take into consideration the plethora of firms who might adopt and apply an invention, as an innovation, sometime after its original date of invention (Rogers 2003). A firm might adopt a technology that previously existed within its own or within an alternative context, only for it to be seen as innovate because the technology adopted is novel to the firm or context in question. Construction firms have been typified by this study as Innovation Adopting Organisations (IAOs) who practice extensive on-site problem solving. They tend to draw from technologies and solutions that already exist elsewhere in construction to apply them in novel ways; perhaps to novel situations. Therefore, despite delivering innovations in the form recognised by this work (i.e. application of a concept novel to the firm); such innovations would not be captured by the firm’s patent count. Harris & Halkett (2007) conclude the frailty of patents as an innovation indicator, asserting that only 1% of construction firms apply for any patents thus is not at all representative of innovation in construction.

Another long-standing innovation indicator is R&D (Smith 2004). R&D expenditure is considered to demonstrate with the conscious effort of a firm to invest to develop or adopt innovative solutions; its use is underpinned by the notion that actors of research and discovery underpin innovation (Smith 2004). Still, this is argued to be a flawed measure of firm level innovation in construction.

R&D expenditure in UK construction firms is lower compared to both other sectors and EU construction firms. Moreover, R&D spending by construction firms has been decreasing within the UK since 2000 (BIS 2013), indicating that it has little function within construction. Although often used to explain the lack of innovation within construction, both Barrett et al. (2007), and Reichstein et al. (2008) contend that R&D expenditure is not associated with innovation in construction firms and its measurement does little to indicate high or low rates of innovation in construction. R&D expenditure represents the formal interest of a firm in innovative activities. However, a large portion, if not the majority, of innovation in construction is argued to occur through informal learning and development (Harris & Halkett 2007). Firms innovate in the face of problems (often encountered on site) using immediately available resources and expertise to formulate innovative solutions (Shaw et al. 2010). Such activity would not be captured by a measure of firm R&D expenditure; thus preventing meaningful
comparison between construction firms themselves, and with firms from other sectors where innovative activities are predominately formalised and planned through R&D (Groák 1994). Furthermore, R&D measures only one type of input, which is argued to be part of the innovation process itself, and not its initiating factor. Innovation requires a large number of inputs across the firm, not only R&D but also a number of tangible and intangible resources (Oerlemans & Pretorius 2008). Further to this R&D is part of the on-going problem-solving process associated with developing innovation, but is not what initiates the process (Smith 2004).

BIS (2013) recognised that construction contractors – a key type of construction firm – invested between two and three times more on intangible assets such as design and organisational innovation, than the amount spent of tangible assets such as machinery and tools. Indicating that expenditure on innovation exists within construction, which is not captured by the traditional measure of R&D expenditure. In addition, R&D expenditure, although considered to be highly correlated with innovation output, does not guarantee that innovation will emerge from the research.

Due to these failures of comparability and measurement, it is argued that innovation in construction, and in general, cannot be appropriately measured using ‘traditional’ measures (i.e. patents, R&D expenditure). A measure of firm patents fails to capture the true nature of innovation in construction, while R&D expenditure fails to capture the extent of activity within construction firms towards innovation.

The final issue is that the purpose of this study is to understand and test organisational slack as a determinant (i.e. input) of firm level innovation. Whilst a number of alternative indicators of innovation also exist (see Gambatese & Hallowell 2011), these rely upon management level determinants and predictors of innovation, which are also inputs, and do not measure innovation outcomes. It is not suitable in this study to examine a slack-innovation relationship based upon two predictors or inputs of innovation. The failure to capture innovation in construction presents an obstacle for this study, and fundamental flaw in the rhetoric in promoting innovation within the construction industry. Whilst efforts are made to encourage innovation, how can these returns be recognised if they cannot be accurately measured?
However, at hand is the issue of examining the interaction between slack and innovation within construction firms, and of determining the nature of the slack-innovation relationship in the face of measures that are not capable of capturing innovation within the construction context. Therefore, it is argued that an alternate measure be used to represent innovation, and to quantify the outcomes of firm level innovation, and thus allow a relationship with slack to be tested and examined. For this measure to be appropriate it must be capable of accurately demonstrating the outcomes of innovation within the firm (i.e. be closely related to innovation), and/or it must replicate the interaction between slack and firm level innovation (i.e. share the same relationship with slack as innovation). It is proposed that the most appropriate measure firm level innovation outcomes is firm performance. The following discusses the relationship between firm level innovation and firm level performance, and develops constructs to support the use of firm performance as an appropriate indicator of innovation outcomes.

4.8 Identification of a Proxy Measure: Performance as a measure of innovation outcomes

As argued above, traditional measures of innovation are thought to fail to capture the true extent of innovation in construction. As such, to examine the impact of slack on firm level innovation, and consequently the firm, an alternative measure must be established. This measure must indicate increased rates of firm level innovation and therefore replicate the slack-innovation relationship. This section argues that firm level performance is an appropriate measure for innovation. In this section, focus is returned to the purpose of innovation and definition of innovation which is too “…enhance overall organizational performance” Barrett & Sexton (2006:337). Here innovation is argued to provide firms with improved financial performance within the market. This section establishes a relationship between slack and performance that is indicative of a slack-innovation relationship. Thus, allowing the researcher to test a relationship with the level of slack within the firm via performance.

Innovations as objects can provide many advantages to the firm. In construction firms, they have been identified as sources of growth (Mousa & Chowdhury 2014a), survival (Erbil & Akincitürk 2010), time and cost reductions (Shaw et al. 2010) and competitive advantage (Kissi et al. 2012). These advantages are argued to relate how the firm performs in the market, represented by firm financial performance. The reduction of
production time or production costs, for example, reduces overall costs of production allowing it to generate greater returns from the market. The firm innovates to alter its current practices so that it can continue to function within the market (survival), or to improve the current state of its activities and thus perform better within the market. Rosenbusch et al. (2011) were able to identify in a meta-analysis that there is a positive relationship between the innovation and financial performance of SMEs, which dominate the construction sector (Sexton & Barrett 2003); as such, there is considered a relationship between innovation and firm performance.

Myers (2013) defined construction firms as entities that convert factors of production into profits. This definition mimics the RBV of the firm adopted by this study, in which unique resource combinations result in innovations that provide superior rents to the firm. As such, it is argued that the purpose and function of innovation at the firm level is to provide improved performance in the market. Cost reductions, sustained competitive advantage, value added, or increased sales from new products; all of which manifest in improved or superior financial performance. IAOs, which are argued to be typical of the construction sector, engage within innovation as a means of supporting further organisational goals (Damanpour & Wischnevsky 2006). Therefore, it is argued that the purpose of innovation in construction firms is to reduce costs or obtain a competitive advantage not for its own sake but to support the financial performance of the firm in the market. Consequently, firms that innovate perform better within the market, due to the advantages innovation affords, and demonstrate higher levels of financial performance as a result. Thus, firm level financial performance is positioned as an alternative measure for firm level innovation. The following sections provide further evidence and theoretical support for this positioning.

4.8.1 Performance Enhancement through Innovation and Slack

Innovation is often argued to be closely associated with firm level performance (Choi et al. 2009) to the extent that innovation has even been used as a measure of firm performance (Richard et al. 2009), indicating a compatibility, and convention in measuring innovation through firm performance. Although the definition of innovation, taken from Barrett & Sexton (2006:337) defines innovation as an idea that “...enhances overall organisational performance”. It is vital to further support this relationship, as an innovation-performance relationship might be diminished due to a large number of
factors that dictate firm performance (Capon et al. 1990; Richard et al. 2009). Whilst this research presents organisational slack and innovation as determinants of performance, in practice however, it is unlikely that any single factor will determine firm performance. Instead, it is likely to be a combination of factors that differentiate the best from the worst performers (Capon et al. 1990). Thus, this limitation must be recognised and accounted for within the research design, used to test the slack-performance relationship.

It is argued that the relationship between organisational slack, innovation and performance (i.e. differing levels of slack leads to greater innovation, in turn leading to greater performance) is supported more extensively by an examination of the common determinants of innovation and performance, as opposed to focusing upon innovation as a determinant of performance. Geroski et al. (1993) presents two perspectives on the relationship of innovation and performance: the ‘product view’ and the ‘process view’. The product view assumes the conventional, direct relationship between the innovation itself and firm performance wherein innovations emerge from activities within the firm and are directly and solely responsible for improved performance by favourably influencing the firm’s market position and, consequently, performance. The process view argues that improved firm level performance is not the result of innovation per se but is instead determined by the internal capabilities of the firm, which also generate innovation outputs. As these capabilities are also required to develop innovations, the determinants of innovation and performance are shared. It is these internal capabilities, which are argued to relate to organisation slack.

The two perspectives are differentiated by whether or not the returns generated by an innovation (i.e. superior firm level performance) are the result of a specific innovation (product view) or whether they are a result of permanent and consistent differences between innovating and non-innovating firms (process view) (Geroski et al. 1993). It is argued that, from the ‘product view’, that superior performance of the firm can be maintained until competitors are able to imitate and reduce the rents derived from the firm’s short-term market position. Alternatively, the ‘process view’ sees the activities associated with innovation as driver for fundamental changes in the competencies of the firm, improving its speed, flexibility and adaptability in ways that are not apparent in non-innovative firms. With this latter view, innovation is not the result of a mechanical
set process, but the result of a fundamental transformation within and of the firm, that distinguishes innovative and non-innovative firms. These perspectives are demonstrated in Figure 16 below.

![Figure 16: Product and process views of the relationship between innovation and performance](image)

It is the ‘process view’ is considered the most appropriate representation of the association between innovation and performance, as it is compatible with the RBV discussed above, and enables slack to represent a common determinant of firm level innovation and performance. To expand: according to the RBV, the capabilities of the firm energise combinations of resources to derive Ricardian rents (i.e. profits) from the market and, similarly, novel combinations of resources are deemed innovation. Similarly, both Hartmann (2006) and Egbu et al. (1998) identified cultural aspects of the construction firm that were argued to distinguish innovative from non-innovative firms. These cultural aspects, such as the encouragement and support of innovation, and risk accepting behaviour (Hartmann 2006), are argued to be closely associated with the internal capabilities of the firm seen in the process view. Finally, general management literature has espoused slack as a common determinant of both innovation (Troilo et al. 2014) and of performance (George 2005); a position that has been presented in Section 4.6 as underpinning the cultural determinants – namely ability and willingness to innovate – identified in the construction literature (Egbu et al. 1998; Hartmann 2006; Kissi et al. 2012).

In the adoption of the ‘process view’ of innovation, the relationships between slack, innovation and performance but me clearly articulated. Firms seek to improve overall firm performance through the adoption of generation of innovation(s), however, the
mechanism by which firm achieve their goal of improved performance (not innovation \textit{per se}) is through the internal capabilities (or cultural aspects) of the firm, which are underpinned by the presence of organisational slack. Therefore, organisational slack is argued to be a determinant of both firm level innovation and performance. This therefore, both justifies the approach of slack through innovation, yet diminishes its direct relationship with firm performance, which must be shared via the common determinants.

The process view of innovation is argued to mirror the RBV of the firm (see Figure 14 page 112). The RBV argues that the performance of the firm (superior rent generated from interaction with the market) and firm level innovation (unique combinations of resources) share the same determinants. Both constructs – innovation and performance – rely upon the heterogeneous resources within the firm that are combined to extract superior rent from the market. Likewise, the RBV emphasises the internal capabilities of the firm – which are intrinsic, firm specific processes – as essential for developing innovation and a sustained competitive advantage, in turn providing increased performance (Kostopoulos 2002). The commonalities between all the relationships above are argued to provide support for measuring firm performance in lieu of measuring innovation. As the purpose of innovation is to improve overall performance, the measurement of firm performance allows the researcher to measure the outcomes of innovation, is light of not being able to measure innovation directly.

Within prior broader management research actively testing the relationship, providing substantial evidence that there is a relationship between innovation and performance. Bowen \textit{et al.} (2010) demonstrated that there is a positive relationship between innovation and performance (when measured through market performance), i.e. more innovation equals greater performance. This supports the findings of Lööf \& Heshmati (2006), who demonstrated a strong association between innovation output and firm profit. In addition to innovation outcomes supporting performance, (Terziovski 2010) concluded that SME firms are able to improve their performance by implementing an innovative culture and strategy.

\subsection*{4.8.2 Associating Slack with Innovation}
This section returns to the relationship between organisational slack and innovation. Section 3.6 of the previous chapter addresses innovation among a number of functions
of the slack. Section 4.6 above, extrapolates links between slack and existing construction research, however, this is largely to aid the readers understanding of how slack might function within the firm. The following draws upon slack literature to addresses the slack-innovation relationship in its own right.

As forwarded previously innovation is a critical component to a firms competitive position in the market, a crucial element in the development of innovations are the organisational resources needed to support it (Herold et al. 2006). Organisational slack is necessary for firm to innovate, as innovation requires the investments that are beyond the immediate operational needs of the firm. (Mousa & Chowdhury 2014) argue that organisational slack allows firms to divert attention away from current activities, what they call “firefighting”, and focus upon innovative projects which involve risk and expansive thinking.

Importantly slack resources protect the firm form the uncertainty of experimental projects, which is argued to allow innovative cultures within the firm to develop enabling innovation (Bourgeois 1981; Nohria & Gulati 1996; Geiger & Makri 2006). Empirical studies have supported this relationship, indicating that slack promotes the pursuit of innovation as it cushions the firm from risk and uncertainty (Damanpour 1987; Singh 1986; Nohria & Gulati 1997).

Furthermore, innovation demands a significant amount of resources. Due to the required longevity of construction products, the development and testing of the products can become extremely expensive (Erbil and Akincitürk 2010). Construction researchers Gambatese and Hallowell (2011b) cost the average technical innovation requires 38 months, 4700 worker-hours and US$ 836,000 to successfully develop, implement and diffuse the innovation. Only firms with considerable levels of slack are able to commit to the development of projects such as this.

In contrast to the above, some academics condemn slack, arguing that it inhibits innovation within firms. While it might be seen as a cushion or buffer to protect the firm by some, others argue it blinds the firm from external demands (Oerlemans & Pretorius 2008). Slack is argued to incentivise managers to act in their own best interest, as opposed to the interest for the firm (Jensen 1986; Geiger & Makri 2006). In the presence of slack controls are relaxed, resulting in sub-optimal performance and a lack
of discipline (Leibenstein 1969). Additionally managers will pursue personal empire building, and fund ‘pet’ projects with high uncertainty or low reward which otherwise would not be supported (Nohria & Gulati 1997).

As discussed in Section 3.7.3 these conflicting perspectives are sought to be reconciled in a curvilinear relationship, where in both the positive and negative relationships are found. In a curvilinear relationship, the positive or negative relationship between slack and innovation is based upon how much slack exists within the firm (Geiger & Cashen 2002). Conventionally this relationship forms an inverted-U shape (∩), and was first demonstrated by (Nohria & Gulati 1996), in this relationship moderate level of slack produce an equilibrium between the benefits and detriments of slack, providing an optimum point which managers must balance in order to maximise innovation.

An alternative reconciliation of these conflicting relationships is the U-shaped curvilinear relationship (∪). In this relationship, it is argued that lower and higher levels of slack promote innovation, whilst moderate levels produce less innovation. At lower levels the firm remains agile, utilising its lean resource position to innovate readily, alternatively higher slack levels also allow the firm to exploit positions and opportunities it otherwise could not afford. This relationship has been demonstrated by (Chiu & Liaw 2009) in relation to firm performance, however, there is a lack of evidence for this relationship with innovation.

4.8.3 Connecting Innovation-Performance Relationship with Slack

Both firm outcomes (innovation and performance) are theorised to be impacted by presence of organisational slack and its influence within the firm (Troilo et al. 2014; Stan et al. 2014; Bourgeois 1981). This thesis has demonstrated that slack is a determinant of both firm level innovation (Troilo et al. 2014; Chen & Huang 2010; Geiger & Cashen 2002; Oerlemans & Pretorius 2008) as well as performance (Tan 2003; George 2005; Kim et al. 2008; Singh 1986; Wefald et al. 2010). The relationship between innovation and performance is considered to be established via the process view of innovation (Geroski et al. 1993), where firm level performance is supported by organisational slack both directly, and indirectly via innovation and its outcomes.

Slack literature argues that innovation and performance share a relationship with slack, and are subject to comparative positive and negative influences. For example, Tan &
Peng (2003) theorise and support the same inverse-U shaped relationship (\(\cap\)) between slack and performance that is theorised and supported between slack and innovation (Nohria & Gulati 1997). In addition, slack literature has been able to demonstrate that an inverse U-shaped relationship (\(\cap\)) exists between both innovation and performance, owing to the association between the two constructs.

In order to associate performance as a measure of innovation outcomes, this work looks to the associated innovative determinants of ability and willingness. It is argued that innovation and firm level performance (as a measure of innovation outcomes) are inextricably connected due to being mutually determined by the level of slack within the firm. Cyert & March (1963) argue that firms are continually motivated to slack search, continually improving upon activities and consequently innovate to meet sub unit goals which relate to overall firm performance.

Vroom (1964) identified that ‘performance’ of the individual is a product of both their willingness and ability. This work by Vroom (1964) on motivating performance is argued to be echoed in the work of Hartmann (2006) who focuses upon motivating innovation. Both argued the interdependent nature of the ability and motivation/willingness. While Vroom discussed performance in its own right, Hartmann (2006) discussed innovation performance. Building upon this, the process view of innovation may be adjusted to include the constructs of ability and willingness:

![Figure 17: Constructed process view of innovation model](image)

In Figure 16 above, performance and innovation share the same driver; internal capabilities. As a result, it is argued that firm level innovation and firm level performance are mutually determined by the ability and willingness. However, what remains is that both constructs are related to the same determinants, already established
Relating Innovation in Construction Firms to Organisational Slack

to be underpinned by the presence of slack (Section 4.6). Slack therefore, must also be
established within this model, to demonstrate its connection with innovation and
performance.

Figure 18 below illustrates the synthesis of the arguments throughout this thesis. Slack
is theoretically linked to both innovation and performance, which is supported by the
RBV of the firm. Firm level performance is supported by innovation, through
innovation outcomes such as cost reductions and increased turnover. Both performance
and innovation are driven by the internal capabilities of the firm, made up of the ability
and willingness. The development and maintenance of these factors are in turn are
underpinned by the presence slack (excess resources) within the firm. Without slack, the
managerial actions identified within Hartmann (2006) cannot be enacted to support
innovation. Similarly, excess resources are required to protect the firm and maintain
performance when faced with internal and external variability (Bourgeois 1981).
Following the process view of innovation, it is seen that the internal capabilities of the
firm support both firm level innovation and performance directly. Therefore, firm level
performance offers a suitable measure for innovation outcomes, in order to determine
slacks’ interaction with the firm.

4.9 Development of Hypotheses

Despite establishing an association between slack, innovation and performance above,
the nature of this relationship remains unclear. As detailed in section 3.7, there are
conflicting interpretations of the impact of slack relative to both innovation and
performance. Despite accepting the positive role slack can play within the firm, the
negative consequences of its presence cannot be ignored. As in the previous chapter, it
is put forth that a curvilinear relationship exists between the level of organisational

Figure 18: Synthesised model of perspectives determining firm innovation and performance
slack within the firm and the benefit the firm derives; in this case associated with performance both directly and via innovation.

In their meta-analysis of slack research, Daniel et al. (2004) found substantial evidence for both negative and positive relationships between slack and performance of the firm. Although concluding there is greater support for a positive linear relationship, where more slack equals more innovation, Daniel et al. (2004) do not consider non-linear relationships such as those proposed in this thesis and illustrated in Figure 14.

Although the majority of slack researchers provide evidence in support of inverse U-shaped curvilinear relationships, some evidence has been provided for the U-shaped relationship (∩ or ∪) (Mousa & Reed 2013; Lin et al. 2009; Chiu & Liaw 2009). As such, without further investigation it cannot be sufficiently determined what the shape of the curvilinear relationship is. Therefore, both relationships, inverse U-shaped and U shaped are maintained, and must be tested within this research. The hypotheses are formalised as:

**H1** - The relationship between slack and innovation outcomes is curvilinear. In the level of slack improves innovation to a maximum point, after which further increases in slack reduces innovation. In other words, the relationship is inverse U-shaped (∩).

**H2** - The relationship between slack and innovation outcomes is curvilinear. Where increases in the level of slack decreases innovation to a minimum point, after which further increases in slack improves innovation. In other words, the relationship is U-shaped (∪).

### 4.10 Chapter Summary

In this chapter theoretical links were extrapolated in order to connect the hitherto individually examined concepts of innovation in construction and organisational slack. This was aided by the critical examination of three key theories of the firm: the Behavioural Theory of the Firm (Cyert & March 1992); the Theory of Growth of the Firm (Penrose 1959); and the Resource Based View of the Firm (Wernerfelt 1984). Ultimately, the author selected the RBV as the most appropriate framework for discussing slack innovation and firm performance. Drawing upon the resource
dependency of the cultural determinants of innovation within construction firms, links were made between the managerial actions and the presence and functions of slack within the firm.

Although theoretical links were made, it was argued that the ability to test this relationship was fundamentally defective due to the inability to capture the true extent of innovation within the construction context (Barrett et al. 2007). Patents, a common measure of innovation output, were argued to be unsuitable as they relate more closely to inventions as opposed to innovations (Rogers 2003). Additionally, R&D expenditure cannot be associated within innovation in construction (Reichstein et al. 2008).

Ultimately, performance of the firm is forwarded as a suitable measure for innovation outcomes. It is argued that innovation is closely associated with firm performance (Choi et al. 2009) when adopting Geroski et al.’s (1993) process view of innovation wherein innovation and performance are considered to share common determinates. Figure 18 illustrates the synthesis of these arguments using slack as a determinant of innovation in relation to established concepts within the construction literature, the resource based view of the firm (Wernerfelt 1984). This establishes performance as a suitable proxy measure for innovation using the process view (Geroski et al. 1993) and common determinates identified in Vroom (1964) and Bourgeois (1981).
Chapter 5. Methodology and Research Design

5.1 Introduction

The following chapter outlines the adopted methodology, selection of the research method and development of the research design for this thesis. The chapter draws upon the concept of organisational slack as a previously unexplored determinant of firm level innovation with the construction context; the aims and objectives of the research and an understanding of organisational slack; and firm level innovation and performance. These are then related to the selection of the most appropriate ontological, epistemological and methodological choices presented to the research.

This chapter begins by examining the purpose and nature of research, prior to an exploration and selection of a research strategy, paradigm, and research stance for this investigation. The researcher adopts a deductive research strategy, having developed a theoretical framework and hypotheses for testing. The ontological and epistemological positions of the researcher are positivism and realism respectively, in accordance with these positions the researcher takes the stance of an outside expert.

As stated within the introduction chapter, the study adopts both an econometric approach to understanding the determinants of innovation and performance in construction firms, and an interview based approach to gather primary data on innovation, slack and performance in construction. Following the selection of ontological and epistemological positions, this chapter discusses and supports the selection of a mixed research method as the most appropriate research method for this study. Finally, the chapter develops and explains the research design adopted for this research, outlining data collection and analysis procedures to test the hypotheses developed within this thesis.

5.2 Review of Synthesis and Research Problem

The previous chapter provided a review of the concepts of innovation and organisational slack. It was argued that due to the failures of conventional measures of innovation, the research would be unable to accurately measure instances of innovation in construction firms. Therefore, a measure of innovation outcomes was proposed in lieu of a direct measure, this was adopted a means of measuring the impact and
frequency of innovation. It was concluded that firm performance was an appropriate proxy, due not only to for its association with innovation, but its established linkages with slack.

The study of prior organisational slack research, found that the conflicting arguments surrounding the beneficial and detrimental impacts of slack resulted in a conceptualised curvilinear relationship between the level of slack and the benefit to the firm (typically innovation or performance). It was argued that innovation in construction firms is subject to the same resource constraints and impacts as firms identified outside the sector. The previously established determinants of innovation “ability and willingness” are underpinned by the beneficial impacts resulting from the presence of slack within the firm.

Due to the unique nature of construction (Hillebrandt 1985), and the lack of prior exploration of the concept of slack within the construction context, it is unclear as to the shape or direction of the relationship between the level of slack within the construction firm and innovation outcomes. This work seeks to test the slack-innovation relationship, in order to determine if slack as a viable determinant of innovation within the construction context. The understanding of the slack-innovation relationship has been established within the literature review. As a result, the hypotheses were presented:

**H1** - The relationship between slack and innovation outcomes is curvilinear. In the level of slack improves innovation to a maximum point, after which further increases in slack reduces innovation. In other words, the relationship is inverse U-shaped (\(\cap\)).

**H2** - The relationship between slack and innovation outcomes is curvilinear. Where increases in the level of slack decreases innovation to a minimum point, after which further increases in slack improves innovation. In other words, the relationship is U-shaped (\(\cup\)).

The first hypothesis adopts the more frequently established inverse U-shaped relationship between slack and benefit to the firm, while the latter addresses and alternative resolution adopting a U-shaped relationship. The following chapter develops the position and approaches taken by the researcher in order to test the above hypotheses within the construction context.
5.3 What is Research?

Prior to debating the various methods and philosophical positions a researcher might adopt, briefly, the concept of research itself must also be discussed. In doing so, boundaries may be set in order to distinguish what is considered to be research from other activities and pursuits.

Sekaran (2000) describes research as “a systemic and organized effort to investigate a specific problem that needs a solution”. Prior to this Buckley et al. (1976) argued that research need to satisfy a number of criteria:

1) Provide and orderly investigation of a problem;
2) Use appropriate scientific methods;
3) Gather adequate and representative evidence;
4) Draw conclusions on the basis of evidence and logical reasoning void of bias;
5) Demonstrate validity of conclusions drawn; and
6) Ensure that research yields results that may be replicated under similar conditions.

As discussed later these criteria may be associated (specifically number 6) with the virtues of a good theory put forth by Wacker (1998), which are later examined against the developments of the theory developed within this thesis (i.e. slack and the RBV). Buckley et al. (1976) go on to describe actions that do not constitute research, these include creativity and speculation. Although these are actions in directing research, they do not constitute research in isolation. Likewise, the gathering of data, although a significant part of research, cannot be considered research alone. In research, it is the investigator that approaches a problem with a scientific or rationalised method, and approaches it with a systemic line of inquiry in order to describe, explain, test or predict phenomena using data collected for that purpose (Sekaran 2000). The following chapter, which includes the research design, develops what is considered the researcher’s systematic line of inquiry for tackling the research problem.

The Genesis of the Research Problem

Questioning the nature of the research problem prompts the reflection of how a research problem is generated by the researcher. Buckley et al. (1976) contend that the origins or
genesis of any research problem being developed is through situations of either problem solving or problem finding. During a problem solving situation, the required hypothesis or research question relating to the research is argued to be self-evident to the researcher, where the researcher is presented with a problem and consequently investigates and attempts to resolve this problem. On the other hand, research problems originating from problem finding are considered more complex. Problem finding challenges existing structures in order to advance knowledge, prior to the development of a research problem and subsequent solving of said problem. Buckley et al. (1976) proposes that problems may be generated (either problem finding or solving) by both formal and informal approaches to the subject of inquiry. The former implies the use of meticulous and methodological procedures; while the latter is subjective and non-routine in nature. The purpose of this reflection on the origins of the research problem is to correctly and precisely define the problem; pose the problem in solvable terms, connect the problem logically to its environment and screen against existing knowledge to ensure its uniqueness and the problems potential contribution (Buckley et al. 1976). The generation of research problems may fall into two categories; formal and informal, the following lists the approaches to generating research problems as detailed by Buckley et al. (1976:16-19).

The Formal Approaches to Subject Inquiry

These methods to identifying a research problem use methodical procedures to identify, and generate, problems. It is argued by Buckley et al. (1976) that formal approaches to research, generate higher quality research problems. The following are a number of formal approached to inquiry:

- Analogue – uses knowledge obtained in one area to question a related area
- Renovation – identifies defective or valueless components through a systems analysis
- Dialectic – analyses the advantages and disadvantages of a process to support its current form using logical disputation.
- Extrapolation – tests optional scenarios by extending current processes.
- Morphology – analyses the combination of possibilities inherent in complex problems. This ensures that the total number of possibilities are realised before selecting a particular course of action.
- Decomposition – the breakdown of a problem into its component parts.

- Aggregation – involves taking existing theories from distinct areas and combining them to form a composite theory for exposing a complex problem.

### The Informal Approaches to Subject Inquiry

Informal approaches to research problems are subjective and non-routinized, where the research follows intuition regarding a potential problem. Despite the assertion that better quality research problems are generated through formal inquiry, Buckley et al. (1976) notes that approaches like conjecture play a vital role in scientific research. The following are a number of informal approaches to inquiry:

- Conjecture – the identification of a possible problem relying on the intuition of the researcher

- Eventuation – the identification of a problem which is caused by the development of technology or social attitude.

- Consensus – problems that are raised by a task group or quality systems etc.

- Experimental – a problem experienced, commonly is a threat to the business.

In the context of the research problem stated in (Section 1.5.1), it is proposed that a number of approaches to inquiry are suitable. The proposed inquiry into slack originates from a breaking down of the drivers of innovation established within construction, suggesting a decomposition approach. However, knowledge of organizational slack was gained from general management literature to be applied within a construction context, thus supporting an analogue approach. Ultimately, however, it is argued that the proposed research problem originates from an aggregation approach (formal approach). The connections established within the synthesis between innovation and slack draws upon theories found within distinct areas, which have been combined and supported with other existing theories in order to develop hypotheses for testing the slack-innovation relationship within the construction context. The testing of this relationship will determine if slack is a viable construct within the construction context.

### 5.4 Research Strategy

An integral consideration to research, prior to all else is the reasoning strategy taken by the researcher. Reasoning being the ‘logical’ process used to derive conclusions, make
predictions or infer explanations through the use of existing knowledge or observations (Schmidt 2014). The reasoning process adopted by scientific research is generally considered to be primarily inductive or deductive in nature, which is here termed the research strategy (RS). Induction is the process by which theory is generated, while deduction is the process by which theory is tested (Buckley et al. 1976). However, Buckley et al. (1976) argued that it is essential to stress whether the research is “primarily” inductive or deductive in nature. To some degree both strategies of are present within all research. Blaikie (2007) expands these research strategies to include retroductive and abductive research strategies. He further offers a comparison of the logics and differences between these strategies are seen below in Table 6.

<table>
<thead>
<tr>
<th></th>
<th>Inductive</th>
<th>Deductive</th>
<th>Retroductive</th>
<th>Abductive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aim:</strong></td>
<td>To establish universal generalisations to be used as pattern explanations</td>
<td>To test theories, to eliminate false ones and corroborate the survivor</td>
<td>To discover underlying mechanisms to explain observed regularities</td>
<td>To describe and understand social life in terms of social actors’ motives and understanding</td>
</tr>
<tr>
<td><strong>Start:</strong></td>
<td>Accumulate observations or data</td>
<td>Identify a regularity to be explained</td>
<td>Document and model a regularity</td>
<td>Discover everyday lay concepts, meaning and motives</td>
</tr>
<tr>
<td></td>
<td>Produce Generalisations</td>
<td>Construct a theory and deduce hypotheses</td>
<td>Construct a hypothetical model of a mechanism</td>
<td>Produce a technical account from lay accounts</td>
</tr>
<tr>
<td><strong>Finish:</strong></td>
<td>Use these ‘laws’ as patterns to explain further observations</td>
<td>Test the hypotheses by matching them with data</td>
<td>Find the real mechanism by observation and/or experiment</td>
<td>Develop a theory and test it iteratively</td>
</tr>
</tbody>
</table>

The deductive approach to research represents the most common research strategy, where the researcher uses existing knowledge and theories on a particular domain to deduce a hypothesis, which must then be tested using empirical scrutiny (Bryman & Bell 2007). This strategy starts with the researcher identifying a regularity or pattern that has been established, which requires further explanation. The research must then find or formulate a possible explanation for the phenomenon (Blaikie 2007). Existing knowledge and theoretical considerations are developed and accumulated through a scan of theory to find explanation to the phenomenon. These are then used to derive logical conclusions and presented in the form of hypotheses. Unlike inductive or abductive research, deductive research always begins with a given theoretical framework: hypotheses or propositions, which are given prior to any empirical research,
where they are tested and evaluated (Kovács & Spens 2005). The task of the researcher is to test these deduced hypotheses or propositions through the collection of appropriate data. The conclusion of this strategy is supporting the theory through matching data or similar results, or the modification/rejection of the theory should the data not match (Blaikie 2007). Kovács & Spens (2005) illustrate the differences between the deductive and inductive research processes (see Figure 18 below) described in this section. The deductive process requires the stages discussed above to be formulated prior to testing the hypotheses and the final conclusions. On the other hand the inductive approach follows an opposite path, where observations about the world lead to propositions and generalisations in theoretical frame (Kovács & Spens 2005). Reviewing these differing research strategies, it can be seen that there are multiple valid approached with the research might take to pursue and revolve a research problem.

![Diagram of Purely deductive and inductive research processes](image)

**Figure 19: Purely deductive and inductive research processes, after Kovács & Spens (2005:137)**

The researcher argues that due to the lack of exploration of slack as a construct with the construction context, that both an inductive and deductive research strategy are necessary. Although the deductive research strategy matches most appropriately with
this research, an inductive research strategy is necessary to inform the framework for
the research.

Reflecting upon the discussion in chapter 1, the research problem and questions posited,
this research leans towards the identification and testing of theory. Namely the testing
of: how the quantity or level of organisational slack within the firm influences its ability
to innovate and perform within its environment? This was developed through the
identification of innovation as a phenomenon to be explained within the construction
context, where currently theories or arguments had failed. Following this, the concept of
organisational slack was explored as an explanation for discrepancies in firm level
innovation unexplored within the construction context. From a literature review
discussing innovation and slack, linkages were made between the concepts within the
construction context. This resulted in the development of two hypotheses (H1 and H2).
The task for the deductive research strategy, and this research is to test these hypotheses
using a research design (Blaikie 2007), which is generated through the research methods
and research design in the rest of this chapter. This therefore cements the deductive
research strategy as the appropriate approach to this research.

Additionally this research has also sought to establish slack as a universal generalisation
between innovative firms in construction, as a patterned explanation for the disparity
between innovative and non-innovative firms. This indicated that the inductive research
strategy is also appropriate. In order to complete this strategy the researcher must obtain
observations from real life to allow generalisations to be made, which will inform a
framework for understanding a construct.

Offering a critical examination of the researcher’s selection if research strategy, it is
suggested that a retroductive RS might have also be appropriate for this research study.,
forwarding slack as a discovered mechanism to explain innovation (see Table 6).
Nevertheless, the retroductive RS strategy is argued to be less representative of this
research than the deductive RS. The retroductive RS requires that the researcher work
back from data to an explanation, in order to discover and establish an underlying
mechanism (Blaikie 2007). The discover and establish an underlying unknown
mechanism firstly has not been done here, and secondly would prove complex due to
the lack of exploration of the concept of slack within the construction context. The
transposition of the concept of slack does not require slack to be ‘rediscovered’ within
the novel context of construction, as it is well documented within existing literature. However, observations are necessary to informal framework for the research. While the functions of slack, relating to the hypotheses developed within this project, need only be tested. Therefore, for this research both the inductive and deductive research strategy are selected and carried forward, as both are necessary to full understand slack in construction. As stated previously all research to some degree contains both inductive and deductive research (Buckley et al. 1976), This research is primarily deductive in nature, but is informed to a degree by inductive research. Consideration of Research Paradigms

Paradigms of inquiry (Burrell & Morgan 1979), also known as ‘knowledge claims’ (Creswell 1998), are used to define how the researcher perceives the world and what is considered to be the limits of legitimate inquiry (Denzin & Lincoln 2008). These are examined to allow the reader to understand the perspectives of the researcher. Paradigms of inquiry represent a researcher’s allegiance to a particular set of assumptions regarding ontology, epistemology and methodology, which must be formed as part of any research explanation. They cannot be assumed by readers (Burrell & Morgan 1979). The following broadly outlines the commonly accepted definitions of ontology, epistemology and methodology and represents the dominant choices facing researchers:

Ontology is a metaphysical branch of philosophy, which is concerned with the nature of reality. From a social science perspective ontologies answer the question “what is the nature of social reality?” (Blaikie, 2007:13). The ontological assumptions are concerned with reality being either a) externally manifested and independent of the activities of the observer, imposing itself upon the individuals consciousness, or, b) is not independent for the observer, but the product of the individuals consciousness (Burrell & Morgan 1979; Blaikie 2007)

Epistemology is concerned with the theory of knowledge, answering how human beings come to have knowledge of their environment, how we know what is known (Blaikie 2007). From the perspective of social sciences, epistemological perspectives offer explanations to how a social reality can be known, and how one might understand this reality and communicate it to others. For example: whether knowledge is based upon
human experience or if it must be first based upon theory leading to subjective observation.

The final assumption, methodology, like the above is concerned with knowledge, however in this instance focus is placed upon how knowledge can be obtained (Burrell & Morgan 1979). Principally this perspective relates to how an inquirer would seek out knowledge that he or she believes can be obtained (Denzin & Lincoln 2008). Burrell & Morgan (1979) assert that the ontological and epistemological choices have a direct impact upon methodological assumptions. Each choice relates to a different methodology and the researchers approach to obtaining ‘knowledge’ (Burrell & Morgan 1979). Methodological assumptions fall between the extremes ideographic and nomothetic. The former approach is based on an argument that knowledge of the social world can only be obtained first-hand. It stresses the importance of hands-on subjective inquiry. The latter, nomothetic, maintains that research be based upon the systematic protocol and technique like that demonstrated within the natural sciences. Here focus is placed upon testing hypotheses through scientific tests employing quantitative analysis techniques (Burrell & Morgan 1979).

Table 7: Polarities and assumptions adopted by researchers, adapted from and Burrell and Morgan (1979:3)

<table>
<thead>
<tr>
<th>Continuum</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontology</td>
<td>Nominalism – Realism</td>
</tr>
<tr>
<td></td>
<td>Whether the object of investigation is the product of consciousness (nominalism) or whether it exists independently (realism).</td>
</tr>
<tr>
<td>Epistemology</td>
<td>Anti-positivism – Positivism</td>
</tr>
<tr>
<td></td>
<td>What our grounds of knowledge are.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Ideographic – Nomothetic</td>
</tr>
<tr>
<td></td>
<td>Ideographic ('concrete’) or nomothetic (abstract) approaches to evidence collection.</td>
</tr>
</tbody>
</table>

Although some researchers might argue for an allegiance to a certain position or another within research, the author maintains that the choices of research paradigm, research stance, methodology and research method must adjust to not only the research problem at hand but also to some degree the researcher him/herself. Therefore, the is no single approach or solution to a problem. From this the researcher also considered the perspective of Fernie (2005), wherein the researcher is considered as a paradigm of inquiry. It is considered essential that the researcher reflect on questions regarding the nature by which assumptions are chosen and research is carried out. For example: Do researchers objectively select assumptions underpinning paradigms?; are they capable
of freely selecting assumption or are they pre-disposed to certain assumptions? Or, do they post-rationalise assumptions to suit the research questions proposed and research conducted? What is developed first by the researcher, a paradigm of inquiry or a research question? And are these fixed or free to vary (Fernie 2005)? In answer to these questions the research follows Denzin & Lincoln (2008) concept of a socially situated ‘researcher’ where in:

“Behind the terms [ontology, epistemology and methodology] stands the personal biography of the gendered researcher, who speaks from a particular class, racial, cultural, and ethnic community perspective. The gendered, multi-culturally situated researcher approaches the world with a set of ideas, a framework (theory, ontology) that specifies a set of questions (epistemology) that are then examined (methodology, analysis) in specific ways”  (Denzin & Lincoln 2008:23)

Therein, while the researcher chooses to approach research according to certain assumptions or modes, and while these selections might by articulated using clear logic, to a certain degree the researcher approaches these choices with a plethora of personal experiences and assumptions which lend themselves sympathetically to a particular context or ontological affinity (Creswell 1998). Despite this, it remains necessary for the development of the methodology for the researcher to accept the assumptions of one particular paradigm of enquiry. However, in doing so, the researcher is aware of the idiosyncratic assumptions of themselves, and a possible leaning towards one particular paradigm of inquiry over another.

In consideration of this research, the research must lean towards the dominant approach to testing a relationship with organisational slack, established in prior research. To depart heavily from prior when transposing the concept of slack to a new context (i.e. construction) would further remove this work from prior developments. The majority of prior slack research has sought to test relationships through the use of econometrics, lending itself to a positivist research paradigm. Further to this, the deductive research strategy, which most closely reflects the development of this research also seeks to test hypotheses developed from literature. Therefore the adopted research paradigm for this research is ‘positivism’.
The positivist perspective is argued to seek to discover, and or test underlying and
generalizable principles within the research problem (Easterby-Smith et al. 2002). This
is considered to be the perspective most akin to the research, which aims to test the
underlying principles of innovation, in this case argued to be slack, within the novel
context of construction.

5.4.1 Ontological Position of the Researcher

The ontological position of the research is informed by the research paradigm, the
selection of a certain position in one area generally leads to an affinity to the
corresponding position in another (Burrell & Morgan 1979). A realist views the world as
concrete and external to the researcher. Observations are arguably the only means of
investigation (Easterby-Smith et al. 2002).

In his book on social research Blaikie (2007) provides a number of ontological positions,
that go beyond the dichotomous nominalism-realism positions (Easterby-Smith et al.
2002; Burrell & Morgan 1979) seen above in Table 7. Moving away from what is
termed the shallow realist, where there is considered to be a single observable reality,
Blaikie (2007) presents the cautious realist ontology. The cautious realist, a sub set of
the realist position, maintains that there is an external reality, but one that cannot be
perceived accurately due to the imperfections of human observation (Blaikie 2007).
This position requires the research to be critical about their work. The researcher must be
cautious, as one cannot fully determine if the true reality of the investigated phenomena
has been uncovered. Essentially research must be critical and provide where possible
justification for any measures chosen, in that the imperfect measurement of reality
might be reduced. This is reflected in research design which justifies the selection of
each measure, variable and statistical approach. This is further supported in the critical
examination of this project and developed list of limitation of this project, detailed in
Chapter 8.

The researcher’s ontological position of a realist (Burrell & Morgan 1979), or more
accurately a cautious realist according to Blaikie (2007), is associated with the
epistemological positon of a positivist (Burrell & Morgan 1979), or falsification when
reading Blaikie (2007). Both of which are associated with a deductive research strategy
(Blaikie 2007).
5.4.2 Epistemological Position of the Researcher

Much of the debate within construction management research on the dichotomous nature of various paradigms of inquiry and the legitimacy of each approach (see: Seymour et al. 1997; Runeson 1997; Raftery et al. 1997; Seymour et al. 1998; Harriss 1998; Wing et al. 1998), may for this research be overlooked to a larger extent. As previously stated in this thesis, the research has a predisposition towards an econometric investigation due to the previously established approaches in prior research. Therefore, the debates over the choice of epistemology are a moot point, as a research paradigm and underlying choices have already been made. The predisposition of the researcher is informed heavily by the traditions of slack research within general management literature, which predominantly adopts econometrics as a means of testing the impact of slack research. It is argued that due to the nature of the vast majority of slack research, this end to an affinity by the researcher towards a similar approach, and a positivist epistemology; relying upon the measured observations and statistical results to provide evidence for relationships. The positivist epistemology is argued to describe most accurately the positon for this research project. Table 8 taken from Easterby-Smith et al. (2002) illustrates the contrast between the positivist and social constructivist research paradigms.

Table 8: Contrasting implications of positivism and social constructivism, after Easterby-Smith et al. (2002)

<table>
<thead>
<tr>
<th></th>
<th>Positivism</th>
<th>Social Constructivism</th>
</tr>
</thead>
<tbody>
<tr>
<td>The observer</td>
<td>Must be independent</td>
<td>Is part of what is being observed</td>
</tr>
<tr>
<td>Human interests</td>
<td>Should be irrelevant</td>
<td>Are the main drivers of science</td>
</tr>
<tr>
<td>Explanations</td>
<td>Must demonstrate causality</td>
<td>Aim to increase general understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of the situation</td>
</tr>
<tr>
<td>Research progresses</td>
<td>Hypothesis and deductions</td>
<td>Gathering rich data from which ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>are inducted</td>
</tr>
<tr>
<td>through Concepts</td>
<td>Need to be defined so that they</td>
<td>Should incorporate stakeholder</td>
</tr>
<tr>
<td></td>
<td>can be measured</td>
<td>perspectives</td>
</tr>
<tr>
<td>Units of analysis</td>
<td>Should be reduced to simplest</td>
<td>May include the complexity of “whole”</td>
</tr>
<tr>
<td></td>
<td>terms</td>
<td>situations</td>
</tr>
<tr>
<td>Generalisation through</td>
<td>Statistical probability</td>
<td>Theoretical abstraction</td>
</tr>
<tr>
<td>Sampling requires</td>
<td>Large numbers selected randomly</td>
<td>Small numbers of cases chosen for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>specific reasons</td>
</tr>
</tbody>
</table>

A positivist epistemology views the researcher as external to the events being observed, arguing that knowledge of the social reality develops only through the objective
observation of facts, which cannot be influenced by the researcher (Blumberg et al. 2005). As previously stated the tradition of slack research, and the research here, adopts an econometric approach to research as one research method, which resonates with the positivist epistemology. Econometrics is the use of economic data, mathematics and statistical method to test the relationship between variables (Gujarati 2012). Slack researchers (see George 2005; Bradley, Wiklund, et al. 2011; Mousa et al. 2013) are removed from that which is being tested, and draw data from firms’ annual reports and use this information and the use of statistical analysis, and the use of probability to demonstrate causality, in this case between slack and innovation in construction firms.

The epistemological dichotomy of positivist and anti-positivist Burrell & Morgan (1979), is broken down further by Blaikie (2007). While the position of positivist is taken, Blaikie (2007) presents a more refined position of falsificationism. This positon argues that theories are invented to account for observations, not derived from them. This leads to the primary role of further observation and research being the testing of theories, to reject false theories (Blaikie 2007). This follows closely to the deductive research strategy above and the ontological position described below.

The positivist epistemology, and the position of falsificationism, follow closely to the deductive research strategy (discussed above), which requires hypotheses and deductions to be established prior to the resting of causality.

5.4.3 Summary

The researcher is underpinned by a positivist epistemological position, and a realist ontological position. This is further informed Blaikie (2007) where the research will embrace falsificationism and a cautious realist position. Such choices are in part informed by the research problem and the aims of the research. It is further argued that the research is sympathetic to these paradigms of inquiry based upon the traditions of slack research to expose relationships using econometric and financial measures of the firm. As such the researcher has been exposed predominantly to what is considered a positivist epistemological position, where research aims to discover a relationship using techniques measuring slack within the firm (Easterby-Smith et al. 2002). Having detailed the choice of positions underlying the research paradigm, the researcher can now make an informed decision regarding, the stance of the researcher, the
methodological position of the research, and the underlying research methods which may be chosen for the research.

5.5 Researchers Stance

Closely related to the approaches and the research mode (or what might termed research strategy by Blaikie (2007). What are also considered vital are the choices of the researcher regarding their stance. The researcher’s stance dictates the relationship between the researcher and what is being researched, the level of knowledge by which a problem is approached and the involvement the research has with participants. Although Easterby-Smith et al. (2002) present similar choices regarding research, these are more focused upon research design choices. Therefore the following focuses upon three stance choices for the researcher described by Blaikie (2007:11).

5.5.1 Outside or Inside Learner

Here the research must choose the type of relationship they wish to have with the research participants when trying to generate new knowledge (Blaikie 2007), and if the research should be distanced or involved with the research (Easterby-Smith et al. 2002). The outsider researcher stands back from the phenomenon being investigated, maintaining a professional distance in order to not be influenced by what is being researched. The insider research actively immerses oneself into a social situation, engaging in relationships with the participants, in turn influencing and being influenced by those researched (Blaikie 2007).

Within this research an outsider stance is taken in order to prevent the researcher influencing the social phenomena, distorting the results or demonstrating bias. Furthermore the adoption of the positivist research paradigm limits the application of the inside learner (Easterby-Smith et al. 2002). As discussed slack is a complex phenomenon, and care must be taken when investigating it to not influence participants perceptions or responses by demonstrating what the researcher wishes to be true.

5.5.2 Expert or Learner

As with the above, the researcher must also choose between two levels of knowledge when tackling a research problem; choosing to be either an expert or a learner. The former approaches a problem equipped with the required existing knowledge, while the latter sets aside existing knowledge allowing research participants to reveal how they understand the research problem (Blaikie 2007).
For this the researcher takes an expert stance, taking knowledge obtained regarding the concept of slack and innovation in order to ascertain a relationship between the two concepts. Depending on the choice of research method, participants could be asked to explain their view on the concept, lending evidence towards a learner stance. However, the researcher used prior knowledge in order to determine the research problem and the means of gathering information. This coincides with the deductive RS seen in Table 8, which was selected as the most appropriate research strategy, where hypotheses for testing are generated prior to research through the literature review (or search of theory) (Kovács & Spens 2005). Therefore the research takes the stance of the ‘Expert’.

5.5.3 On, For or With People
The final stance choice runs in parallel with the above choice, and concerns the nature of the relationship between the researcher and the research participants. Research may be done on participants, for participants, or with participants. In the first case, those researched are subjects of inquiry, where researcher is done primarily for the benefit of the researcher. In the next case (for participants), the researcher acts as a consultant, doing research for a group to generate knowledge requested. The final stance sees the researcher as a facilitator assisting in the research with a group. This stance choice reflects the purpose of the thesis, and the research problem being investigated. The researcher here takes the “on” stance, where by participants (or the unit of analysis) are being researched, and not with or for. The research problem was not generated from consultancy or from the needs of others, but developed from a concept by the researcher.

5.6 Consideration of Research Methodology
The methodology here is argued to collectively refer to the researcher’s choices regarding research strategy, research methods, data collection methods and analysis (Silverman 2001). Yin (2009) argue that the goal of developing a methodology is to avoid what is termed ‘gross miss fit’. Echoing this Miles & Huberman (2014) argue that there are no bad methodological choices, only certain methodologies that are more or less useful to the research in differing circumstances. The following seeks to develop a methodology most appropriate for the research problem, by examining and exploring the suitability of common research methods to avoid ‘gross misfit’.
This thesis seeks to test the hypothesis generated in Chapter 4. Understanding of the concepts of innovation and organisational slack have been provided in chapter 2 and 3, while Chapter 4 offers and explanation for the relationship between the level of organisational slack and innovation outcomes. Therefore, what remains is to predict a relationship (provided by the hypotheses) and then test these empirically using a suitable research method.

5.7 Research Method

In consideration of the choice of research method for this thesis relating to the research problem, it is maintained that observation of the problem is “theory laden” (Gill & Johnson 1997). Therefore, there is no completely independent or neutral point from which the researcher can observe the world. So that to some extent, all analytical perspectives, including those in this research are not objective, but subjective (Astley 1984). Therefore, the research method is always the choice of the researcher, and is not entirely subject to the research problem. Figure 19 below illustrates a matrix range of possible research methods available to the researcher, in relation to the assumptions and stance adopted by the researcher. In the section above, the researcher chose a positivist epistemological position, and the stance of the outside expert. This leads to a potential predisposition to the top left quadrant, circled below. However, this does not require the researcher to be restricted to only the indicated research methods, as this might not be suitable to the investigation.

![Figure 20: Matrix of research designs, after Easterby-Smith et al. (2002)](image-url)
The figure above however, is only one among many means of selecting appropriate research methods. Buckley et al. (1976:23-27) argued that the choice of research methods might be reflected according to the extent of control the researcher wishes to maintain for the developing research. Research methods can be divided into four categories; empirical methods, database methods, opinion survey and logical deduction.

The relationship of the various research methods between the four categories and the amount of control is illustrated in Figure 20, which presents possible research against their research groupings. Buckley et al. (1976) contends that the specific research method selected by the researcher is largely of their own choice, but will be influenced by the researcher’s epistemological choice as this will dictate to some extent the degree to which the researcher can maintain control of the research. In order to select the appropriate research method it is argued that the researcher must reconsider the nature of the research problem, as a means of eliminating poorly fitting research methods, and thus avoiding ‘gross miss fit’ (Yin 2009).

![Figure 21: Choice of research method based on research control, adapted from Buckley et al. (1976)](image)

Prior to selecting a particular method for research, it is necessary to consider the nature of the problem at hand. When considering the appropriateness of one method over the other, it is a process of finding one to best fit the research proposal, as opposed to finding a perfect match (Bryman & Bell 2007). Therefore, the selection of a research method remains open, and is not restricted by the highlighted area in Figure 9. The research must explore the research problem further prior to selection the research method of ‘best-fit’.
5.7.1 Slack-Innovation Problem – Level of Analysis and Unit of Analysis

In the selection of the most appropriate research method it is necessary to determine first the nature of the “slack-innovation” problem, summarised here:

- In spite of debates regarding the legitimacy of claims regarding construction as poor at innovating, innovation remains a central issue for the survival of construction firms.

- The propensity of the firm for innovation is rooted in a resource dependency, and the presence and visibility of excess resources which underpinned innovation drivers such as firm culture.

- Slack resources impact the firm, facilitating a number of functions which are argued to simultaneously benefit and harm the firm in varying degrees, leading to the argument for a curvilinear relationship between slack and the benefit to the firm ($\cap$ or $\cup$).

- Although it is has been recognised that a lack of slack inhibits innovation in construction, and that it is good practice to maintain slack within the firm, this concept has not been established or explored previously within the construction context.

- Therefore, the relationship between slack and innovation must be both understood in greater depth and tested within the construction context to determine if slack a viable determinant of innovation.

Having summarised the nature of the slack-innovation problem above, it is also critical to articulate the research object, unit of analysis and level of analysis taken by the research. This lends itself to the selection of an appropriate research method, and conveys to the reader essential information regarding the approach to the research problem.

The research object for this thesis is innovation. This thesis is interested in how firms are able to innovate, and has presented organisational slack as an explanation for the discrepancy of rates of innovation between firms.

The level of analysis has two interpretations. The first relates to placing the subject of study in context, establishing the research as operating at either a philosophical, theoretical or practical level (Yurdusev 1993). This work is argued to function at the practical level, wherein the research focuses on concrete forms and practices within the realm of everyday reality (Yurdusev 1993). At this level the research focuses upon the
direct implications and influences of a problem, which is being done here within this research methodology in testing the relationship between slack and innovation. Although it could be argued that this work functions on the theoretical content of the problem, this is restricted to the literature review, as this work focus upon the analysis of the problem itself and not the theoretical underpinnings. The second interpretation of the level of analysis, refers to the level at which the research takes place in the social world. The level of analysis for this research is at the firm level, examining individual firms’ levels of resources in relation to innovation outcomes at the firm level.

The unit of analysis concerns the relates simply to what is being studied, the ‘thing’ under investigation (Yurdusev 1993; Miles & Huberman 2014). As such this denotes some form of entity to be studied and investigated, and may consist of people, firms, groups, or humanity as a whole. While the level analysis is considered to envelope the unit of analysis, it does not dictate its selection, and the research may select any form of unit irrespective of the level of analysis (Yurdusev 1993). For this thesis, as stated throughout, the firm is chosen as the unit of analysis. The firm is defined following Myers (2013:97) as “an organisation that brings together different factors of production, such as labour, Land and capital, to produce a product or service which is hoped to be sold for a profit”.

Selection Rationale

Although the work of Easterby-Smith et al. (2002) and Buckley et al. (1976) were insightful, further refinement of the research methods is needed. In order to find a single research method, five common research methods are assessed against three conditions proposed in Yin (2009:8). These conditions are (i) the type of research question (s) that have been proposed (ii) the extent of control the investigator has over behavioural events and finally (iii) whether the focus is on contemporary or historical events. Each condition provides insight to the research method considered, and its appropriateness to the proposed research problem. The research methods considered following Yin (2009) are: experiments, surveys (both questionnaire and interview based), case study and archival analysis. The responses to the proposed conditions are illustrated in Table 9 below.
Table 9: Research choices, adapted from (Yin 2009:8)

<table>
<thead>
<tr>
<th>Method</th>
<th>Form of research</th>
<th>Requires control of behavioural events?</th>
<th>Focus on contemporary events?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>How, why?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Survey – Interview/Questionnaire</td>
<td>Who, what, where, how many, how much?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Archival (statistical) analysis</td>
<td>Who, what, where, how many, how much?</td>
<td>No</td>
<td>Yes/ No</td>
</tr>
<tr>
<td>Case study</td>
<td>How, why?</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The following discusses the rationale for excluding or including the above research methods based upon the considerations put forth by Yin (2009). Due to the need to both explain (inductive) and test (deductive) the impact of slack within the construction context, further to this the research must answer this research adopts a mix-methods approach to research. Wherein, the research adopts two distinct forms of research to provide different but complementary information used to complete a framework or understanding of a construct. The following sections address the section rationale for the inductive and deductive research strategies respectively.

**Inductive research selection rationale**

For this research strategy the researcher attempt to produce generalisations from observations in order to generate a framework of a construct. In this instance, the research has forwarded slack as a universal component of innovative firms, which allows the firm to generate and maintain a number of factors that improve its propensity for innovation. Without slack firms are unable to innovate due to a lack of funding and the absence of the benefits slack affords.

**Research Problem: Form of research**

As stated previously the research problem seek to understand the relationship between slack and innovation in construction firms. Although informed by prior research, the unique attributes of construction as a novel context call into question to suitability of slack as a construct. Therefore, it is necessary to develop a framework to understand “how and why?” slack affects firm level innovation. Although this is largely done with the literature review, further support is required in the form of primary data to reinforce
the assumptions required to test a slack-innovation relationship (See Study 1 Section 5.11)

This requirement reveals that Surveys and Archival research methods are not suitable for the inductive research strategy, and this part of the research project, but maintains Experiments and Case Studies research methods as being suitable.

Control of Behaviours
It is argued that the research problem does not require the control of behavioural events; as the purpose of it is to allow behaviours to manifest freely under differing levels of slack. In order to understand organisational slack in an experimental setting would require behaviours and other variables to be controlled, potentially obscuring the relationship between slack and innovation outcomes. Traditionally within slack research behavioural event are not controlled, the research focus upon either survey (Singh 1986; Nohria & Gulati 1996; Bowen 2002) or archival (Cheng 1997; Tan 2003; Lin et al. 2009) research methods. However, not controlling for behavioural events also leaves the researcher open to a case study research method

Contemporary Events
As this selection rational focuses upon the inductive research strategy, it is argued that there is no special requirement regarding a need to focus upon contemporary events. As the inductive research, strategy requires observations from real-life. However, this does not specify when these observations occurred. Therefore, these may be historical instances, or contemporary depending upon the requirements of the research problem and other constraints of the research.

Deductive research selection rationale
Research Problem: Form of research
The proposed research problem has two purposes, first to understand and second to test the relationship between changing levels of slack and the performance of the firm (as a proxy for innovation outcomes). The inductive rationale focuses upon the “how and why” forms of research, developing a further understanding of how slack impacts the firm. Therefore, for the deductive research rationale requires a form of research which focuses on measuring the amount, or quantity of slack within the firm, and its
corresponding outcomes. This leads to the form of research requiring answering the questions; “how many and how much?”

This requirement reveals that Experiments and Case Studies are not suitable for this research project, but maintains Survey and Archival research methods as being suitable for the research. Although not appropriate for this research project, case studies, for example by Egbu et al. (1998) were integral in revealing the cultural determinates of innovation, which in turn were used to established linkages between the concept of slack and the novel context; construction.

Control of Behaviours
As stated, the research problem does not require the control of behavioural events; in fact, the purpose of it is to allow behaviours to manifest freely. Developing an experiment to test a slack-innovation outcome relationship would require the researcher to control the behaviours of participants. This therefore could potentially restrict the functions of slack from occurring naturally, and the observation of the functions or the benefits derived from them. Within prior slack research behavioural events are not controlled for, where researchers have focused upon either archival research (Cheng 1997; Tan 2003; Lin et al. 2009) or survey research (Singh 1986; Nohria & Gulati 1996; Bowen 2002). An appropriate method for this research should not require the control of behaviours, therefore excluding experimentation from the possible choices.

Contemporary focus
It is argued that it is unnecessary for the research method to focus upon contemporary events. Conventionally, slack research does not require the researcher to focus upon contemporary events. For instance Tan & Peng (2003) focus upon slack during the economic transition of Chinese State owned enterprises in 1996 and 1997, similarly Latham & Braun (2008) focus upon the economic recession and recovery of software firms from 2001-2003.

Although research methods such as surveys, case studies, and experiments, were considered, they were deemed less suitable than an archival analysis. Archival analysis research is argued to better match the proposed research questions. The ability of this research method to focus upon prior events and also is well established within previous organisational slack research. Archival analyses, in the methods demonstrated within slack research, are necessary when venturing into a new context. Upon establishing a
tradition of research within the construction context on organisational slack, it is argued that other more in-depth analyses might be utilised in order to uncover new information, or deepen the support for a curvilinear inverse-U shaped relationship between innovation and performance. While some examples exist of contemporary event focus, in slack research this is less common than a focus on past event (see Nohria & Gulati 1997; Singh 1986; Bowen 2002).

5.8 Mixed Method research
For this research, the research adopts a mixed method approach in order to satisfy the requirements of both the research problem and the subsequent research strategies carried forward (inductive and deductive).

Greene et al. (2005) argue that studies that adopt mixed methods are distinctively capable of generating better results than studies restricted to a single method. A mixed approach to research can be classified into two categories: mixed-method research and mixed model research (Saunders et al. 2007). This research adopts the former, wherein both qualitative and quantitative research methods are used at the same time, but the results are not combined. Although this research uses two methods to obtain data, this information is analysed separately; quantitative data using quantitative techniques, qualitative data using qualitative techniques.

The following sections detail the research methods chosen for this thesis, based upon the selection rationale above. The interviews satisfy the requirements of real world observations and primary data collection for inductive research, while the archival analysis enables the testing of hypotheses for the deductive analysis.

5.8.1 Interviews – Inductive Analysis
For this research project an interview method is selected as one of the two appropriate methods for use. Interviews consist of open-ended questions and probes, which allow the research to obtain in-depth information regarding the interviewees’ experiences, perceptions and knowledge (Patton 2002), thus allowing the inductive research strategy requirements to be met. Interviews can help researchers to gather valid and reliable data relevant to their research questions and objectives (Saunders et al. 2007). The aim of this research method is for the researcher is to stimulate reflection and exploration by the interviewees. Interviews are enabling the researcher to learn, at first hand, about people’s perspectives on the subject chosen as the project focus (Davies, 2007).
There are three different types of interviews, which depend on the types of information the interviewer is trying to obtain and the degree of flexibility in the line of questioning: unstructured, semi-structured and structured (Kumar 2005; Willis et al. 2007; Wilson 2010). For this research semi-structured interviews are adopted, this interview style consist mainly of open-ended questions based on topics that need to be covered relating to research problem and questions. Each question is use to probe of a list of topical areas, in this case: Innovation, innovation outcomes and organisational slack. The responses to these open questions are then recorded for analysis (Fellows and Liu, 2008).

The use of semi-structured interviews remains suitable for the ontological and epistemological positons of the researcher. The ontological stance as a cautious realist argues that the researcher must be critical regarding observations. Therefore, responses must be examined in a critical frame assuming that there is imperfections of human observation (Blaikie 2007). The epistemological position of falsificationism requires the research to test theories to ensure validity (Blaikie 2007). The use of interviews in this research ensures that the observations which form the basis of the hypotheses are also tested, to ensure that the slack-innovation relationship resonates within construction. There is however, a lack of existing research which approaches the concept of slack using interviews as the research method, in comparison to the use of archival analysis. Therefore, for this research method there is no structure or foundation that must be followed.

5.8.2 Archival Analysis – Deductive Analysis

For this research project an archival analysis method is selected as the most appropriate method for use. The use of an archival approach offers the researcher several key advantages when examining the firm and the impact of slack. Firstly, easily accessible data, lending to potential for replication and comparison across studies (Boyd et al. 2013) that is not as easily possible with other approaches. Secondly, the use of secondary sources required for data gathering reduce the issues of bias inherit in subjective responses (Boyd et al. 2013).

Moreover the Archival statistical analysis research method is most suitable to the ontological and epistemological positons of the researcher. Archival analysis maintains the researcher as being external from that which is being observed, most critically as the
event under observation may occur prior to the research project. Slack research has a tradition of archival analysis, focusing on econometrics derived from firm annual report, although exemptions to this have been reported (Bowen 2002; Nohria & Gulati 1997).

Having provided a theoretical framework for the research and a having selected suitable research methods, this chapter examines the quality of the theory developed for this research project, prior to the design of the Archival research method for this project.

5.9 A Good Theory

For this thesis, theory is defined as “an ordered set of assertions about a generic behaviour or structure assumed to hold throughout a significantly broad range of specific instances” (Wacker 1998:364, Sutherland 1976: 9). A good theory is described by Eisenhardt (1989) as being: parsimonious, testable, and logically coherent. A good theory is defined by Poole & Ven (1989) as being ‘a limited and fairly precise picture’. For that reason the theory does not encompass everything, but instead outlines scope and limitations of itself.

Recalling Section 5.4.1 the ontological position of a cautious realist, the researcher must be critical regarding the selected approach to research. Although this thesis does not seek to build new theory or build upon existing theory, the following seeks to examine the theory adopted within this work, in relation to what is considered a good theory.

During the development of a theory it is argued by Whetten (1989) that “logic replaces data as the basis for evaluation”, therefore it is essential to ensure that the developed hypotheses are sound, the research must ensure that the theory used within this research project passes the logical test of a good theory. Building upon Eisenhardt (1989)’s list of requirements, Wacker (1998) presents the following virtues demonstrated by a good theory: uniqueness, conservation, generalizability, fecundity, internal consistency, empirical riskiness, and abstraction. It is against these criteria that the theory of the resource based view of the firm (RBV), slack and the theoretical linkages connecting slack to the construction context in Section 4.6 are assessed. The characteristics of these criteria can be found below in Table 10, which argue that the presented theory relates to each criterion in determining it as ‘good theory’.
5.9.1 Criteria of a Good Theory

When developing or adopting a theory the researcher must consider the strength of the selected theory, the evidence grounding the proposed theory, the analytical procedure conducted, supporting evidence and other possible explanations for the same phenomena. In order to provide a sound theory there should be sufficient evidence to allow others to reach similar conclusions (Eisenhardt 1989), provide something new, and ultimately lead to the goal of a new theory. Wacker (1998) argues that the goal of a good theory is to suggest and support why relationships exist in the theory and what its outcomes are. It is further suggested by Wacker (1998) that theory meets four basic criteria; conceptual definitions, domain limitations, relationship-building, and predictions.

This thesis seeks to test theory, specifically the relationship between the level of slack and firm level performance (acting as a proxy for firm level innovation). However, it remains necessary to test the robustness of that theory, and the linkages developed to allow for its transposition to the construction context. The following examines these criteria against the theory of slack, and the theoretical linkages transposing slack to the construction context presented within this research project, in order to meet the necessary criteria for theory presented by Wacker (1998). The virtues of a ‘good’ theory, developed from Wacker (1998)’s basic research criteria are demonstrated below in Table 10. The virtues below are extensions of the criteria discussed above; the table below serves as a summary of the discussion above.

| Virtue         | Key Feature                              | Appropriateness of this theory                                                                 |
|---------------|------------------------------------------|-------------------------------------------------------------------------------------------------
| Uniqueness    | Theory differentiates from another       | The theory of organisational slack is unique to the construction context never having been explored theoretically or measured within this context. |
| Conservatism  | Superior than existing theory if replacing | The theory of slack does not seek to replace a theory, but build upon the existing resources based view of innovation already established within the construction context. |
| Generalizability | The more areas of application the better the theory | The theory of slack has previously been established and investigated within a wide variety of contexts see Appendix 2, and is also approached as not being limited to particular firm types or industry, but is universal in the function and behaviour of firms. |
| Fecundity     | Expands the area of investigation into new conceptual areas | The context of study expands the narrowly defined construction industry to include “fringe” firms such as architects to examine the construction sector. With the construction sector being the subject of this research project, and one that is novel to research concerning the theory of slack. It is argued that these “fringe” firms are not outside the construction context, but a relevant and
Parsimony/simplicity | The fewer the assumptions the better | Few assumptions have been made throughout the development, focusing upon logical development through established theory. It is assumed that firm level performance is a suitable proxy for innovation, based upon theoretical links between common determinants.

Internal consistency | Logically explains the relationship between variables | The relationship between slack and the firm have been examined clearly within the thesis, in relation to both innovation and performance. Further developments with innovation and performance logically and coherently supported.

Abstraction | Better to integrate many relationships and variables into a larger theory | Research has provided an exhaustive review of contemporary literature discussing the nature of the relationship between slack and the firm, and specifically firm innovation and performance.

Empirical test refutability | The theory that predicts the most unlikely event is the superior | For this research project, two predictions have been made: The first argues that an inverse U-shaped relationship (\(\cap\)), the second predicts a U-shaped relationship (\(\cup\)) between the level of slack and firm performance, used as a proxy for innovation. The following research design details the process by which these predictions are to be supported/refuted through empirical evidence.

5.10 Study 1 Archival analysis: Research Design

5.10.1 Introduction
The following section describes the research design that was conducted in order to test the hypotheses developed following a synthesis between the concept of organisational slack, innovation and firm performance seen in chapter 4. Multiple regression analysis was adopted as an analytical tool test the strength and direction of the relationship between organisational slack and firm performance thus following the tradition laid out in existing slack literature.

Chapter 4 argued that due to the inability to appropriately measure innovation construction firms a proxy measure would be required for analysis to take place. The chapter subsequently established theoretical links associating the presence of slack to firm level innovation outcomes and performance. However, due to the lack of exploration of the construction context, it is unclear what impact the presence of slack has on firm performance (as a proxy for innovation outcomes); as a result, the following hypotheses are presented. There develop the Hypothesis 1 and 2 based upon the selected measures of firm performance seen later in Section 5.10.3:

**H1a** - The relationship between slack and firm financial performance, measured as *Return on Assets* (ROA) is curvilinear and inverse U-shaped (\(\cap\)).
**H1b** - The relationship between slack and firm financial performance, measured as *pre-tax Profits* is curvilinear and inverse U-shaped (∩).

**H2a** - The relationship between slack and firm financial performance, measured as *Return on Assets* (ROA) is curvilinear and U-shaped (∪).

**H2b** - The relationship between slack and firm financial performance, measured as *pre-tax Profits* is curvilinear and U-shaped (∪).

The following details the selection of measures that are adopted to measure both organisational slack and firm performance. Moreover, the following discusses the selection of statistical measure used to test and validate the hypotheses of a curvilinear relationship between organisational slack and firm performance.

As seen previously the researcher has adopted a positivist epistemological position, which lends itself most appropriately to the use of quantitative data sources.

*5.10.2 Data Collection: Unit of analysis, population, data source and limitations*

The following section details the approach to the data collection for the research project, prior to designing the specific measures required for analysis.

**Unit of Analysis**

Quite simply as stated throughout the thesis, the unit of analysis for this research is ‘the firm’. Within which the ‘black box’ of the innovation process draws upon the resources within the firm to produce innovations in order to benefit the firm. The firm was defined earlier as “an organisation [functioning as a legal entity] that brings together different factors of production, such as labour, Land and capital, to produce a product or service which is hoped to be sold for a profit” (Myers 2013:97). Using the firm as the unit of analysis, a suitable source of data was required which may be used to the hypotheses that have been developed.

**Population: Construction**

As discussed throughout this thesis, the author elected to focus upon the broadly defined construction sector established within Chapter 1: Introduction and classified within BIS (2013). Which allows the examination of a broader variety of firms that engage within the construction process such as architects, consultants and suppliers, which form in integral part of the construction process but are conventionally excluded from the more
narrowly defined construction industry (O.N.S 2007). These additional firms were considered to permeate the boundary, or rather for the more distinct firms exist within the overlap between the manufacturing and construction industries. By including them within the study it was thought that they might illuminate differences and similarities between a broader range of firms within the construction sector.

Although the inclusion of ‘peripheral’ firms to the conceptualisation of the construction sector within this study, might detraet from the suitability of the results from the ‘core’ construction firms, is maintained that ‘construction’ cannot continue to be defined so narrowly to include only ‘core construction firms’. This is supported by research within construction broadening its boundaries to include firms previously considered to be on the periphery of the boundary of what is considered construction. For example, Barrett et al. (2007) note the existence of parallel activities such as architectural and technical consultancy and upstream activities such as mining, quarrying and manufacturing as being part of the construction sector. However, conventionally when using only standard SIC codes these firm types would be excluded. Research must consider construction as a broader construct, and accept the large array of firms that support and function within the construction context. Therefore, so must this research consider how the level of slack impacts innovation outcomes in not just core construction firms, but also firms that support and develop construction innovations, such as those included within the population stated within Appendix 1.

Full specifications of the population from which the data sample was taken can be found within Appendix 1, which details the BIS (2013) classifications incorporated into each firm type. Although the results will pertain to a much broader sample than what is considered the ‘core construction’ firms following SIC (2007), the results remain suitable for the broader conceptualisation of the construction sector as dictated in BIS (2012) and Appendix 1, thus clearly indicating what parts of the construction sector are to be included within the population for this research. ‘Construction’ as a whole is much broader than simply its core, overlapping and connecting with many other industries with ill-defined boundaries (Groáč 1994). The inclusion of what might be considered ‘peripheral’ firms adds to construction quantity surveying and design activities which are an essential part of construction (Reichstein et al. 2005).
Data Source: Annual reports as a secondary source

The research method selected as most appropriate for this research project is the Archival research method. In order to conduct an archival research method data must be sourced for use in the analysis. Study 1 focuses upon an econometric analysis (Gujarati 2012), which is prominent within slack research.

Following the traditions of slack research the relevant information is to be sourced using financial data obtained from annual reports from a secondary source. Secondary source data is information or data that has already been gathered and recorded by someone. Annual reports of public companies like that used here are an often used source of secondary data (Blumberg et al. 2005). Secondary sources of data are useful to the researcher as they can save time, and effort that is often wasted contacting respondents and collection information required for other forms of analysis (Blumberg et al. 2005).

Following an archival approach, and traditions of slack research, data was gathered using information gathered from firm annual reports. In order to collect the relevant data, the author accessed the F.A.M.E. (Financial Analysis Made Easy) database maintained by Bureau van Dijk as a secondary source for the financial information. The F.A.M.E. database provides access to the annual financial reports of firms within the UK and Ireland, and allows access to current and historical (limited to 10 years) data regarding the financial standing of firms and additional structural information. This database was used for its ease of access, ease of operation and its detail records regarding the relevant UK construction sector.

Prior to selecting the appropriate measures to use to test the relationship between slack and firm level performance, the researcher must first select appropriate data to be sourced from the database.

Data Limitations

It is recognised by the researcher that the use of quantitative data, using financial measures derived from annual reports may be considered limited. The level of resources within the firm, and therefore its slack is more fluid construction than often considered. Bourgeois (1981) recognised that although annual report data was useful for extracting information, it presents only a snapshot of the firms activities on a particular year. However, alternative sources of information are also considered to be limited in their ability to measure slack: subjective responses require participants to reliably assess their
environment and how much it will be affected by change (Richard et al., 2009), additionally participants might also be reluctant to reveal how much slack they think exists due to fear of it being removed (Bourgeois, 1981). When measuring slack any approach will be limited in some regard, the advantages of an archival analysis allows for a large sample from which to examine the data.

The obtained data may also be limited based upon the unique characteristics of the construction context, compared to alternative contexts. Hillebrandt (1985) argued that the construction industry while sharing similarities with other industries has a unique combination of characteristics unseen elsewhere in the economy, further arguing that construction firms’ annual reports are different from other firms. As such, it is possible that the selected measures for analysis do not accurately represent the variables they are selected for, thus preventing an accurate analysis. It is argued that due to the lack of exploration of the construction context, this possibility cannot be supported by evidence. Therefore, at this time cannot be determined to be an accurate limitation of exploring slack in the construction context. The researcher cannot ensure 100% accuracy or quality of the data, and must rely upon the information provided in prior research to guide the approach to measuring slack in construction.

Blumberg et al. (2005) warns that the main issue with secondary data sources is that they are not research problem specific, therefore a complete research design must ensure that; the data gathered is relevant and sufficient to answer the research problem, the data addresses the same population under investigation and that the data applies to the relevant time period. The following section and the remainder of the research design ensures that these criteria are met.

Obtaining relevant data

As examined within Chapter 5 earlier there are a number of methods for engaging with research, likewise in Chapter 3 the variety of slack research methods were also examined both quantitative and qualitative approaches. Following these examinations it was concluded that the archival research method was most suitable for this research, and most appropriate to explain the relationship between the proxy measure for innovation, firm performance, and the level of organisational slack within the firm. Reflecting once again upon the approaches to slack research, the author also elects to follow the slack research tradition labelled “objective-absolute” research. This method
Methodology and Research Design

involves a cross-sectional econometric analysis of relevant information on firms at a
single point in time (Koop 2005). This research method traditionally requires the
collection and subsequent analysis of quantitative financial data which is used to
represent innovation, performance and slack variables. This tradition was replicated in
order to establish a foundation of slack research within the previously unexplored
construction context.

However, in order for the analysis to be relevant, the data gather must relate not only to
the research problem (Blumberg et al. 2005), but also correspond between what is
intended to be measure and what actually is measured (Boyd et al. 2013). It is also
essential that for the development of a good theory that issues regarding measurement
be clearly discussed for possible future research (Wacker 1998).

The following sections develop the research design further to answer the two major
questions of quantitative research: what is to be measured; and how should those
measures be made (Fellows & Liu 2003)? Prior slack research is used to justify the
selection of measures and ensure that the intended resources are captured by the
selected measures.

5.10.3 Selection of measures

The following discusses the selection of the measures that were incorporated into this
research in order to test the relationship between the level of slack and performance
within construction firms in accordance with the hypotheses put forward and the
analytical strategy proposed.

Approach to measurement

Within the previous Section 5.7 an archival analysis was selected as the most
appropriate approach to addressing the research problem. An archival analysis matches
the objective-absolute approach discussed in Chapter 3 Section 3.8. As stated in Section
3.8, ‘objective’ here refers to the means by which data is gathered, in comparison to
subjective perceptual measures, and it is recognised that quantitative is not necessarily
objective. An objective-absolute approach to measuring slack has been seen within
slack research to take two dominant forms: A cross-sectional analysis, examining a
large number of firms at a single year, for Tan (2003) and Wu et al. (2011).
Alternatively, the research may adopt panel data analysis, examining a smaller number

- 168 -
of firms over a number of years, where each firm-year represents a distinct case, for Geiger & Makri (2006).

The researcher elected to take a cross-sectional analysis. This approach was adopted due to the ease at which data can be obtained, and its popularity within existing slack literature. However, despite its popularity within slack literature and management literature in general there is no current consensus on how organisational slack (Daniel & Lohrke 2004) or firm performance (Richard et al. 2009) are to be measured.

The following discusses the variables of organisational slack, performance and additional control variables that were adopted in this research design, and the measures used to represent these variables to test the effect of organisational slack on the firm.

**Independent variables: Organisational slack**

The independent variables are the measurable characteristics which influence an outcome within a model (Creswell 1998). It has been hypothesised that the level organisational slack affects innovation, and consequently innovation outcomes, either in U-shaped or inverse U-shaped fashion ($\cup$ or $\cap$). The following details the measures of resources adopted within this research to provide an indication of the amount of slack within the firm. The author chose to incorporate multiple slack variables namely: absorbed slack, unabsorbed slack, human resource slack and financial slack into the research. Each variable represents the accumulation of different types of resources within the firm, which were adopted to represent the forms of slack illustrated in Figure 21 below, which was first demonstrated in Chapter 3.
Distinct measures for high and low discretionary slack were not taken as they were argued to heavily overlap with absorbed and unabsorbed slack, as previously stated demonstrated both constructs having the same or very similar measures within distinct research. The following discusses the selection of the measures for *absorbed* slack, *unabsorbed* slack, *human resource* slack and *financial* slack. As with all measures of slack, it is recognised that they cannot capture the extent of slack within the firm in its entirety (Love & Nohria 2005), but can be used here to indicate the level of slack for certain resources within the construction firm to give an indication for its overall level of slack.

Although slack research is conventionally limited to two or three slack variables, by adopting a broader spectrum of slack variables it offered the opportunity to test the presently unknown effects of different slack types on the performance (and firm level innovation) of construction firms. The additional variables provided the opportunity to gather amounts information on whether specific slack emerges in isolation or paired with others, and how combinations of these resources can predict firm performance.

**Absorbed slack: Expense Ratio**

The first slack which was adopted was absorbed slack, which represents the excess costs within the firm which might be recovered (Singh 1986). The level of absorbed slack indicates of resources being channelled into overhead and staff expenses increased
wages, perks which can support innovative activities and improved firm performance (Love & Nohria 2005).

The level of absorbed slack within the firm was measured as the percentage of Sales, General and Administrative (SG&A) expenses relative to the firm’s turnover taken from Love & Nohria (2005). SG&A expenses provides an indication of the cost the firm for assigning resources to certain operational activities (Chiu & Liaw 2009). This amount was measured relative to turnover (see below).

\[
\text{Absorbed Slack} = \frac{SG&A \text{ expenses}}{\text{turnover}} - \text{Industry ave}.
\]


SG&A expenses was seen as the most appropriate measure of absorbed slack within the firm, as it contains the excess costs and overheads to the firm which might relate to the application of slack resources as a workflow buffer or as forms of inducement and prestige, relating to the managerial action to generate an innovative culture (Hartmann 2006). The use of SG&A expenses as a measure of absorbed slack has also been replicated within existing slack research studies including (Geiger & Cashen 2002; Geiger & Makri 2006; Cheng & Kesner 1997; Bradley, Wiklund, et al. 2011).

Unabsorbed Slack: Liquidity Ratio

The next slack variable included within this research design was unabsorbed slack, which captures the uncommitted resources with the firm (Lee 2011). A higher level of unabsorbed slack indicates resources that might be used to fund innovative activities or encourage behaviours in order to stimulate improved performance.

In order to measure the amount of unabsorbed slack within the firm, the liquidity ratio was adopted. The liquidity ratio provides an indication of the abundance or lack of resources within the firm which can easily be converted to cash within the firm. Further to this liquidity ratio might be described as the firm’s ability to meet its immediate obligations with said resources (Cheng & Kesner 1997), but is most suitably described by Geiger & Makri (2006) as untapped resources that are readily available within the firm.

The liquidity ratio was adopted following Herold et al. (2006) over the ‘current ratio’. Different firm types within a sample might require higher or lower levels of inventories,
but are not representative of slack within the firm. The construction sector from which the sample was taken incorporates a wide variety of firm types. Whilst some firms might, require large inventories due to the nature of their work, other might not require any inventory at all. Thus by not incorporating into the measure of unabsorbed slack it prevents under or over estimation of the amount of slack. The liquidity ratio is calculated as:

\[
\frac{Current\ assets - Inventories}{Current\ liabilities} - Industry\ ave.
\]

Equation 2: Unabsorbed slack after Herold et al. (2006)

The liquidity ratio was chosen as the appropriate representation of unabsorbed slack, which represents uncommitted resources within the firm. Although current assets might be considered as a measure of unabsorbed slack, the liquidity ratio is more representative of slack within the firm as it reveals the level of resources that are not required to meet the short term obligations of the firm (current liabilities). The liquidity ratio (a.k.a. quick ratio) has been used as a measure of unabsorbed slack in a number of studies including (Geiger & Makri 2006; Herold et al. 2006; Geiger & Cashen 2002). The popularity of this measure and its ability to capture accessible resources within the firm make it an appropriate measure for the variable unabsorbed slack.

Human Resource Slack

The next slack variable adopted within this study was human resource slack taken from Mishina et al. (2004). The previous variables focus solely upon the financial or inanimate resources within the firm, but overlook the importance of human resources. Human resource slack provides an indication of possible autonomy and workflow buffering within the firm, which allows for innovative activities to occur with the firm, allows for temporary variability in demands and the freedom to learn and change, all of which supports firm performance.

Human resource slack, following Mishina et al. (2004) was measured as the ratio of the available employees relative to that year’s turnover. Providing the number of £’000 generated per employee, see below.

\[
HR\ Slack = \frac{Firm\ employees}{Firm\ sales} - Industry\ ave
\]
Firms with excess capacity or work autonomy within the firm are more likely to have additional employees relative to their turnover, which can be related to higher level of HR slack. Although first developed by Mishina et al. (2004) this measure has been used more recently within Mellahi & Wilkinson (2010)

**Financial Slack: Cash Ratio**

The fourth and final adopted slack variable for this research design was financial slack. Although financial slack might be considered to be identical with unabsorbed slack, within this research design the measurement of financial slack was considered distinct from unabsorbed slack following Figure 21 above. The measure adopted to represents purely the availability of financial resources within the firm (i.e. cash). While unabsorbed slack (above) represents a number of uncommitted resources within the firm that might repurposed, thus representing a broader range of resources. Therefore, financial and unabsorbed slack measure two different types of slack. Financial slack indicates the level of resources available to the firm to invest and fund innovative activities to improve firm performance. Accordingly, this variable was measured as the amount of cash reserves within the firm relative to that year’s turnover, as cash reserves represent the amount of available financial resources within the system of the firm which can be drawn upon to support activities within the firm.

\[
\text{Financial Slack} = \frac{\text{Cash reserves}}{\text{Turnover}} - \text{Industry ave}
\]

**Equation 4: Financial slack**

Cash reserves have been used in a number of studies such as (Bradley, Shepherd, et al. 2011; Voss et al. 2008; George 2005). Cash resources represent the most easily deployed resources that also provide the greatest degree of freedom in its use (George 2005) and can be repurposed to virtually any purpose (Voss et al. 2008). A higher level of cash resources indicates more resources available to fund innovative activities provide incentives, resolve conflict within the firm and improve firm performance.

**Resource heterogeneity and mean-centring**

To correct for the possibility of differences in base level resources across firm types, the measures of slack were corrected against an industry average level. This provided the researcher with data that demonstrated firms with either a higher or lower level of slack.
compared to the industry average. This was done by manually computing the mean ratios of the slack variables and removing that value from the firm’s slack ratio. This is demonstrated in the equations of the slack variables above.

This practice is common within slack research in order to correct for resource heterogeneity and allows for mean centring around zero, and can be found within Love & Nohria (2005) and Mishina et al. (2004). Absorbed slack in Love & Nohria (2005) and HR slack in Mishina et al. (2004) were calculated against a ‘target’ level of slack for that industry. Mishina et al. (2004) recognised although this a crude estimation for the target level, it provides some indication of firms with higher or lower levels of slack resources in relation to other firms within the same industry.

The process of mean-centring is also recommended by Dalal & Zickar (2012). Dalal & Zickar (2012) argued that mean-centring reduces the ill-conditioning in the data, and provides meaningful zero-points for analysis. This is argued to aid interpretability of the results, as stated above, indicating higher and lower results.

Slack ratios are the absolute measures of the amount of slack, which are not used within the analysis, but are used in order to create the slack variables, as seen above. Slack variables are those used within the final analysis of the final data set. Following the research protocol in Figure 23 (see page 201), which was used to generate the final data for analysis from raw data is presented, Step 13 within this protocol indicates the conversion of slack ratios which are the raw measures, to slack variables.

**Non-linear relationship**

The hypotheses argue that the relationship between firm level performance and organisational slack in construction firms is non-linear, demonstrating either in inverse-U or U-shaped relationship (\( \cap \) or \( \cup \)). H1a/b argues that as the level of slack increases so does performance (or innovation) until a maxima is reached where upon the negative effects of slack overwhelm the positive reducing performance. H2a/b argues that optimal performance is achieved at the extreme levels of slack either very high or very low, and that moderate levels of slack deteriorate performance.

In order to test for the hypothesised non-linear relationships stipulated, it was necessary to transform the slack variables. The statistical analysis technique, multiple regression, adopted within the analytical strategy can test only linear relationships. In order to
non-linear relationship, linear independent variables were converted into non-linear terms. This was done by adding the minimum value + 1 to each case to remove negative and zero values which cannot be squared, and would distort the data. This value was then squared to produce the non-linear term.

These non-linear variables were incorporated into the regression models with the linear terms to test the hypotheses. The use of non-linear terms is common within slack research and can be found in Tan (2003), Tan & Peng (2003) and Chiu & Liaw (2009) where each author similarly predicts a non-linear relationship between slack and the outcome variables.

Dependent variable: Performance as a proxy for innovation

Dependent variables are those which are determined or influenced by changes in the independent variables, otherwise known as outcome or response variables (Creswell 1998). Initially within this research emphasis was placed upon understanding the determinants of innovation, thus suggesting a measure of innovation as the dependent variable. However, after revealing the inaccuracy of innovation measures, and their inability to capture with the conceptualisation and definition of innovation seen in Chapter 2, an alternative dependent variable was suggested. Following a synthesis of theories seen within Chapter 4, firm level performance was forwarded as a measure for innovation outcomes (recall section 4.8), as both innovation and performance share the same drivers, and that the intended outcome of innovation is to improve overall performance of the firm.

Organisational slack in itself was also been associated with both innovation and performance, sharing the same hypothesised curvilinear relationships. Therefore, in lieu of an appropriate measure of innovation with the construction context, a relationship between organisational slack and firm performance (as a measure of innovation outcomes) was tested as. However, there is no consensus on how firm performance might be defined or measured (Richard et al. 2009). Researches use a wide variety of different measures, often without justification (Rosenbusch et al. 2011).

Selection of Firm level Performance measures

As with innovation, it is vital to debate the selection of appropriate measures for firm level performance. Specific measures of performance are established in order to test the slack-performance relationship, and establish slack as a determinant of performance,
and consequently the underlying innovation within construction firms. However as noted by (Richard et al. 2009) there is no consensus on how firm performance might be defined or measured, with performance management being a integral part of management (Bassioni et al. 2004) is one that is rarely defined (Neely et al. 2005).

Performance measurement, and its improvement, has significant interest among researchers and practitioners (Bassioni et al. 2004; Chenhall & Langfield-Smith 2007; Deng et al. 2012). As discussed in Ahmad-Latifﬁ (2012) there are vast array of definitions of performance measurement. This thesis defines performance measurement as “A process of quantifying the efficiency and effectiveness of past actions” (Neely et al. 2005). As such the selected measures of performance must represent either the efficiency (how economic the firm functions), or the effectiveness (the extent to which requirements are met) of the firms actions. This section debates the various means of performance measurement, and performance measurement systems (PMS) available to researchers and practitioners. In the following discussion of performance, it must be remembered that performance is only one type of effectiveness indicator, having both advantages and disadvantages in its measurement (Richard et al. 2009). Within this thesis, it is maintained that single measures or even broader PMS can only capture a small part of the complexity that is the performance of the firm in relation to the market.

Despite the prominence organisational performance within many areas (including economics, finance, accounting and strategic management) (Richard et al. 2009), as stated above there is no agreement on how to measure firm performance, and there remains a wide variety of measures of performance from which to choose from. Richard et al. (2009) identified 207 different measures of performance over 213 academic papers that used performance as a variable. Similarly construction researchers Bassioni et al. (2004), Robinson et al. (2005) and Deng et al. (2012) also identify a number of different performance measures. Selected measures of performance must be chosen based on what firms want to achieve (Ahmad-Latifﬁ 2012).

A popular means of measuring performance is the Balanced Scorecard (BSC), which is a performance measurement tool that incorporates multiple financial and non-financial measures of performance (Kaplan & Norton 1992). Construction researchers Bassioni et al. (2004) recognise the BSC as one of the most important management tools of the last 75 years. The ability to measure internal performance (i.e. project performance; a
serious concern for the project-based construction industry (Deng et al. 2012) and its improvement has a decisive impact on the business performance of a firm (Bassioni et al. 2005). Specifically within the construction industry, non-financial measures are gaining prominence (Robinson et al. 2005). The BSC adopt multiple measures which are used to prevent an over reliance on a single source of information. The measures that are chosen within the BSC must relate to certain perspectives namely; financial performance, customer performance, internal business processes, and learning and growth. This allows for customisation based on the actives of the individual firm in question.

Other systems of performance measurement and managed exist alternatives to the BSC, within construction and the wider economy. For example the EFQM Excellence Model (Beatham 2003). The EFQM Excellence model is PMS that is a non-prescriptive framework, it was designed to allow companies to assess their abilities and recognise limitations and provide solutions. Ultimately allowing firms to assess where they are on ‘the path to excellence’ (Beatham et al. 2004). This PMS model is used as a tool by firm to aid the definition and assessment of continual organisational improvement. The EFQM excellence model like the BSC above is a tool for self-assessment, which enables a systematic and frequent review of organisational activities and results against the model criteria (Beatham et al. 2004).

It is argued that in light of the above, that BSC, EFQM Excellence model or other PMS are highly useful for practitioners as a means of gauging continual improvement within the firm, however, is unsuitable for use within this research as a proxy measure of innovation outcomes. Firstly, due to the variability of measures that might be selected by firms for the BSC, meaningful cross firm or cross-industry comparisons cannot be made. Whilst the customisation of measures is essential for the individual firm, doing so prevents comparative analysis as each collection of measures are tailored to the specific needs and activities of the firm in question. Within construction, evidence shows that different performance measures are emphasised by contractors than by consultants when considering metrics for customer satisfaction, their product/services and their impact on society for example (Robinson et al. 2005). Secondly, the use of multiple measures of performance would add further convolution, rather than simplification, to the proposed relationships and further detach itself from the intended purpose of representing innovation, and its impact within the firm. Thirdly, these PMS are tools for
individual self-assessment and the critique of individual idiosyncratic activities, as a means to enable re-assessment and improvement. Finally, and most importantly, PMS are recognised as a means to for firms to maximise profits. Whilst financial and non-financial criteria are included within most PMS, the purpose of PMS is to improve business practice and ultimately enable firms maximise and sustain profits (Ahmad-Latiffi 2012).

In order to establish a suitable measure of firm performance, which related to innovation outcomes, it is argued that this thesis must look to established slack research, and a definition of performance. The definition of innovation adopted in Section 2.5 relates to ‘improve overall performance’; it is essential then to briefly define performance for this thesis. Even more so than innovation, performance is defined variably in management research studies (Richard et al. 2009). Performance is considered here to relate to the ability of a unit of analysis to conduct an activity relative to a measurable metric. This study defines performance as “the ability of the firm to extract returns through interaction with the market.” The construction firm is the unit of analysis and it performs activities to generate (predominately-financial) returns from the market place. Returning to the definition of performance measurement, which is to measure the efficiency and effectiveness of the firm’s actions, measures can be forwarded which relate to the efficiency and effectiveness of the firm to extract returns to the firm. The following section forward specific measures of performance to act as measures of innovation outcomes, to enable slack-innovation relationship to be tested.

Due to the variable nature of the performance as a construct, slack researchers often adopt a number of financial measures of firm level performance (see Wefald et al. 2010, Chiu & Liaw 2009), offering a broader level of analysis. For this thesis, the research elects to use financial metrics Return on Assets (ROA) and Profits to measure firm performance. The use of ROA, relates the efficiency of the firm to utilise its assets, while Profits relates to the effectiveness of the firm within the market place. Two measures were used to provide a broader spectrum of analysis, and additional testing of the relationship between organisational slack and firm performance within construction firms.
Return on Assets (ROA)

The first adopted measure of firm performance was Return on Assets (ROA), which represents the ability of the firm to convert existing resources in the firm into financial returns (Richard et al. 2009). ROA is considered to be one of the more widely used financial measures, which determines the firm’s ability to unitise its assets (Tangen 2003). Within slack literature, Geiger & Makri (2006) reason that this measure reflects the efficiency of the firm in utilising its assets. Expressed as a percentage (%), ROA measures the profits generated by the firm in relation to the total assets of the firm. A higher ROA value indicates greater returns to the firm in relation to a set number of assets held by the firm. Therefore firms with greater ROA are capable of utilising firm resources in the most effective manner to provide returns to the firm. As such the measurement of ROA captures the concept of performance generation within RBV of the firm, where combinations of resources are utilised to provide super ordinary returns to the firm.

ROA has been a frequently used measure of firm performance within slack research, for example Tan (2003), Chiu & Liaw (2009), Lee (2011) and Chen & Miller (2007).

Pre-tax Profits (£)

The second adopted measure of performance was ‘Pre-tax profits’, also referred to as earnings before interest and tax (EBIT). Several variations of measures of profits are noted by Richards as being a popular measure of performance, with Tan & Peng (2003) arguing that it is the most important measure of performance that managers can focus upon. Lööf & Heshmati (2006) were also able to demonstrate that the level of profit for firms was closely associated within the level of innovation for firms.

As explained by Tan & Peng (2003) pre-tax profits was selected over straight forward profits, as firms in different which engage with different activities will also be taxed differently. The construction sector as defined for this study incorporates a number of firms, and extends beyond the classical industry definition with O.N.S (2007), to include firms who provide products and services related to construction (BIS 2013). As such they are likely to experience different tax requirements for different firms, thus pre-tax profits are used to lessen this discrepancy. Pre-tax profits, has been used with both Tan & Peng (2003) and more recently in Bradley, Shepherd, et al. (2011) for the same reasons.
Debating financial measures of Performance

Financial measures of firm performance are seen to be the most common and readily available means of measuring organisational performance (Richard et al. 2009), and are traditionally determine the success of a firm (Tangen 2003). Both measures above are common measures of performance within slack literature (Herold et al. 2006; Luan et al. 2013) and broader management literature (Richard et al. 2009). The use of financial measures to represent innovation outcomes has precedence within slack research. (Oerlemans & Pretorius 2008) use sales as an external component measure of the effects of innovation of the firm.

These measures however, are limited in that they rely upon historic activity over future performance, and do not accurately reflect the interests of stakeholders (Kaplan and Norton, 1996; Love and Holt 2000). Accounting measures are also susceptible to the regulatory and institutional environment, which can prevent the comparison of firms through certain economic measures of performance. Accounting measures, whilst useful, fail to quantify a number of improvements that have no direct monetary value (Tangen 2003), such as customer satisfaction, or social responsibility (Richard et al. 2009). For construction firms, financial measures can be misleading representations of firm performance. Due to single projects often representing a significant promotion of a year’s income, depending upon the cash flow of said project, this can lead to either an over or under estimation of firm performance (Hillebrandt 1985). Whilst it is agreed that financial measures of performance alone are no longer sufficient for practitioners to understand firm performance in a dynamic environment such as construction (Ahmad-Latifff 2012). Their use remains prominent within both slack and boarder management literature as a means of differentiating the market performance of firms when conducting research, therefore their use is maintained within this thesis. Thus, Pre-tax Profits and ROA were maintained as viable measures of innovation outcomes and firm level performance.

Control variables

In addition to independent and dependent variables, it is necessary to clearly establish control variables. These variables are considered to influence other variables, or mediate the relationship between other variables (Creswell 1998). The following discusses the control variables to be included within the statistical models that are considered to explain to a certain degree the variance in the dependent variable and also the
independent variables. These are the size of the firm, age of the firm and type of firm, each of which is seen to be used within management and slack literature as partial explanations for the difference in firm performance. These variables are incorporated to attempt to isolate the slack and innovation outcome relationship from other factors or variation, to allow a connection to be made. As demonstrated by Capon et al. (1990) there are a very large number of variables which might determine firm performance, whilst a model cannot incorporate every variable, it must consider the most prevalent which has been done here, following prior slack research.

**Size**

According to Mishina et al. (2004) larger firms have more resources and more developed market positions than smaller firms. By controlling for firm size in the regression models the variability in performance explained by size can be eliminated. Likewise, using the Pearson correlation analysis outlined in the analytical strategy (see Section 5.10.7) it was possible to see how size is correlated against differing slack variables.

It is suggested by Singh (1986) that there are three common measures of firm size 1) total sales or turnover 2) net assets and 3) number of employees. In order to control for the size of the firm within the statistical analysis, two measures were adopted, both Net assets and number of employees. This was done as each provides a different interpretation of firm size, but it was unclear if these factors determined firm performance or how they interacted with organisational slack.

**Firm Age**

Along with the size and type of the firm, traditionally within slack research the age of the firm is also controlled for. As firms become more experienced they are afforded more opportunities to develop and amass higher levels of slack not seen within younger firms (Mishina et al. 2004). Older firms typically have greater access to resources which allow them to pursue different strategies (Bradley, Wiklund, et al. 2011). Incorporating age as a control variable removed the variability in performance explained by the age of the firm and allows focus upon the impact of slack variables.

Age was calculated by taking the year from ‘date of incorporation’ away from the year at which independent variables are measured. This was done to give an integer number of years the firm has operated within its market.
Firm Type

As noted by Groák (1994) firms differ in the resource bases from which they draw from to perform their activities. Slack literature has argued (Daniel et al. 2004), and demonstrated (Wefald et al. 2010), that the nature of an industry has an impact on the firm and its relationship with slack. As a result, the difference between firm types must be considered as it might impact the relationship between slack and performance. Firms of different types might require comparatively higher or lower base levels of resources, which might be mistaken for excess or a lack of slack. Moreover different firm types might typically exhibit comparatively higher or lower performance according to the measures that are a result of the firm type and not its capabilities to produce innovations or function within its market.

In order to control for this possible variability in the resource dependency, firm type was controlled by classifying firms based on the type of activities they conduct and coding them accordingly. The definition of the construction sector adopted within this research follows a broader conceptualisation following BIS (2013) which expands the conventional construction industry classification (O.N.S 2007) to incorporate firms which produce construction products and provide construction related services. BIS (2013) distinguished between three types of construction firms 1) Contracting, 2) Service and 3) Product firms. From these firm types, ‘Contracting’ was split further in relation to its two-digit SIC code to provide 3 sub-classifications of 1) Construction, 2) Civil engineering and 3) Specialist. Firms were labelled with these five classifications then numerically coded accordingly a number from one to five.

These codes however, cannot be included within a multiple regression as their value is an arbitrary nominal classification as opposed to a scale of meaningful value (Field 2005). These codes were transformed into a number of dummy variables to represent the firm types. Transforming these codes into a number of dummy variables allowed the researcher to incorporate firm types into the statistical analysis as ordinal variables (Field 2005). Dummy variables generate ordinal data from categorical data, by coding firms at either 0 or 1 for a number of dummy variables. In this instance Contracting firms are used a reference for other firm types and hence coded 0 for all dummy variables. It is necessary to have one less dummy variable than number of categories in order to prevent collinearity (Gujarati 2012).
The use of dummy variables is a common practice in slack research which uses a sample of firms across a variety of industries and subsectors (Love & Nohria 2005; Bradley, Wiklund, et al. 2011; Mishina et al. 2004; Chiu & Liaw 2009). The five firm classifications were then recoded into four dummy variables for use within the statistical analysis with contracting firms being used as a baseline. Table 11 below illustrates the dummy variable classifications in relation to the BIS (2013) and SIC codes (O.N.S 2007) used to define the construction sector.

<table>
<thead>
<tr>
<th>Firm Type/Classification</th>
<th>BIS classification</th>
<th>SIC code</th>
<th>Dummy 1</th>
<th>Dummy 2</th>
<th>Dummy 3</th>
<th>Dummy 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contracting</td>
<td>1</td>
<td>41</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>1</td>
<td>42</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Specialist</td>
<td>1</td>
<td>43</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Service</td>
<td>2</td>
<td>Varies</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Product</td>
<td>3</td>
<td>Varies</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

It is a common practice within organisational slack research to control for the types of firms under study, especially when the sample under study covers a broad range of sectors (Bradley, Wiklund, et al. 2011; Chiu & Liaw 2009; Love & Nohria 2005). While in this case the research focuses solely upon the construction sector, it remains important to control for different firm types. This allowed the author to eliminate the mediating impact of the nature of the firm, but also examine the differences between firms by separating the analysis based on firm type.

**Time lag**

A Time lag between dependent and independent variables is a common component included within slack research in order to ensure the validity of the hypothesised relationship. As recognised within Bourgeois (1981) slack-performance represents a cyclical relationship, where greater performance leads to greater amounts of slack in the firm, and vice versa. Moreover Mishina et al. (2004) argue that the current amount of slack does not impact current innovation or performance, as slack resources require time to be redeployed. Therefore, the performance of the firm at time “t” is argued to be dependent upon the level of slack at time “t-n”.

Accordingly a time lag was implemented to dictate the direction of the relationship, ensuring that superior performance is determined by changes in slack, as opposed to the
other way around. In this instance the data required for the independent variables was taken at two different time frames. This allows the researcher to examine how elongating the time difference between slack and performance impact the relationship. For this research design data for the performance variables were taken at time $t$ (2012), and the independent variables at both time $t-1$ (2011) and $t-2$ (2010). A greater time difference between variables was not incorporated as extending the relationship further might limit the validity of findings, as other factors might start to exert greater influence on firm performance (Richard et al. 2009)

Summary

The above provides a detailed description of the variables and their measures adopted for this research design. Each variable was chosen for a specific purpose, be it measuring performance or determining the level of organisational slack within the firm. The adopted independent variables (slack variables) were measured and corrected by industry averages to provide the final slack variables, and then squared to produce non-linear terms. These variables were also lagged at $t-1$ and $t-2$ against performance measures to ensure the direction of the relationship between variables. Firm types were classified numerically, and then transformed to provide dummy variables that allow statistical analysis to occur. A summary of the adopted variables and their measures can be found below in Table 12. This information is later used to inform the selection of the data sample from the F.A.M.E. database.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Required</th>
<th>Variable Type</th>
<th>Year (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance 1</td>
<td>ROA</td>
<td>Continuous</td>
<td>2012</td>
</tr>
<tr>
<td>Performance 2</td>
<td>Profits before tax</td>
<td>Continuous</td>
<td>2012</td>
</tr>
<tr>
<td>Size</td>
<td>Net Assets</td>
<td>Continuous</td>
<td>2011 &amp; 2010</td>
</tr>
<tr>
<td>No of employees</td>
<td>Number of employees</td>
<td>Discrete</td>
<td>2011 &amp; 2010</td>
</tr>
<tr>
<td>Age</td>
<td>2012-Year of incorporation</td>
<td>Discrete</td>
<td>2011 &amp; 2010</td>
</tr>
<tr>
<td>Dummy 1</td>
<td>Civil v Sample</td>
<td>Nominal</td>
<td>-</td>
</tr>
<tr>
<td>Dummy 2</td>
<td>Specialist vs Sample</td>
<td>Nominal</td>
<td>-</td>
</tr>
<tr>
<td>Dummy 3</td>
<td>Services vs Sample</td>
<td>Nominal</td>
<td>-</td>
</tr>
<tr>
<td>Dummy 4</td>
<td>Products vs Sample</td>
<td>Nominal</td>
<td>-</td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>(SG&amp;A/Turnover) - Average</td>
<td>Continuous</td>
<td>2011 &amp; 2010</td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>Liquidity Ratio - Average</td>
<td>Continuous</td>
<td>2011 &amp; 2010</td>
</tr>
<tr>
<td>HR Slack</td>
<td>(No of Employees/Turnover) – Average</td>
<td>Continuous</td>
<td>2011 &amp; 2010</td>
</tr>
<tr>
<td>Financial Slack</td>
<td>(Cash Reserves/Turnover) – Average</td>
<td>Continuous</td>
<td>2011 &amp; 2010</td>
</tr>
</tbody>
</table>
Methodology and Research Design

Absorbed Slack$^2$ \( (\text{Absorbed Slack}+1+\text{minimum})^2 - \text{Ave} \) Continuous 2011 & 2010
Unabsorbed Slack$^2$ \( (\text{Unabs. Slack}+1+\text{minimum})^2 - \text{Ave} \) Continuous 2011 & 2010
HR Slack$^2$ \( (\text{HR Slack}+1+\text{minimum})^2 - \text{Ave} \) Continuous 2011 & 2010
Financial Slack$^2$ \( (\text{Financial Slack}+1+\text{minimum})^2 - \text{Ave} \) Continuous 2011 & 2010

5.10.4 Cross industry comparison

The above has detailed the research design employed to examine the relationship between organisational slack and firm level performance within the previously unexplored construction context, following an archival, cross sectional, econometric analysis of the firm (Koop 2005). Whilst steps were taken to ensure the validity of this model within a novel context, such as the selection of measures to represent slack variables, and the control of firm types and possible resource heterogeneity, alone results these results cannot be generalised. It would be unclear if the obtained results were unique to the construction context, or the result of the research design model itself.

Were the results to suggest that slack does not function within the construction industry, or functions differently to that demonstrated in prior research, how might this be supported as being the result of the population under investigation rather than possible errors in the research design? In order to support the analysis of the construction context, it is suggested that a comparison be made between it and another population sample following the same analysis. It is suggested that a comparison be made between construction and the more thoroughly explored manufacturing context.

In order to provide a basis for comparison the research design detailed above, must be repeated in its entirety, following the same sequential steps detailed in Figure 22, but incorporating a manufacturing context as opposed to construction. A mixture of manufacturing firms types are selected to represent this context, these firm types are selected using SIC codes commonly found within slack research (Bradley, Wiklund, et al. 2011; Wefald et al. 2010; Geiger & Makri 2006). The use of a comparative analysis offers the researcher an opportunity to compare the firm level differences between construction and manufacturing contexts within the confines of this slack research, indicating levels of slack types within firms, and the strength and direction of relationships of different slack types.

The use of a cross industry comparison within the same study has not been done in existing slack research. Although Tan & Peng (2003) conduct two studies within their work this consists of two separate research designs within the same context. Although
there are limitations in comparing the statistical results of two different samples, by having them separate as opposed to combined within the same sample, this provided the author more opportunities for comparison and development of the models within each context. As construction is a previously unexplored context, it is unclear what extent the proposed models are valid within this context. The use of two contexts also offered the author a basis from which to compare the quality and validity of the models.

Firms were selected based upon some prior use within slack research to ensure their appropriateness for analysis. The population from which the sample was taken consisted of four broad groups 1) Manufacturing firms, 2) Electronics firms, 3) Chemical and pharmaceutical firms and 4) Wholesale and retail firms. The primary S.I.C codes (O.N.S 2007) used within these groups and the dummy variables they were converted into are detailed below in Table 13.

<table>
<thead>
<tr>
<th>Firm Type/Classification</th>
<th>SIC code(s)</th>
<th>CODE</th>
<th>Dummy 1</th>
<th>Dummy 2</th>
<th>Dummy 3</th>
<th>Dummy 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicle</td>
<td>28, 29, 30</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronics</td>
<td>26, 27</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chemicals and Pharmaceutical</td>
<td>20, 21</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wholesale and Retail</td>
<td>45</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Media</td>
<td>59</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Incorporating the same measures to represent slack variables and the same independent and control variables, the sample was again collected using F.A.M.E. to produce an initial data set. Following the collection of the sample, the same analytical procedures as the construction context were applied as detailed in Figure 22. This sample then followed the same analytical techniques as the sample from the construction context, and results and comparisons can be seen in Chapter 6 (Analysis) and Chapter 7 (Evaluation).

5.10.5 Statistical Analysis Design

5.10.5.1 Data selection

As stated previously, to collect the relevant data, the author accessed the F.A.M.E. (financial analysis made easy) database maintained by Bureau van Dijk. The F.A.M.E. database provides access to the annual financial reports of firms within the UK and Ireland. The data sample was taken dependent upon four key aspects; SIC classification
codes prescribed by BIS (2013), availability of data, and minimum firm size. Using, F.A.M.E. a selection strategy is produced which details the availability of data with each required step. Below Table 14 demonstrates a blank selection strategy for obtaining the relevant raw data for analysis from the F.A.M.E. database. This table in the analysis chapter demonstrates the reduction in the possible sample size at each step of the selection process, which filters the relevant data based upon the availability of the required data to measure all variables. This selection strategy is applied to both contexts which are analysed within this research, Construction and Manufacturing. For details regarding the firm included with each context see Appendix 1.

Table 14: Blank Data sample selection strategy

<table>
<thead>
<tr>
<th>Search Number</th>
<th>Search</th>
<th>Year</th>
<th>Step Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All Active Companies (Not In Receivership Nor Dormant) And Companies With Unknown Situation</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Firms With The Context Under Analysis</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Return On Total Assets (%)</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Profit (Loss) Before Taxation</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Liquidity Ratio</td>
<td>2011, 2010</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Total Reserves</td>
<td>2011, 2010</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Profit Margin (%)</td>
<td>2011, 2010</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Administration Expenses:</td>
<td>2011, 2010</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Number Of Employees: Min=25</td>
<td>2011, 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.10.5.2 Statistical Analysis

There exist multiple forms of statistical analysis available to the researcher, capable of providing a wide variety of information on the selected data. The following outlines the analytic strategy that was carried out on the final data sample following the research protocol in Figure 22 and provides information for the reader to aid interpretation of the results in the following chapter. The researcher chose to explore the data following slack research tradition and illustrate the descriptive statistics of the variables following a univariate analysis, the Pearson’s correlation coefficients following a bivariate analysis, and a number of statistics from the multiple regression analysis. These statistical techniques are detailed below.
Selecting a Statistical Technique

As detailed in the previous chapter, the selected research method deemed most appropriate for this research is archival analysis. Following a deductive research approach, and archival research method was chosen as the most appropriate means to answering the proposed research problem (Buckley et al. 1976). As seen previously in Section 3.8, a large proportion of slack research papers adopt an archival research method in order to examine the relationship between slack and the firm.

Within the research method of archival analysis there exist a wide variety of statistical techniques that may be adopted in order to answer potential research problems. Tabachnick & Fidell (2001:27-29) offer a guide to choosing among the numerous statistical techniques, in order for the researcher to select the most appropriate technique. Techniques are chosen according to the research question, dependent and independent variables. An excerpt of this decision tree is illustrated below in Table 16.

<table>
<thead>
<tr>
<th>Major Research Question</th>
<th>Number (kind) of Dependent Variables (DV)</th>
<th>Number (kind) of Independent Variables (IV)</th>
<th>Covariates</th>
<th>Analytic Strategy</th>
<th>Goal of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of relationship among variables</td>
<td>One (continuous)</td>
<td>One (continuous)</td>
<td>None</td>
<td>Bivariate r</td>
<td>Create a linear combination of IVs to optimally predict DV</td>
</tr>
<tr>
<td></td>
<td>Multiple (continuous)</td>
<td>Multiple (continuous)</td>
<td>Some</td>
<td>Multiple R</td>
<td>Maximally correlate a linear combination of DVs with a linear combination of IVs</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>Multiple (discrete)</td>
<td>Multiway frequency analysis</td>
<td>Multiway frequency analysis</td>
<td>Create a log-linear combination of IVs to optimally predict category frequencies</td>
</tr>
</tbody>
</table>

This research sought to understand the relationship between variables, namely the level of slack within the firm and its level of innovation (indicated via a proxy measure of performance). Next only a single dependent variable was considered; performance and multiple independent variables are considered to predict this dependent variable. Ultimately, this research adopted the multiple regressions as its statistical technique, which also follows the foundation of existing slack research.
The following details the design of an analytical research method, used for the measurement of slack and performance within the construction sector, based upon an existing foundation of slack research within alternative contexts.

Meeting Statistical Assumptions

Whilst statistical analysis through multiple regression analysis is common, its use requires assumptions to be met in order for the analysis to be robust. Field (2005) provides a number of assumptions that have to be met in order to perform a valid statistical analysis. Following the collection of initial sample of raw data, it was found that this sample did not meet these statistical assumptions required for analysis. The dependent variables were heavily kurtosis and skewed (see Appendix 3), and therefore had to be normalised. The research protocol in Figure 22 at the end of this chapter illustrates the process by which the raw data was made valid for statistical analysis and the slack and dummy were variables generated for the regression analysis. The initial sample was reduced in order to eliminate outlier cases that distorted the distribution of the performance variables, and cases from the control and slack variable which might distort the result of the statistical analysis and or render the result invalid. A detailed description of the statistics generated from the research protocol can be found in Appendix 3, along with explanations of the manual operation used. Although the process of removing outliers significantly reduced the sample size, this process was necessary to provide a sample for a valid statistical analysis (Field 2005).

5.10.6 Data Sample and Selection Criteria

Following the Data generation and analysis protocol in Figure 22 and the data collection procedure detailed in Appendix 3, an initial sample of 4,299 cases were collected for analysis from the construction context. The selection procedure and the progressive filtering of search results by additional search criteria within the F.A.M.E. database (FAME 2014) are presented in Table 16.
Table 16: F.A.M.E. selection procedure for the construction context

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>Step result</th>
<th>Search result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All active companies (not in receivership nor dormant) and companies with unknown situation</td>
<td>3,137,208</td>
<td>3,137,208</td>
</tr>
<tr>
<td>2. Firm SIC codes included in Construction Context</td>
<td>666,050</td>
<td>281,283</td>
</tr>
<tr>
<td>3. Return on Total Assets (%): All companies with a known value, 2012</td>
<td>266,721</td>
<td>21,619</td>
</tr>
<tr>
<td>4. Profit (Loss) before Tax: All companies with a known value, 2012</td>
<td>275,602</td>
<td>21,619</td>
</tr>
<tr>
<td>5. Turnover: All companies with a known value, 2012, 2011, 2010, for all the selected periods</td>
<td>172,939</td>
<td>12,380</td>
</tr>
<tr>
<td>6. Administration Expenses: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>230,454</td>
<td>11,954</td>
</tr>
<tr>
<td>7. Liquidity ratio (x): All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,408,331</td>
<td>11,693</td>
</tr>
<tr>
<td>8. Total Reserves: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,547,479</td>
<td>11,617</td>
</tr>
<tr>
<td>9. Number of Employees: 2011, 2010, min=10, for all the selected periods</td>
<td>59,666</td>
<td>4,299</td>
</tr>
<tr>
<td>10. Net assets: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,893,216</td>
<td>4,299</td>
</tr>
<tr>
<td>11. Turnover per employee (unit): All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>87,021</td>
<td>4,299</td>
</tr>
<tr>
<td>12. Incorporation date prior to 30/12/2012</td>
<td>8,148,228</td>
<td>4,299</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4,299</strong></td>
<td></td>
</tr>
</tbody>
</table>

The initial sample of 4,299 firms failed to meet the normality assumptions necessary for regression analysis of the raw sample. Thus, their collected state was unsuitable for analysis. Data processing was conducted in accordance with the analysis protocol in Figure 22 and is presented in Appendix 3. Following the removal of outlier values, a final sample of 3,407 firms was produced. This final dataset was then analysed to characterise construction firms as detailed in Chapter 6; following the analysis protocol steps 15, 16 and 17. Justification for the data sources and the population from which the sample was drawn can be found within Section 5.10.2 above.

5.10.7 Analytic Techniques application

5.10.7.1 Univariate Analysis

Univariate analysis examines variables individually to detail a range of properties of the variable in relation to a number of measures (Walliman 2006). The above statistics allow the research to understand the variance and distribution of the individual variables. The skew statistic indicates the symmetry of the frequency distribution of the variable; a positive value indicates clustering to the left of normal, while a negative value indicates clustering to the right of normal (Tabachnick & Fidell 2001). Kurtosis is
another statistic concerned with distribution, and indicates the extent to which the data is more peaked or flat compared to normal; peaked distributions have values greater than 0, while flattened distributions have values less than 0 (Field 2005).

5.10.7.2 Bivariate Analysis
A Pearson’s $r$ correlation coefficient test allows for multiple variables to be sequentially accessed against one another, in order to test the linear association of two variables in a sample (Kleinbaum et al. 2008). The resulting value measures the correlation between two variables, $X$ and $Y$, providing a coefficient ‘$r$’. The values are constrained between 0 (no correlation) and 1 (perfect correlation). Values can also be given a negative value to indicate a negative relationship (Field 2005). This analysis was used to extract the direction and degree of association between two variables, allowing the research to assess the extent to which individual slack variable are associated, and how related different performance variables are. According to Field (2005), Cohen (1992) provides suggestions on what values indicate a strong or a weak correlation:

- $r \geq .10$ : Small effect
- $r \geq .30$ : Medium effect
- $r \geq .50$ : Large effect

The use of a Pearson’s correlation analysis is used extensively within prior slack research as a means of revealing relationships between variables (see Chiu & Liaw 2009; Chen & Huang 2010; Tan 2003; Liu et al. 2012).

Although insightful to direct relationships, this test is somewhat limited as it does not indicate how multiple variables such as both unabsorbed and absorbed slack correlate with ROA, thus further analysis was required examining the effect of multiple variables. Furthermore, although the correlation coefficient $r$ can be considered how much one variable impacts the other, a research must be careful as correlation of two variables does not necessarily indicate causation (Field 2005). Finally Musil et al. (1998) warns that during correlation analysis the distinction is not made between predictor and outcome variables, thus the research must be cautious if drawing conclusions solely from correlation results.
5.10.7.3 Multiple Regression analysis

Unlike the analytical techniques above, Multiple regression analysis allows the researcher to assess the extent to which values of a single dependent variable might be predicted by a set of independent variables (Tabachnick & Fidell 2001). The bivariate analysis only functions for two variables, and its therefore limited in explaining complex problems such as the impact of slack. In order to estimate the variability of firm performance a number of models are presented with varying combinations of variables, in order to find the model that can best estimate the variability of performance. This follows slack research tradition which conventionally examines a number of models in order to determine not only the best model, but how variables interact and their effect on the outcome variable. Examples of progressive model building such as that used in this thesis can be seen in (Bradley, Shepherd, et al. 2011; Lin et al. 2009; Chiu & Liaw 2009; Love & Nohria 2005). Multiple regression analysis was selected over similar analysis techniques by following Tabachnick & Fidell (2001:27)’s decision tree of statistical techniques seen earlier in Table 15.

Multiple regression analysis uses the provided data to resolve the model equation providing regression coefficients of standardised beta values for the model in Equation 5 below. The $\beta_n$ values represent the standardised coefficients provided for each variable in the model, and dictate the strength and direction of this variables relationship with the outcome variable $Y$. The multiple regression models with explanatory variables are written as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_n X_n$$

Equation 5: Multiple regression equation (continuous variables)

The following details the design of the multiple regression analysis that will be used to test the hypotheses, and determine the relationship between the level of slack in the firm and firm level performance in both the construction and manufacturing contexts.

Regression method

A forced entry (Field 2005) or standard (Tabachnick & Fidell 2001) method of regression analysis is selected for this research, where in by all predictors are forced into the model simultaneously (Field 2005). Although theoretical development might allow the use of a hierarchical method (selecting the order in which variables are input
(Field 2005)) was considered, this was rejected due to the uncertainty of how variables interact within this unexplored environment. A more traditional forced entry method was selected, wherein all variables within the model were analysed simultaneously.

Model Design

In order obtain sufficient information to test the proposed hypotheses a number of models are proposed. It is common within slack research to investigate differing model designs, which incorporate different combinations of variables. This might be the sequential application of linear then squared terms (Lin et al. 2009; Bradley, Shepherd, et al. 2011), or the inclusion of slack variables as moderating variable (Chiu & Liaw 2009; Wu et al. 2011). Typically, more advanced models are examined, progressively incorporating more variables, to a point where all variables are included in a final model, to indicate the extent to which the entire sample data explains a phenomenon.

Within this research a number of control and four distinct slack variables have been proposed, as such a number of models are required to test how these differing slack variable function individually and paired with their counterparts. An example table of the models and the variables included in each is illustrated below in Table 17. These models are examined against both performance variable ROA and pre-tax Profits, at both a one year and two year time lag. The designed models in Table 17 incorporate different combinations of slack resources to reveal how these combinations affect firm performance, and reveal which hypothesis is supported. In the latter models non-linear terms for each slack variable are included to test for curvilinear relationships, and to support the either hypothesis 1 or 2. Ruddock (2008) argues that when testing relationships between variables the researcher must demonstrate the relationship in its concrete form i.e. the algebraic representation of the multiple regression equation. The following describes the purpose of the multiple regression models, and illustrates the algebraic equation associated with this model:

**MODEL 1** – Control model, tests the amount of variance explained by only the control variables. Doing so provides a baseline from which latter models might be compared, removing the variation that might be the result of the dummy firm type variables and control variables, and not the proposed slack variables.

\[
\text{Performance} = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 \text{Age} + \beta_6 \text{Size} + \beta_7 \text{No Employees} + \epsilon
\]

Equation 6: Regression model equation for dummy and control variables (Model 1)
MODELS 2-5 – These models incorporated each slack variable individually in isolation. This was used to reveal the impact of each individual slack variable on the model in isolation and the relationship it shares with performance. Although only using linear variables, the $\beta_i$ values are vital from these models provide evidence for either hypothesis. Moreover their application in isolation reveals the extent to which individual slack variable explain performance variance.

$$\text{Performance} = \beta_0 + \text{Control Variables} + \beta_i(\text{LINEAR SLACK VARIABLE}) + \epsilon$$

Equation 7: Regression model equation for single slack variable example (Models 2, 3, 4 and 5)

MODELS 6-8 – As seen within Stan et al. (2014) slack variables are traditionally examined in pairs. This research incorporated two constructs of slack; absorbed & unabsorbed, and human resources and financial (Stan et al. 2014). These constructs were chosen because other constructs were rejected (see Section 0). Models 6 and 7 examine the extent to which these pairs of linear variables can predict firm performance). Model 8 incorporates all four linear variables to provide an indication of the overlap between variables (see Figure 7). By comparing chances between these three models, the author can infer the extent to which HR slack and absorbed slack similarly predict firm performance.

$$\text{Performance} = \beta_0 + \text{Control Variables} + \beta_8(\text{Absorbed SLack}) + \beta_8(\text{Unabsorbed SLack}) + \epsilon$$

Equation 8: Regression model equation for multiple slack variables example (Model 6)

MODELS 9-11 – Models 9 and 10 were used to improve upon the models seen earlier by incorporating additional variables that are non-linear terms. It is these models that will be used to infer a curvilinear relationship between slack and firm level performance that relates to either H1 or H2. Model 11 as with model 8 incorporates all possible variables.

$$\text{Performance} = \beta_0 + \text{Control Variables} + \beta_8(\text{Absorbed SLack}) + \beta_9(\text{Unabsorbed SLack}) + \beta_0(\text{Absorbed SLack Squared}) + \beta_1(\text{Unabsorbed SLack Squared}) + \epsilon$$

Equation 9: Regression model equation for non-linear slack variables example (Model 9)

Below Table 17 illustrates the proposed models for regression analysis, indicating the variables included in each model, which relate to the regression equations above. As can be seen there are different pairings of slack variables within the models, and the control variables are maintained throughout the models, in accordance to the forced entry method (Field 2005).
Table 17: Example of multiple regression analysis results table

<table>
<thead>
<tr>
<th>Variables</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>M9</th>
<th>M10</th>
<th>M11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Specialist</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Products</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Services</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Age</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Size</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR Slack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>8</td>
<td>9</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Financial Slack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Multiple regression statistics for analysis

The following briefly details the purpose of the statistics focused upon by the researcher and how they might be interpreted by the reader.

**R^2** – also referred to as the coefficient of determination, is the amount of variance of the dependent variable explained by the model (Field 2005). The R^2 value, expressed as a percentage, indicates the amount of variation in the outcome variable that is accounted for by the model. As a consequence provides an indication to how well or poor the model is at explaining the variance in performance.

**Adjusted R^2** – This measure, unlike the above statistic is designed to decrease in value depending upon the number of terms included in the regression equation. The value can increase like the above when the model fits, but its value is penalised for the use of additional variables, especially those which do not add explanatory power to the model (Tabachnick & Fidell 2001).

**F-ratio** – Is a measure of how much the model has improved the prediction of the outcome compared to the level of inaccuracy of the model (Field 2005). A larger F-ratio indicates that the variables included in the model explain more variation than the
inaccuracy of model. The F-ratio statistics are to be assessed against minimum critical values derived from the f-distribution which can be found in (Field 2005:756).

**Durbin-Watson** – Tests for autocorrelation of residual errors within the model. Value of 2 is ideal, where values lower than two (positive correlation) inflates results, while results higher than 2 (negative correlation) results in a loss of power (Tabachnick & Fidell 2001). Field (2005) suggests that values should exist within a range 1 and 3.

**Variation Inflation Factor (VIF)** – Examines the level of multicollinearity within the model. If the average VIF is substantially greater than 1 then the regression may be biased (Field 2005). This test is common within in slack literature for example Tan & Peng (2003), Bradley, Wiklund, *et al.* (2011) and Lin *et al.* (2009). However, in the case where squared terms were used it was expected that this test will fail due to correlations between the linear and non-linear variables, therefore, will be ignore for those models. For the linear models, the VIF is tested against a maximum critical value, which assumes that one variable has a VIF of 10 and the remainder a VIF of 1, which is then averaged across the number of variable. This is seen in Equation 10.

\[
\text{Equation 10: Critical variation inflation factor value developed from Field (2005)}
\]

\[
\text{Critical VIF value} = (df - 1) + 10/df
\]

**Coefficient** – In isolation, these coefficients are used to interpret the relationship between the organisational slack variables and firm performance variables. For the subsequent analysis, the research reports Standardised Coefficient (\(\beta_i\)), as opposed to the unstandardized regression coefficients (B). The \(\beta_i\) value indicates the number of standard deviations that the outcome variable (performance) will change as a result on one standard deviation change in the predictor variable (for example age) (Field 2005). These are reported as opposed to the regression coefficients the values are easier to interpret and compare across variables, as they are not dependent upon the nits of measurement of the variable (Tabachnick & Fidell 2001). Due to the difference in the slack variables units, and the differences in their variability, beta values allow for a more accurate comparison then non-standardised b-values, thus allowing the research to reveal comparative importance or impact of predictor variables.
Although these values represent the slope of the regression line Field (2005:156) argues that it is more useful to think of them as representing “the change in the outcome associated with a unit change in the predictor”.

**Coefficient (non-linear)** – Although commonly considered to be restricted to linear relationships between variables, multiple regression can be used to analyse non-linear relationships by incorporating squared variables (Tabachnick & Fidell 2001), which has been done in this research design. For non-linear predictor variables (aka squared terms), the $\beta_i$ values cannot be interpreted in the same way due to the curvilinear relationship they represent. For these $\beta_i$ values a negative coefficient indicates an inverse u-shaped relationship (∩) and a positive coefficient a U-shaped relationship (∪) (Tan & Peng 2003).

**Significance** – Tests the null hypothesis that the coefficient is zero. If statistic is significant then we accept the hypothesis that the beta coefficient or “$b$” value is different from zero. The confidence intervals for this thesis that were recognised as statistically significant are: * p<0.05 = 5%, ** p < 0.01 = 1% and *** p< 0.001 = 0.1%

### 5.11 Study 2 Interview: Research Design

#### 5.11.1 Introduction

The following section details the research design generated for the semi-structured interviews used to further understand the slack-innovation relationship in construction. Semi-structured interviews were adopted for the inductive research strategy to allow the researcher to learn gather primary data, and to learn first-hand about people’s perspectives on the subject chosen as the project focus (Davies 2007).

Chapter 4 argued that there is a relationship between the level of organisational slack and innovation outcomes (as a measure of innovation), forwarding a hypotheses about this relationship being either inverse-U shaped or U-shaped (∩ or ∪). However, due to the lack of exploration of the construction context, it is unclear if the presence of slack has an impact on the firm, and how well these theories (that are developed outside construction) resonate within this unexplored context. In essence it is not clear if slack, innovation and innovation outcomes can be associated with one another. In addition to the critical analysis of the literature on the theoretical development of organisational slack, and the econometric research linking the level of slack to innovation outcomes,
this study uses semi-structured interviews as an approach to gain further information from the construction industry. The semi-structured interviews were selected as a style of interviewing for this research as they give form to the interviews whilst allowing probing (Bassioni et al., 2005; Fellows and Liu, 2008).

5.11.2 Sample and selection strategy

The interviews took place within a population of UK construction sector firms respondents represented key personnel in firm involved in innovative and strategic decision within their firm. A total of five interviews were conducted. Respondents represented different sections of the broader construction sector identified within Chapter 1. Each respondent represents a classification used within this research; Contracting, Civil Engineering, Specialist, Services and Product firms. The respondents were Product Development Managers, Construction Directors and Technical Directors within the sample firms.

Firms represented by respondents were selected from the sample used within Study 1, which adopted the SIC (2007) codes from BIS (2013) to represent the construction sector. Full specifications of the population from which the data sample was taken can be found within Appendix 1. A shortlist of firms was collected from the initial 4,299 sample (See Appendix 3), firms were selected at random to represent each firm type. This followed BIS (2013) which distinguished between three types of construction firms 1) Contracting, 2) Service and 3) Product firms. From these firm types, ‘Contracting’ was split further in relation to its two-digit SIC code to provide 3 sub-classifications of 1) Construction, 2) Civil engineering and 3) Specialist. The short list firms were contacted via email and telephone in order to obtain an interviewee to represent the firm. Once an respondent was confirmed, the search for interviewee ceased for that firm type.

Use of multiple firm types provided a cross-section of perspectives across construction, which allowed comparisons to be made between firms based upon their function. This could not be done if all firms were taken from the same construction type (i.e. civil engineering) as it would only represent a single part of what makes up the broader construction sector. However, it is recognised that the perspectives uncovered within this research method might be limited to the firms studied and firm specific, limiting its
generalisation. This however, is the case for any small sample size. The firms within the sample varied in size, turnover and profit offering the opportunity for varied response.

5.11.3 Qualitative data collection – Semi structured interview

In order to obtain observations from practitioners in construction on their views on the slack-innovation relationship, interviews were adopted as a research method. There are three predominant types of interview type; structured, semi-structured and unstructured (Fellows & Liu 2003). Structured interviews impose a definitive structure to the interview conducted, while unstructured interviews compose of open-ended and uncategorised narratives (McQueen & Knussen 2002). The research chose to adopt semi-structured interview technique, a hybrid of the aforementioned approaches. This approach comprises of set of interview questions developed to aid the direction of the interview, whilst also providing scope for the respondent to elaborate and raise questions and themes (Wilson 2010). This technique also allows for flexibility in the order and approach to asking questions, and is often a favoured technique in business research (Wilson 2010). The development of these questions was based upon the research questions and research problem stated previously. The interview questions were issued to respondents prior to the interview in order to allow them to think over the questions and prepare insightful responses. Butcher and Sheehan (2010) state that the purpose of this is to allow participants or respondents to gather their thoughts about the subject in advance of the interview. An example of the interview sheet can be found in Appendix 4. Furthermore, the semi-structured format of the interviews allows respondent to provide descriptive in-depth responses, whilst also providing a framework to aid the researcher in analysis of the interview transcript (McQueen & Knussen 2002). The questions used within the interviews comprised of a mixture of factual and opinion based questions (Fellows & Liu 2003). All participants received and responded to the same questions as follows:

☐ Preliminary: Respondents’ Background

This part was to prompt information on respondents’ background. The information requested concerned work experience, years at the firm, and role within the firm. This information was used to generally differentiate participants and understand their background.
Part 1: Innovation

The first section of questioning required respondents to consider the concept of ‘innovation’. The line of questioning first asked respondents to contemplate how they would define innovation, in order to ascertain if the definition of innovation in this thesis resonates with practitioners. Continuing on the subject of innovation this part asked about the firms engagement with innovation, its’ innovative accomplishments, the assumed purpose of innovation, and the determinants of innovation.

Part 2: Organisational Slack

The second line of questioning concerned the understanding and assessment of the firms level of organisational slack. This part was developed by adapting questionnaire questions from prior slack research (Nohria & Gulati 1996; Troilo et al. 2014). Respondents were asked to determine the impact of changes to their environment, and question the slack-innovation relationship.


The final section of questions sought to unearth the links between slack, innovation and firm performance (as a measure of innovation outcomes). The purpose of this part of the interview was to probe responses relating to the importance of firm performance and its measurement, while also investigating the association between innovation and performance directly.

5.11.4 Advantages and Disadvantages of interview research

Patton (2002) mentions that interviews are open-ended questions and probes, which yield in-depth responses about people’s experiences, perceptions, opinions, feelings and knowledge. The two-way communicative nature of semi-structured interviews allows for feedback, and the gathering of further information and data through probing (Fellows and Liu 2008). The purpose of the interview is to examine the participants’ world, their views, behaviours and characteristics, and a means to reveal the participants experiences.

As previously stated semi-structured interviews are selected for this research study. Structured interviews are limiting, as the interviewer has little scope for probing those
responses by asking supplementary questions to obtain more details and to pursue new and interesting aspects. In contrast the semi-structured interview process allows for some probing of topics associated with the discussion, and the collection of more information which might reveal important that could not be collected otherwise. There are a number of advantages to conducting interviews over other forms of research. The main advantages include:

1. Researcher can probe for clarification and elaboration in areas not possible in other research methods.
2. Researcher can build rapport and closeness with respondents, potentially revealing greater depth of information.
3. Interviewer can adjust questions to suit changes in context, and changes in direction.
4. Interviews also allow informants the freedom to express their views in their own terms in an informal environment.
5. Respondents remain anonymous, despite large information being gathered.
6. Data can be gathered using voice recorders or audiotapes, and a permanent record for others to use.

However, like all forms of research there are also limitations to its use, and consequences to its selection, where other methods might be more suitable. The following summarises the disadvantages in selecting interviews as a research method:

1. Interviews are Time consuming, involving a lengthy process of both conducting and transcribing recordings.
2. Limited number of participants due to time demands, and reduction of willing participants, thus limiting generalisation of responses for a population.
3. Challenge of proper sampling arises when individuals cannot be interviewed.
4. Lack of respondents’ haziness.
5. Researcher physical characteristics and social position may lead to bias in respondents’ answers.
6. Difficulty in cross comparison of studies due to unique contexts and environments of each participant.
5.11.5 Data Analysis and Coding

Unlike quantitative data, where there exists a number of set formulae or process to enable the analysis of data, for qualitative analysis there is typically not set format for analysis. Fellows and Liu (2008) state that the analysis of qualitative data can be difficult for the researcher, as the data must be handled systematically. Punch (2009) argues that there is no single system or methodological framework to carry out quantitative analysis, as the analysis itself is dependent upon the purpose of the research. The data collected is shaped by and collected in accordance with the research aims and purpose. Yin (2009) discusses a number of tools and techniques that can assist the research in the analysis of qualitative data, which in turn are influenced by the data.

Content analysis is the process of systematically reviewing, analysing and interpreting data from open-ended questions, observations and records from all types of human communication. This technique analyses data set by counting the number of times an activity occurs or a topic is mentioned (Fellows and Liu 2009). This technique however, is considered simplistic and biased. By simply discussing a topic in more detail the number of instances a phrase or topic is discussed can lead to distorted results.

Instead, this thesis adopts the method of interpretive coding to aid the analysis of the interview transcripts. Due to the semi structured, or conversational, nature of the collected data, many of the structured tools available to quantify arguments fall short in their interpretation. The codes used, as demonstrated in Appendix 5, represent tags or labels, which were placed against sections of conversations or data, which consist of phases words or chunks of the data (Punch 2009).

5.11.6 Construct Validity

During the research process, it is critical that the research data be valid when constructed, ensuring that the conclusions are illustrative of a suitably through methodological process. Table 18 below from Yin (2009) illustrates a number of tests, which can be used to validate research data.
Table 18: Methods used to construct validity - adapted from Yin (2009:41)

<table>
<thead>
<tr>
<th>Tests</th>
<th>Study Tactic</th>
<th>Phase of Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct Validity</td>
<td><strong>Use of multiple sources of evidence</strong></td>
<td>Data Collection</td>
</tr>
<tr>
<td></td>
<td>Establish chain of evidence (limited)</td>
<td>Data Collection</td>
</tr>
<tr>
<td></td>
<td>Have key informants review draft case study</td>
<td>Data Collection</td>
</tr>
<tr>
<td>Internal Validity</td>
<td>Do pattern Matching</td>
<td>Data Analysis</td>
</tr>
<tr>
<td></td>
<td>Do explanation building</td>
<td>Data Analysis</td>
</tr>
<tr>
<td></td>
<td>Address rival explanations</td>
<td>Data Analysis</td>
</tr>
<tr>
<td></td>
<td>Use logic models</td>
<td>Data Analysis</td>
</tr>
<tr>
<td>External Validity</td>
<td>Use theory in single-case studies</td>
<td>Research Design</td>
</tr>
<tr>
<td></td>
<td>Use replication logic in multiple case studies</td>
<td>Research Design</td>
</tr>
<tr>
<td>Reliability</td>
<td>Use study protocol</td>
<td>Data Collection</td>
</tr>
<tr>
<td></td>
<td>Develop Study database</td>
<td>Data Collection</td>
</tr>
</tbody>
</table>

The table above addresses some of the techniques that can be used to establish improved validity and the phase of research where this occurs. The object highlighted in bold are addressed within this research project. It is conceded by the researcher that a more meticulous and developed approach to the data collection, analysis and testing could possibly be produced for this research. However, due to time, resource and opportunity constraints this was not possible for this research project.

5.12 Chapter Summary

This chapter has identified the methodological considerations that underpin the research methods chosen within this project. A methodological tradition of cautious-realist and an ontological positon of falsifications were concluded as being the most representative of this work. These traditions were discussed in the approach to selecting an appropriate research method. The study incorporates two studies, one in the form of a deductive approach the other taking an inductive approach. The above has provided a detailed research design for both Study 1 and Study 2 which were used to test and explore the relationship between the level of organisational slack and innovation outcomes in construction firms.

The measures and variables incorporated within this research design were built to provide a foundation of slack research within the construction context. Subsequently the research design drew heavily from previously established within prior research within...
other contexts in order to find suitable measures and variables for analysis. The research
design used within this research adopted multiple measures of performance in order to
access the differences between alternative performance measures and the theoretically
supported determinant slack. Multiple slack variables were also included, adopting only
absorbed and unabsorbed slack variables but also financial and human resources slack.
Conventional control variables of age, industry type, size and number of employees
were also detailed. This research design was used to test the relationship between firm
performance and slack. The results of this analysis are seen within the next chapter.
This chapter also provided a detailed description of Study 2, an interview based study,
which was used to explore the relationship between slack, innovation and innovation
outcomes in construction firms through the collection of primary data.
Figure 23: Data generation and analysis protocol
Chapter 6. Findings

6.1 Introduction

This chapter details the process by which the data for this research was collected and manipulated prior to presenting the results obtained from its analysis.

To implement the analytical techniques detailed in the previous chapter appropriate data for analysis was required. Following the collection of a sample using the specified selection criteria, this data was further manipulated to meet the statistical assumptions necessary for multiple regression analysis (Field 2005). The steps taken to ensure statistically valid data, including the removal of outlier values are detailed. The applied data preparation produced a final sample of 3,407 case firms for the construction context cases; the same preparations were repeated for the manufacturing context to provide a sample of 3,924 cases.

The data were analysed using univariate, bivariate and multivariate statistical analysis, the results of which are detailed in section 6.2 for construction and section 6.3 for manufacturing. All models met appropriate statistical validity standards. The ability of the models to predict the variability firm in performance was seen to vary across ROA and Profit as dependent variables, and the independent slack variables. Similarly, the significance and direction of coefficients were seen to vary across different slack variables and against different dependent variables. An evaluation of the data and a cross-context comparison are presented in the following chapter.

Due to the expansive amounts information generated by this analysis, the majority of the multiple regression data are presented in Appendix 4.

6.2 Analysis of Organisational Slack in the Construction Context

This section presents statistics describing the sample (STEP 15 of the analysis protocol), the Pearson correlation analysis between variables (STEP 16) and also the multiple regression analysis of the control and slack variables against the performance variables ROA and Profits (STEP 17). STEP 1-14 of the analysis protocol represent the preparations of the data sample, these steps are detailed in Appendix 3.
6.2.1 Descriptive Analysis

The processed dataset was void of outliers within the dependent variables and void of outlier cases within the independent variables. Following the analysis protocol, which itself follows existing slack analysis protocols such as those of Tan and Peng (2003), Mishina et al. (2004) and Love and Nohira (2006), a sequential set of analytical tests were performed on the data: first univariate (descriptive statistics), then bivariate (Pearson’s r), then multivariate (multiple regression). Table 19 provides the descriptive statistics of the sample variables at a one-year time lag, demonstrating the results of the univariate analysis. As in detailed in the research design, independent variables were lagged by one year to ensure the direction of relationships with the dependent variables. For the performance variable data collected at 2012, independent variable data was collected at one year (t-1 = 2011) and two year (t-2 =2010) time lags.

This analysis focused upon the minimum and maximum values to indicate the range of the variables within the study. Also obtained were the skewness and kurtosis to characterise the distributions, along with standard deviations. Even after the removal of outlier cases the independent variables had high kurtosis values, in particular financial slack, which indicates a highly peaked distribution. Table 19 also presents the distribution of firm types within the sample. Of note was that product firms (BIS 2013) make up almost 30% of the construction context sample, while construction firms (O.N.S 2007) make up less than 10%. As such, it could be argued that 45% of the sample comes outside the construction industry limiting the findings applications to the core construction context. However, it is contended that the sample is representative of the expanded construction sector definition frequently referred to throughout this research. The slack variables have a mean of zero, following the preparations of the data sample detailed in the Research design (see Section 5.10.3.2).
As stated previously within section 5.11.6, the analytic techniques and application, bivariate analysis considers the properties shared by two variables (Walliman 2006). It is through bivariate analysis that the direction and degree of association between two variables, termed correlation, can be extracted. Field (2005) provides suggestions on what values of Pearson’s $r$ indicate a strong or a weak correlation:

- $r \geq .10$ : Small effect
- $r \geq .30$ : Medium effect
- $r \geq .50$ : Large effect

These values were used to interpret the output values following the analysis. The use of Pearson’s correlation coefficient is consistent with organisational slack research, which traditionally examines the correlation coefficients between variables prior to a multivariate analysis (Stan et al. 2014). However, it must be noted that the correlation between variables does not, in itself, provide evidence of causation (Field 2005; Gujarati 2012).

<table>
<thead>
<tr>
<th>Continuous Variables</th>
<th>Description</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min, Max</th>
<th>Skew</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA</td>
<td>Return on Assets (%)</td>
<td>4.63</td>
<td>7.108</td>
<td>-18.36, 27.68</td>
<td>.268</td>
<td>1.162</td>
</tr>
<tr>
<td>Pre-tax profits</td>
<td>Profits prior to taxation (£000’s)</td>
<td>474.69</td>
<td>787.958</td>
<td>-2,226, 3,353</td>
<td>.932</td>
<td>2.101</td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>SG&amp;A ÷ turnover (%)</td>
<td>.000</td>
<td>.210</td>
<td>-.27, 2.40</td>
<td>3.013</td>
<td>13.224</td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>Liquidity ratio</td>
<td>.000</td>
<td>1.281</td>
<td>-1.53, 16.29</td>
<td>4.800</td>
<td>37.195</td>
</tr>
<tr>
<td>Human Resource Slack</td>
<td>No of Employees ÷ turnover</td>
<td>.000</td>
<td>5.492</td>
<td>-8.01, 60.89</td>
<td>3.199</td>
<td>19.448</td>
</tr>
<tr>
<td>Financial Slack</td>
<td>Cash resources</td>
<td>.000</td>
<td>.886</td>
<td>-7.01, 19.27</td>
<td>8.635</td>
<td>128.761</td>
</tr>
<tr>
<td>Age</td>
<td>Years since incorporation</td>
<td>27.93</td>
<td>20.419</td>
<td>2, 156</td>
<td>1.564</td>
<td>3.207</td>
</tr>
<tr>
<td>Size</td>
<td>Net Assets</td>
<td>5307.82</td>
<td>10176.08</td>
<td>-29,898, 147,694</td>
<td>5.696</td>
<td>48.833</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>Number of Employees</td>
<td>118.06</td>
<td>159.93</td>
<td>10, 2,270</td>
<td>5.503</td>
<td>45.941</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Categorical Variables</th>
<th>SIC Code</th>
<th>BIS Code</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Type - classifications</td>
<td>Construction</td>
<td>41</td>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Civil Engineering</td>
<td>42</td>
<td>1</td>
<td>943</td>
</tr>
<tr>
<td></td>
<td>Specialist</td>
<td>43</td>
<td>1</td>
<td>634</td>
</tr>
<tr>
<td></td>
<td>Services</td>
<td>Multiple</td>
<td>2</td>
<td>496</td>
</tr>
<tr>
<td></td>
<td>Products</td>
<td>Multiple</td>
<td>3</td>
<td>1034</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>3407</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Findings

The following analysis the results of the Pearson’s correlations, examining the relationship between dependent and independent variables including the non-linear independent variables. The results for Pearson’s $r$ can be found in Table 20 and Table 21 on page 196.

**Dependent variable relationship**

Table 20 demonstrates that there was a strong and significant relationship between the firm’s Return on Assets (ROA) and their Profits ($r = .615$, $p < 0.01$).

The correlation and its significance between these variables indicates that both measures are associated with one-another, which was to be expected as ROA is calculated using net income which is derived from pre-tax Profits in annual financial reports. Despite the strong relationship, it is argued these measures were not so strongly correlated that they indicate the same of firm level performance. Therefore both measures ROA and pre-tax Profits are maintained as individual dependent variables.

**Control variables**

The Age of the firm demonstrated a significant relationship with ROA, but a non-significant relationship with Profit. Age produced a negative but small relationship with ROA, indicating that older firms are less efficient than younger construction firms. However, the Age of the firm had no impact on firm Profits.

The Size of the firm (net assets) was seen to be significantly ($p < 0.01$) correlated against both ROA and Profits. Despite this correlation being negative in directions, and negligible against ROA at both t-1 ($r = -.087$) and t-2 ($r = -.100$), a stronger and positive relationship was seen between Size and Profits ($r = .244$ at t-1, and .211 at t-2). However, such values still represent a small effect on firm Profits. This suggests that Size (measured as firm assets) was a moderate predictor of Profits and a poor indicator of ROA.

Finally, like Size, the Number of Employees in the firm was significantly correlated with both ROA and Profits ($p < 0.01$). This variable was very weakly and negatively correlated with ROA ($r = .047$ at t-1), indicating that firms with more employees have slightly lower ROA. Conversely, Number of Employees was seen to have a small but positive effect on firm Profit ($r = .196$ at t-1).
Independent linear Variables

Absorbed Slack was negatively and significantly correlated against ROA and Profits at t-1, however the $r$ coefficient was very small ($r < 0.1$). Its effect was weaker than the association of either Size or Number of Employees against the performance variables. Unabsorbed Slack was weakly ($r = .062$) and significantly ($p < 0.001$) correlated against ROA ($p < 0.01$), but non-significantly correlated against Profits ($p > 0.05$), and ROA at t-2. Also Unabsorbed Slack was significantly correlated against all control variables.

HR slack was significantly correlated at $p < 0.01$ against Profits, demonstrating larger coefficients than seen for previous slack variables however the coefficients still has a small effect; -.128 at t-1 and -.112 at t-2. HR Slack was non-significantly correlated against firm ROA. Financial Slack, like HR Slack, was non-significantly correlated against ROA at t-1, but significantly correlated against Profits ($r = .048$, $p < 0.01$). However at t-2, Financial Slack becomes weakly correlated against ROA ($r = -.041$, $p < 0.05$). Across all the linear slack variables, their relationships with performance were generally weak ($r < 0.2$).

The Pearson’s correlation analysis also demonstrates that the selected slack variables are not strongly correlated against one another, the strongest correlation demonstrated was between unabsorbed slack and financial slack ($r = .359$, $p < 0.01$), which was expected. This indicated that the measures of slack incorporated within the research design capture distinct pools of resources within the firm, and were therefore suitable for use within analysis of the firm.
### Table 20: Pearson's correlation, construction at t-1

<table>
<thead>
<tr>
<th></th>
<th>ROA</th>
<th>Profit</th>
<th>Civil</th>
<th>Specialist</th>
<th>Services</th>
<th>Products</th>
<th>Age</th>
<th>Size</th>
<th>No. Emp.</th>
<th>Abs Slack</th>
<th>Unabs Slack</th>
<th>HR Slack</th>
<th>Fin Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td>.615**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil</td>
<td>.012</td>
<td>.019</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td>.076**</td>
<td>-.025</td>
<td>-.205**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>.004</td>
<td>.019</td>
<td>-.128**</td>
<td>-.272**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td>-.005</td>
<td>-.020</td>
<td>-.149**</td>
<td>-.316**</td>
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<td>-.084**</td>
<td>.196**</td>
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** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

---

### Table 21: Pearson's correlation, construction at t-2

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<th></th>
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<th>Profit</th>
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<th>Products</th>
<th>Age</th>
<th>Size</th>
<th>No. Emp.</th>
<th>Abs Slack</th>
<th>Unabs Slack</th>
<th>HR Slack</th>
<th>Fin Slack</th>
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<td>.000</td>
<td>.000</td>
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<td>.034**</td>
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<td></td>
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<tr>
<td>Unabsorbed Slack</td>
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<td>.000</td>
<td>.000</td>
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<td>.127**</td>
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<td>.134**</td>
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<td></td>
</tr>
<tr>
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<td>.000</td>
<td>.000</td>
<td>-.021</td>
<td>-.076**</td>
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<td></td>
</tr>
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<td>.429**</td>
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<td>.208**</td>
<td>.295**</td>
<td>.107**</td>
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<td></td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).
6.2.3 Multiple Regression Analysis

Following the developments above, a more sophisticated analysis was required to incorporate the relationships between multiple variables. Just as bivariate analysis looks at the relationship between two variables, multivariate analysis observes relationships between more than two variables (Walliman 2006). It is recognised that there are a number of factors that determine both innovation (Damanpour 1991; Subramanian & Nilakanta 1996) and firm performance (Capon et al. 1990). The use of multiple variables allows the researcher to control for the number of factors that affect innovation, and consequently firm performance to determine the relationship between slack and innovation outcomes. Within a bivariate analysis these cannot be controlled for, although some relationships in the bivariate analysis might be non-significant, it is vital to maintain the variable set throughout the analysis. Additionally, the multivariate analysis has the possibility to reveal significant relationships that might not be obscured in a bivariate analysis. The entire variable set is maintained in the multiple regression analysis as it is unknown what relationships exist prior to accounting for control variables. For this research there were not only multiple independent slack variables but also multiple dependent variables (ROA and Profits), control variables (Size, Age, Number of Employees) and two different time frames (minus one year (t-1) and minus two years (t-2)) to examine. A multivariate analysis was therefore implemented.

Table 23 and Table 24 below illustrate the results from the multiple regression analysis using ROA and pre-tax Profits (hereafter simply “Profits”) as a dependent variable at a time lag of one year (t-1). Due to the number of regression tables required for analysis, the results from the extended time lag (t-2) can be found in Appendix 4. The models within this analysis followed a forced entry (Field 2005) or standard entry (Tabachnick & Fidell 2001) method of regression analysis, wherein by all predictors are forced into the model simultaneously (Field 2005). The following analysis examines each of the dependent variables in isolation of one another before summarising the results. For each dependent variable, the models are examined for; their ability to predict the variability of the performance variable; the validity of the model; the strength and significance of the standardised beta ($\beta_i$) coefficients of the variables; and the impact of extending the time lag to two years on the results.
Findings

Understanding the model results

The following summarises the parameters of the analysis.

**R\(^2\)** – The coefficient of determination expresses the amount of variance of the dependent variable explained by the model (Field 2005). This statistic relates to the ‘goodness of fit’ of a model, and indicates the relationship between predicted values of the modelled dependent variable and the measured values of that same dependent variable.

**Adjusted R\(^2\)** – Similar to the above, this parameter’s value measures the ‘goodness of fit’ of a model, but its value is reduced relative to the inclusion of additional variables which add complexity to the model. This statistic is useful for comparing similar R\(^2\) results between different sized models.

**Durbin-Watson (d)** – Tests for the independence of residual errors in the regression model. Values of \(d\) can range from 0 to 4, with a score of 2 being ideal. Critical values of \(d\) are used to test null hypothesis of non-auto correlated errors (Field 2005). Field (2005) suggests that acceptable values of \(d\) lie within a lower boundary of one and an upper boundary of three. Higher values indicate negative correlation of errors, while lower values indicate positive correlation of errors. This research follows Gujarati (2012) to provide a more stringent critical values and a variable boundary according to the number of variables in each model (Table 22). Values above \(d_u\) indicate there is no evidence of correlation of residuals in the model, while values below \(d_l\) mean the null hypothesis of should be. This is the first test for statistical validity of the model and its results that was performed.

<table>
<thead>
<tr>
<th>Model 1</th>
<th>Models 2, 3, 4, 5</th>
<th>Models 6, 7</th>
<th>Models 8, 9, 10</th>
<th>Model 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Variables</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>(d_l) – lower boundary</td>
<td>1.603</td>
<td>1.592</td>
<td>1.582</td>
<td>1.561</td>
</tr>
<tr>
<td>(d_u) – upper boundary</td>
<td>1.746</td>
<td>1.757</td>
<td>1.768</td>
<td>1.791</td>
</tr>
</tbody>
</table>

**F-ratio** – Tests how much the model has improved the prediction outcome compared to the inaccuracy of the model, represented as value greater than 1. This ratio statistic is also assessed against minimum critical values determined by F-distribution tables (Field 2005). This was the second test for statistical validity of the model and its results that will be performed.
Variation Inflation Factor (VIF) – Tests for multicollinearity within the model. If the largest calculated VIF is greater than 10, then it is a cause for concern. Likewise, the average VIF (calculated across the scores for each independent variable) must not be significantly higher than 1. This was the final test for statistical validity of the model and its results that will be performed.

Standardised Coefficient ($\beta_i$) – Indicates the strength (value) and direction (positive or negative) of the relationship between a predictor and its dependent variable. The beta ($\beta_i$) value indicates the number of standard deviations that the dependent variable will change by as a result of a one standard deviation change in the predictor variable (Field 2005). Thus, by multiplying the beta ($\beta_i$) value by one standard deviation change in the dependent variable, the researcher can demonstrate the amount the variable will change.

Non-linear predictor variables (aka slack squared terms), are added to test for the possibility of a curvilinear relationship between slack and firm performance, and support a hypothesis. To test for this a second order (squared) beta ($\beta_i$) coefficient value is produced. For these beta ($\beta_i$) values a negative coefficient indicates an inverse U-shaped relationship (∩) and a positive coefficient a U-shaped relationship (∪).

Significance ($t$-statistic) - Tests the null hypothesis that the standardised beta coefficient is not zero. If a statistic is significant then it can be accepted that the hypothesis that the $\beta_i$ value is non-zero. Therefore, the researcher accepts that the predictor variable contributes to the ability to estimate values of the dependent variable. The confidence intervals for this thesis are as follows; $p < 0.05 = 5\%$, $p < 0.01 = 1\%$ and $p < 0.001 = 0.1\%$.
<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
<th>Model 8</th>
<th>Model 9</th>
<th>Model 10</th>
<th>Model 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Engineering</td>
<td>0.043 *</td>
<td>0.043 *</td>
<td>0.040 *</td>
<td>0.042 *</td>
<td>0.043 *</td>
<td>0.040 *</td>
<td>0.041 *</td>
<td>0.041 *</td>
<td>0.039</td>
<td>0.035</td>
<td>0.036</td>
</tr>
<tr>
<td>Specialist</td>
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<td>0.104 ***</td>
<td>0.103 ***</td>
<td>0.104 ***</td>
<td>0.100 ***</td>
<td>0.102 ***</td>
<td>0.101 ***</td>
<td>0.100 ***</td>
<td>0.092 ***</td>
<td>0.096 ***</td>
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</tr>
<tr>
<td>Products</td>
<td>0.055 **</td>
<td>0.055 **</td>
<td>0.054 **</td>
<td>0.055 **</td>
<td>0.055 **</td>
<td>0.054 **</td>
<td>0.055 **</td>
<td>0.054 **</td>
<td>0.055 **</td>
<td>0.049 *</td>
<td>0.053 **</td>
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<tr>
<td>Services</td>
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<td>0.052 **</td>
<td>0.051 **</td>
<td>0.052 **</td>
<td>0.051 **</td>
<td>0.051 **</td>
<td>0.051 **</td>
<td>0.051 **</td>
<td>0.046 *</td>
<td>0.049 *</td>
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<td>-0.089 ***</td>
<td>-0.091 ***</td>
<td>-0.091 ***</td>
<td>-0.091 ***</td>
<td>-0.094 ***</td>
<td>-0.091 ***</td>
<td>-0.095 ***</td>
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</tr>
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<td>Size</td>
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<td>-0.046 *</td>
<td>-0.064 **</td>
<td>-0.053 *</td>
<td>-0.047 *</td>
<td>-0.064 ***</td>
<td>-0.056 *</td>
<td>-0.059 **</td>
<td>-0.065 ***</td>
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<td>-0.079 ***</td>
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<td>0.024</td>
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<td>0.015</td>
<td>0.011</td>
<td>0.009</td>
<td>0.003</td>
<td>0.001</td>
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<td>Absorbed Slack</td>
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<td>-0.078 ***</td>
<td></td>
<td>-0.074 ***</td>
<td>-0.227 *</td>
<td>-0.219 *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>0.078 ***</td>
<td></td>
<td>0.089 ***</td>
<td></td>
<td>0.094 ***</td>
<td>0.283 ***</td>
<td>0.278 ***</td>
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</tr>
<tr>
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<td></td>
<td>-0.025</td>
<td></td>
<td>-0.008</td>
<td>-0.056</td>
<td>-0.033</td>
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<td></td>
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</tr>
<tr>
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<td>-0.015</td>
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<td>0.071</td>
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</tr>
</tbody>
</table>

Absorbed Slack$^2$ 0.157 0.153
Unabsorbed Slack$^2$ -0.213 ***-0.209 ***
HR Slack$^2$ 0.029 0.023
Financial Slack$^2$ -0.151 *-0.063

| Number of Observations | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 |
| Degrees of Freedom    | 7    | 8    | 8    | 8    | 9    | 9    | 11   | 11   | 11   | 11   | 15   |
| R$^2$                 | 2.26% | 2.70% | 2.80% | 2.30% | 2.26% | 3.40% | 2.31% | 3.50% | 4.26% | 2.47% | 4.31% |
| Adjusted R$^2$        | 2.06% | 2.46% | 2.62% | 2.08% | 2.03% | 3.20% | 2.10% | 3.15% | 4.00% | 2.15% | 3.88% |
| F-Ratio               | 11.22 | 11.73 | 12.43 | 10.06 | 9.82  | 13.42 | 8.94  | 11.06 | 13.75 | 7.82  | 10.17 |
| Durbin-Watson         | 1.95  | 1.95  | 1.95  | 1.96  | 1.95  | 1.95  | 1.95  | 1.95  | 1.95  | 1.9  | 1.95 |
| Average VIF           | 1.28  | 1.24  | 1.26  | 1.27  | 1.34  | 1.23  | 1.36  | 1.34  | 8.94  | 4.96  | 10.06 |

Standardised Regression Coefficients

***p<.001; **p<.01; *p<.05

- 215 -
Table 24: Multiple regression results: Profits, construction, t-1

<table>
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<tr>
<th>Independent Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
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<th>Model 10</th>
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<td>0.023</td>
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<td>0.023</td>
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<td>0.026</td>
<td>0.02</td>
<td>0.023</td>
</tr>
<tr>
<td>Services</td>
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<td>-0.007</td>
<td>-0.01</td>
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<td>-0.008</td>
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<td>-0.07***</td>
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<td>-0.071***</td>
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<td>0.143***</td>
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<tr>
<td>No. of Employees</td>
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<td>0.117***</td>
<td>0.118***</td>
<td>0.156***</td>
<td>0.111***</td>
<td>0.121***</td>
<td>0.162***</td>
<td>0.163***</td>
<td>0.12***</td>
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<td>0.185***</td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>0.014</td>
<td>0.015</td>
<td>-0.083***</td>
<td>-0.046**</td>
<td>-0.501***</td>
<td>0.031</td>
<td>0.142***</td>
<td>0.146***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td></td>
<td></td>
<td>0.026</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>HR Slack</td>
<td>-0.145***</td>
<td></td>
<td></td>
<td>-0.149**</td>
<td>-0.137***</td>
<td>-0.297***</td>
<td>-0.27***</td>
<td>-0.27***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial Slack</td>
<td>-0.023</td>
<td>0.017</td>
<td>0.013</td>
<td>0.215**</td>
<td>0.187**</td>
<td></td>
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<tr>
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<td>0.427***</td>
<td>0.315**</td>
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<tr>
<td>Unabsorbed Slack^2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.128***</td>
<td>-0.13**</td>
<td></td>
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<tr>
<td>HR Slack^2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.157***</td>
<td>0.143***</td>
<td></td>
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</tr>
<tr>
<td>Financial Slack^2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.19**</td>
<td>-0.152*</td>
<td></td>
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<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>R^2</td>
<td>7.72%</td>
<td>8.35%</td>
<td>7.70%</td>
<td>9.68%</td>
<td>7.80%</td>
<td>8.41%</td>
<td>9.70%</td>
<td>10.00%</td>
<td>9.13%</td>
<td>10.39%</td>
<td>11.08%</td>
</tr>
<tr>
<td>Adjusted R^2</td>
<td>7.50%</td>
<td>8.13%</td>
<td>7.50%</td>
<td>9.46%</td>
<td>7.50%</td>
<td>8.20%</td>
<td>9.46%</td>
<td>9.70%</td>
<td>8.84%</td>
<td>10.10%</td>
<td>10.69%</td>
</tr>
<tr>
<td>F-Ratio</td>
<td>40.63</td>
<td>38.67</td>
<td>35.63</td>
<td>45.50</td>
<td>35.74</td>
<td>34.65</td>
<td>40.54</td>
<td>34.11</td>
<td>31.02</td>
<td>35.78</td>
<td>28.18</td>
</tr>
<tr>
<td>Durbin-Watson</td>
<td>1.79</td>
<td>1.79</td>
<td>1.79</td>
<td>1.81</td>
<td>1.79</td>
<td>1.79</td>
<td>1.81</td>
<td>1.81</td>
<td>1.80</td>
<td>1.82</td>
<td>1.82</td>
</tr>
<tr>
<td>Average VIF</td>
<td>1.28</td>
<td>1.24</td>
<td>1.26</td>
<td>1.27</td>
<td>1.34</td>
<td>1.23</td>
<td>1.36</td>
<td>1.34</td>
<td>8.94</td>
<td>4.96</td>
<td>10.06</td>
</tr>
</tbody>
</table>

Standardised Regression Coefficients
***p<.001; **p<.01; *p< .05
ROA as a performance measure

In this section, the ability of the regression models to predict ROA as a performance measure is discussed by interpreting the results presented in Table 24. The results using Profits as a dependent variable are found in section 6.2.4.3.

$R^2$

This section discusses and interprets the $R^2$ scores, from the results examining ROA as a dependent variable within the construction context. $R^2$, the coefficient of determination, represents the amount of variance of the dependent variable that is explained by the model (Field 2005). This value relates to the ‘goodness of fit’ of the model and indicates the relationship between predicted (i.e. modelled) values of the dependent variable and its actual, measured values.

Absolute Values

According to the results, the proposed models fail to predict a substantial amount of variance in ROA with the construction context. The most accurate model (Model 11) explained only 4.3% of the observed variance in ROA. This indicated that the proposed models, and the level of slack within the firm, might not be a strong indicator of firm level Performance in construction. An alternative explanation might be that the functions of slack do not operate within the construction context, at least in relation to ROA. Moreover, the initial $R^2$ value of 2.3% in Model 1 indicates that the control variables were poor at explaining the variability of ROA in the construction context.

![Figure 24: $R^2$ results from regression analysis against ROA, t-1](image)
Model improvements

Despite the low $R^2$ values obtained overall, substantial relative improvements were made in the ability of progressively more complex models to predict firm performance over the control model (Model 1). For example, Model 1 (which contained only the control variables of Type (a dummy variable), Age, Size and Number of Employees) produced an $R^2$ value of 2.3%. When slack variables (namely, Absorbed Slack and Unabsorbed Slack) were added to form Model 6, the $R^2$ score increased by 1.16%. This indicates that slack is capable of predicting firm level ROA in the construction context, to the same extent as traditional control variables such as Size, Type and Age. Although the ability to predict ROA based upon these characteristics is low.

Validity of the model: F-Ratio, Durbin-Watson, VIF

The following details the results of the validity test applied to the regression models. These tests ensure that the data used and the results obtained are statistical valid and do not break any statistical assumptions as detailed in Field (2005). Failure to meet requirements of these tests would indicate a failure to meet the assumption required for accurate statistical analysis, and render the results of the performance variable invalid for analysis.

F-Ratio

This statistic indicates the extent to which the model has improved the ability to predict the outcome variable, compared to the inaccuracy in the model. Results should exceed the critical values provided by the f-distribution at the confidence level sought (Field 2005). Table 25 demonstrates that, although the F-Ratio results were low, as to be expected from low $R^2$ values, they still exceeded the minimum critical values for significance of the $F$-ratio the $p < .01$ level. These values, however, are still small and indicate that the models do not accurately predict performance variation. Due to exceeding the critical values at both .05 and .01 confidence levels, the models provided are considered valid according to the F-Ratio, and sufficient for analysis.

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of Freedom</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>F-Ratio result</td>
<td>11.22</td>
<td>11.73</td>
<td>12.43</td>
<td>10.06</td>
<td>9.82</td>
<td>13.42</td>
<td>8.94</td>
<td>11.06</td>
<td>13.75</td>
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<td>1.95</td>
<td>1.89</td>
<td>1.89</td>
<td>1.84</td>
<td>1.84</td>
<td>1.84</td>
<td>1.68</td>
</tr>
<tr>
<td></td>
<td>$p &lt; 0.01$</td>
<td>2.66</td>
<td>2.53</td>
<td>2.53</td>
<td>2.53</td>
<td>2.43</td>
<td>2.43</td>
<td>2.34</td>
<td>2.34</td>
<td>2.34</td>
<td>2.06</td>
</tr>
</tbody>
</table>
**Durbin-Watson test**

The Durbin-Watson test a check for autocorrelation of residual errors, a score of 2 indicates that residuals are perfectly uncorrelated (Field 2005). Below in Figure 25 the Durbin-Watson results for the models are illustrated in blue, against the desired perfect score of 2 (in red).

![Durbin-Watson statistic using ROA as a performance measure, construction, t-1](image)

**Figure 25: Durbin-Watson statistic using ROA as a performance measure, construction, t-1**

For each model the Durbin-Watson statistic was produced. Field (2005) states that values below 1 and above 3 are a cause for concern; however more accurate boundaries were adopted from Gujarati (2012). The values above are considered excellent Durbin-Watson scores, which are close to a desired score of 2.0. The values obtained initially begin at 1.95, and only varied by 0.01 throughout all models. The results for this test exceed upper boundary requirements at the 1% confidence level for the Durbin-Watson statistic, detailed in section 6.2.3.1 (recall Table 22). Therefore, confirming that there is no auto correlation of residuals in the models.

**Variance Inflation Factor**

The Variance Inflation Factor (VIF) measures the extent to which there is collinearity between predictor (i.e. independent) variables. An assumption of multiple regression analysis is that no collinearity exists between variables (Field 2005). Following Field (2005), an average VIF critical value was generated. This value assumed that one independent variable scored a maximum VIF value of 10 and the remaining variables scored a VIF of 1. Calculating this average VIF allowed the research to more easily check for collinearity between variables.

Table 26 demonstrates the VIF of each ROA model within the construction context. As can be seen, the majority of the models satisfy the necessary collinearity requirement
for analysis. In the latter models (Models 9, 10, 11 and 12), where non-linear variables are used, the VIF requirement was not satisfied. This was, however, to be expected when incorporating variables which are direct products of one another, as with the linear and non-linear variables. Therefore the increases in VIF are considered acceptable and did not void Models 9, 10 and 11.

### Table 26: VIF of predictor variables, construction, t-1

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average VIF</td>
<td>1.28</td>
<td>1.24</td>
<td>1.26</td>
<td>1.27</td>
<td>1.34</td>
<td>1.23</td>
<td>1.36</td>
<td>1.34</td>
<td>8.94</td>
<td>4.96</td>
<td>10.06</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Critical VIF value</td>
<td>2.29</td>
<td>2.13</td>
<td>2.13</td>
<td>2.13</td>
<td>2.13</td>
<td>2.00</td>
<td>2.00</td>
<td>1.82</td>
<td>1.82</td>
<td>1.82</td>
<td>1.60</td>
</tr>
</tbody>
</table>

**Regression Coefficients**

The following discusses the direction and magnitude of the standardised regression coefficients for each predictor variable incorporated in the analysis. As mentioned previously, these $\beta_i$ values indicate the number of standard deviations that the outcome variable will change as a result of one standard deviation change in the predictor variable (Field 2005). To find the results discussed in this section the reader should refer to Table 24.

Not surprisingly, following the Pearson correlation analysis above, the control variables (Size, Age and Number of Employees) had a weak effect on firm ROA. In the control model the beta ($\beta_i$) values for Age and Size were -.089 and -.048 respectively. An increase in the firms Age of 20.4 years (one standard deviation of Age) would reduce ROA by 0.63%. Also, for every increase in Size (i.e. Net Assets) of £10,175, ROA would reduce by 0.32%. The Number of Employees was not significantly correlated against ROA.

The $\beta_i$ values for the slack predictor variables in the analysis were variable depending on type. *Absorbed Slack* was measured as the ratio of the expenses relative to turnover of that year (recall Equation 2). The $\beta_i$ values for *Absorbed Slack* were consistently negative and significant (mostly $p < .05$ and in some cases $p < .01$). The linear models (Models 2, 6 and 7) demonstrated *Absorbed Slack* beta ($\beta_i$) values between -.066 and -.078, indicating that a 21% increase (one standard deviation) in Absorbed Slack would reduce ROA by between 0.45 to 0.55%. The latter models included squared variables to test for a curvilinear relationship (Model 9 and Model 11). The level of confidence at
which the beta ($\beta_i$) values could be considered significant reduced, yet their magnitude increased (Model 9, $\beta_i = -.227$, $p = 0.030$). In Model 11 the Absorbed Slack squared beta ($\beta_i$) value was non-significant ($p = .153$), preventing the model from demonstrating a curvilinear relationship.

In contrast to the above, the beta ($\beta_i$) values for Unabsorbed Slack were consistently positive and significant (at $p < 0.01$) across all models. The strength of the coefficients in Models 3, 6 and 8 ranged from $\beta_i = .078$ to .094, indicating that an increase of 1.28 in the Quick Ratio (recall Equation 3) was predicted to yield an increase in ROA from 0.55% to 0.67%. Similarly to Absorbed Slack, in the later models (Models 9 and 11), the beta ($\beta_i$) values for Unabsorbed Slack increased to .283 and .278 respectively however, unlike the above, they remained significant ($p < 0.001$). This latter value predicted an increase in ROA of roughly 2% should the firm’s Quick Ratio be increased by 1.28. These values, although contradictory to Absorbed Slack above, demonstrated stronger beta ($\beta_i$) values at higher confidence levels across all models. In Model 11, demonstrated a first order beta ($\beta_i$) of .278 for Unabsorbed Slack, and second order beta value ($\beta_i$) -.209 for Unabsorbed Slack squared ($p < 0.001$). This indicated an inverse U-shaped relationship (∩) between Unabsorbed Slack and Performance when measured as ROA, thus supporting Hypothesis 1a (H1a).

Like Absorbed Slack, the beta ($\beta_i$) coefficients for HR Slack were negative; however, these beta values ($\beta_i$) were not significant across all models, preventing further analysis of the data. Non-significant beta ($\beta_i$) values indicate a non-significant relationship, therefore, not supporting any hypothesis.

The beta ($\beta_i$) values for Financial Slack were not significant in any model. Further, the direction of the relationship between the predictor variable and ROA was inconsistent across models. As such, the Financial Slack variables could not be analysed further due to non-significant beta ($\beta_i$) values.

Models 9, 10 and 11 incorporated the squared slack predictor variables necessary to test for a curvilinear, second-order relationship between varying forms of slack and firm performance when measured as ROA. Within these models, Absorbed Slack, HR Slack and Financial Slack squared provided non-significant beta ($\beta_i$) values, restricting further analysis as above. Unabsorbed Slack, however, demonstrated significant ($p < 0.001$) beta values within Models 9 and 11, supporting Hypothesis 1a.
Effect of Extended Time Lag (t-2)

Remembering the Research Design, this research incorporated and extended time lag to test for the effects of resources over time. Mishina et al. (2004) argued that the current amount of slack does not impact current innovation or performance, as slack resources require time to be redeployed. An extended time lag of two years (t-2) was introduced to test the relationship between the predictor variables and firm performance (as ROA). The results of these tests can be found in Appendix 4.

Overall the impact of the extended time lag was slight. There were minor reductions in the $R^2$ values, and almost negligible variation in the validity of the model results (Durbin Watson, $F$-ratio, and VIF). The main impact of the extended time lag was on the statistical significance of the slack variable standardised beta ($\beta_i$) coefficients. The significant results for Unabsorbed Slack in Model 9 were maintained at the extended time lag. Elsewhere, however, the confidence levels at which the beta ($\beta_i$) values were significant further reduced. Ultimately, the extended time lag had little impact on the analysis. Where differences were seen between the t-1 and t-2 models, the extended time lag was only detrimental to the tests of validity of the models (Durbin Watson, $F$-ratio, and VIF).

Profits as a Performance Measure

In this section, the ability of the regression models to predict Profits as a performance measure is discussed by interpreting the results presented in Table 25. The results concerning ROA are in the section above.

$R^2$

This section discusses and interprets the $R^2$ scores, from the results examining Profits as a dependent variable within the construction context. $R^2$, the coefficient of determination, represents the amount of variance of the dependent variable that is explained by the model (Field 2005). This value relates to the ‘goodness of fit’ of the model and indicates the relationship between predicted (i.e. modelled) values of the dependent variable and its actual, measured values.

Absolute Values

When compared to ROA, the regression of firm Profits provided substantially better $R^2$ scores. As seen in Figure 26, the most accurate model (Model 11) explained 11.1% of the variance within firm Profits (adjusted $R^2$ of 10.7%). The control model (Model 1)
demonstrated an $R^2$ value of 7.7%. These values are much larger than those seen with ROA, indicating that the models were more capable of explaining variance in construction firm Profits than ROA.

![Figure 26: R^2 results from regression analysis against Profits, t-1](image)

**Model improvements**

As the models became more complex and additional slack variables are incorporated, their ability to predict firm Profits improved (recall Table 25). Due to an initially high $R^2$ score in the control model (Model 1), the most complex model within the regression analysis (Model 11) only provided an improvement of 3.36% (c.f. Model 1 $R^2 = 7.72%$; Model 11 $R^2 = 11.08%$). This indicated that the addition of eight slack variables did not extensively improve model ability to predict firm Profits. Of interest however was the spike in the $R^2$ of Model 4, which introduced HR Slack. This addition of HR Slack markedly increased model ability to predict variability in Profits. Considered alone, HR Slack is capable of explaining 2.0% of the variation in firm Profits; more than any other slack variable.

**Validity of the model: F-Ratio, Durbin Watson, VIF**

The following details the results of the validity test applied to the regression models. These tests ensure that the data used and the results obtained are statistical valid and do not break any statistical assumptions as detailed in Field (2005).

**F-ratio**

The role of the F-Ratio was introduced in the discussion of ROA. Table 27 illustrates the F-Ratio results collected for the regression models when applied to firm Profits.
Findings

The results exceeded the critical values at both the $p < .05$ and $p < 0.01$ levels and, as with ROA results, were considered valid. What can also be seen is that the $F$-ratio result varied notably across models. The strongest result was in Model 4 ($F$-ratio = 45.50) yet in Model 11, which incorporates a larger number of variables, the $F$-ratio reduces to 28.18. This indicates that the amount of variation explained by the model does not equal the amount of variation added by additional variables.

Table 27: F-Ratio results of validity of Profit as performance variable, t-1

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>10</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Degrees of Freedom</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>F-Ratio result</td>
<td>40.63</td>
<td>38.67</td>
<td>35.63</td>
<td>45.50</td>
<td>35.74</td>
<td>34.65</td>
<td>40.54</td>
<td>34.11</td>
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<td>28.18</td>
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<tr>
<td>Critical value</td>
<td>$p &lt; 0.05$</td>
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<td>1.95</td>
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<td>1.89</td>
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<td>1.68</td>
</tr>
<tr>
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<td>2.53</td>
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<td>2.43</td>
<td>2.43</td>
<td>2.34</td>
<td>2.34</td>
<td>2.06</td>
</tr>
</tbody>
</table>

Durbin Watson

The Durbin-Watson was used to check for autocorrelation of residual errors as with ROA. Figure 27 illustrates the results. The values of this regression analysis vary from 1.79 and 1.82. These results were maintained as valid for two reasons; first while lower than those demonstrated in the analysis against ROA, the result below are consistent varying by only a maximum of 0.035, indicating any possible autocorrelation was not caused by the addition of slack variables into the model. Second the lowest value of 1.79 remains within the accept boundary dictated by Field (2005), and the result exceed the more stringent boundaries dictated by Gujarati (2012). Thus the null hypothesis that there is no correlation between the regression residuals is maintained across all models.

The Model 11 Durbin-Watson result of 1.823 was marginally below the upper boundary of 1.836 dictated by Gujarati (2012), indicating inconclusive evidence for the presence or absence of residual correlation. However, this was considered inconsequential for the overall analysis as the boundary statistics provided only extend to a maximum observation number of 200 cases, and do not consider much larger sample sizes which would reduce the critical value boundary closer to 0. Thus, allowing the sample within this project to meet the requirements of the critical value.
Findings

Figure 27: Durbin-Watson statistic using Profits as a performance measure, construction, t-1

VIF
As the test for VIF applies solely to the predictor (i.e. independent) variables, these values do not alter when the dependent variable is changed. The results for this validity test therefore remain consistent across the analysis of the performance variables ROA and Profits. Therefore, do not require further reporting.

Coefficients
The following discusses the direction and magnitude of the standardised regression coefficients for each predictor variable incorporated within the analysis. It should be read in conjunction with Table 25 and replicates the interpretation approach taken for ROA above.

The Pearson’s correlation analysis seen previously demonstrated a significant relationship between firm Profits and the control variables Size and Number of Employees. Not surprisingly, this was also demonstrated within the regression analysis. The βi values for Age were significant at the P<0.001 level and were negative, ranging from -.065 to -.071. Model 1 indicated that a c. 20 year increase in firm Age will reduce Profits by c. £54,000.

The beta (βi) values for both Size and Number of Employees were also significant (p < 0.001) and consistently positive across models. According to the beta values from Model 1 for these variables, an increase in firm Size of £8,500 causes an increase in Profits of £167,000; and an additional 115 employees indicates an increase in profits of £91,403. However, how feasible this might be as a means of generating higher profits is unclear. Of note is that, unlike ROA, the control variables were all significant in relation to Profits.
The beta ($\beta_i$) values for *Absorbed Slack* were significant ($p < 0.001$) and negative across all models. Models 2 and 6 illustrated beta ($\beta_i$) values of -0.079 and -0.083 respectively, which indicated that Absorbed Slack had a stronger relationship with Profits than Age. Models 9 and 11 demonstrated an increase in the beta ($\beta_i$) values for absorbed slack to -0.501 and -0.348. This is similar to the effect seen in Models 9 and 11 when regressing against ROA, however in this case a high level of significance is maintained. This indicates that were the amount of absorbed slack to increase by 20% then firm profits would reduce by roughly £395,000 or £274,000 respectively. In Model 9 the beta ($\beta_i$) values were -.501 for the *Absorbed Slack* and .427 for *Absorbed Slack Squared* ($p<0.01$). This indicated a U-shaped relationship ($\cup$) between the level of *Absorbed Slack* and performance when measured as Profit, thus supporting Hypothesis 2b (H2b).

Unlike ROA above, the beta ($\beta_i$) values for *Unabsorbed Slack*, when using Profits to represent firm performance, were not consistently significant. In Models 3, 6 and 8, the beta ($\beta_i$) values for *Unabsorbed Slack* were not significant ($p > 0.05$). Due to their lack of significance, these values could not be further analysed. In the more complex Models 9 and 11 the beta ($\beta_i$) values became significant through the addition of non-linear variables: $\beta_i$ values of .142 and .146 were significant at $p < 0.001$. In Model 9, $\beta_i$ was .142 for the *Unabsorbed Slack* and -.128 for *Unabsorbed Slack squared*. This indicated an inverse U-shaped relationship ($\cap$) between the level of *Unabsorbed Slack* and performance, thus supporting Hypothesis 1b (H1b).

The beta ($\beta_i$) values for *HR Slack* were significant ($p < 0.001$) and consistently negative throughout all the models. For Models 4, 7 and 8 the beta ($\beta_i$) values ranged from -.145 to -.137, this indicates that an increase of 5.5 employees per £1,000 turnover (recall Equation 4) would reduce firm Profits by between £114,000 and £108,000. Like those above in the later models (Models 10 and 11), the beta ($\beta_i$) values for *HR Slack* increased to -.297 and -.270 respectively. In Model 9, the beta ($\beta_i$) values were -.501 for *HR Slack* and .427 for *HR Slack squared*. This indicated a U-shaped relationship ($\cup$) between Unabsorbed Slack and performance, thus supporting Hypothesis 2b (H2b).

The beta ($\beta_i$) values for the final slack variable, *Financial Slack*, were inconsistent in direction and significance. In Models 5, 7 and 8 the beta ($\beta_i$) values were not significant ($p > 0.05$) and their direction was neither consistently negative nor consistently positive. However, similarly to *Unabsorbed Slack*, as the models become more complex in
Models 10 and 11 the additional non-linear variables improved the strength of the beta ($\beta_i$) values and the significance was found with greater confidence. As with ROA, Models 9, 10 and 11 incorporated squared slack variables to test the possibility of non-linear relationships between types of slack resources and firm performance when represented by firm Profits. The beta ($\beta_i$) values within these models were significant for both the linear and non-linear slack variables ($p<0.01$). Previously non-significant beta ($\beta_i$) values from slack variables (Unabsorbed Slack and Financial Slack), become significant through the application of their squared terms. This indicates that there is not a linear relationship between Financial Slack and Profits, but only a curvilinear one. The negative second order coefficient (model 9, $\beta_i = -.190$) indicates an inverse U-shaped relationship ($\cap$) between the level of Unabsorbed Slack and performance, thus supporting Hypothesis 1b (H1b).

Absorbed Slack and HR Slack exhibited positive second-order beta ($\beta_i$) values, which indicated a U-shaped relationship ($\cup$). Unabsorbed Slack and Financial Slack exhibited negative second-order beta values, which indicated an inverse-U relationship ($\cap$). In Model 9, the $\beta_i$ values for Absorbed Slack were the strongest (first-order of -.501 and second-order of .427; both significant at $p < 0.001$). Comparatively, the beta ($\beta_i$) values for Unabsorbed Slack were much lower (first-order of .142 and second-order of -.128; both significant at $p < 0.001$).

Effect of extended time lag (t-2)

To test for a possible delayed effect due to time frame between resource consumption by the firm, and the financial performance of the firm. An extended time lag of two years was introduced to test the relationship between the predictor variables and firm performance at t-2 years. The results of these tests can be found in Appendix 4.

Overall, the impact of the extended time lag was considered slight. Unlike ROA, however, there were larger reductions in $R^2$, reducing the proportion of firm performance explained by the control model (Model 1) from 7.7% to 6.5%. This implied that the extended time lag in measuring independent variables reduced its ability to predict variation in performance measured as Profits. Aside from this, variation in the validity tests of the models was not seen. The extended time lag also reduced the statistical significance of the slack variable standardised beta coefficients.
Ultimately, the extended time lag had little impact on the analysis; effects were only detrimental to the validity tests of the analysis at t-2.

6.2.4 Summary

The following provides a summary of the results obtained above from the construction context by examining the results of the $R^2$, the validity test results and coefficients produced though the regression analysis for the performance measures ROA and Profits.

R2 Summary

The $R^2$ results were heavily dependent upon the performance measure selected. The results for ROA were far lower than for Profits, with the predictor slack measures failing to explain more than 4.3% of the variation in ROA in their varying combinations across the models yet, when predicting Profits they could explain between 7.7% and 11.1% of the variation in those Profits.

The relative impacts of different variable combinations on the $R^2$ results were inconsistent between Profits and ROA (recall Figure 24 and Figure 26). While the addition of Unabsorbed Slack to model 4 and Unabsorbed Slack squared to Model 8 provided a marked increase in the predictability of ROA (see Figure 24), this was not the case for Profits. The $R^2$ results for Profits indicated that incorporating HR Slack improved the predictability of Profits, as demonstrated by Model 4 (recall Figure 26) and as replicated in the later models that also included HR Slack (Models 7, 8, 10 and 11).

Model Validity

All regression models within the construction context are deemed appropriate because they satisfy Durbin-Watson, VIF and F-Ratio requirements, which were used to test the validity of the models, and their ability to meet the statistical assumptions required for regression analysis (Field 2005).

The F-Ratio results using Profits as a dependent variable far exceeded the minimum critical values of F, ensuring that the models were capable of predicting more of the variation in Profits than the inaccuracy of the model. Although much lower values of F were demonstrated by the analysis of ROA, the ROA models still exceeded the minimum critical values necessary to ensure the validity of the models.
For the regression analysis of both ROA and Profits, the Durbin-Watson statistics were deemed acceptable due to their close proximity to the optimum value of 2, and within the boundaries taken from Gujarati (2012). Therefore, the null-hypothesis that the residuals of the regression analysis are non-auto correlated was not rejected, for all regression models, i.e. the residuals are not auto correlated.

Finally, the results of the VIF analysis, which measures the extent to which there is collinearity between independent variables, were also acceptable. Models 1 to 8 maintained an average variable VIF value under the maximum critical value. Indicating an absence of collinearity in the sample. Unlike the prior models, Models 9 to 11 demonstrated average VIF results greatly exceeding this value. However, it was determined that these were the result of collinearity between the squared slack variables and their linear counterparts, as opposed to collinearity among distinct variables which would make the analysis invalid.

**Coefficients Summary**

The beta values ($\beta_i$) produced within the regression analysis varied depending upon the performance variable predicted.

Age was demonstrated as having a negative and significant ($p < 0.001$) relationship with both ROA and Profits, demonstrating that older firms have lower ROA and Profits. Size had a significant ($p < 0.001$) and positive relationship with firm Profits, however against ROA the beta ($\beta_i$) value was only significantly correlated at the $p < .05$ level and was consistently negatively related. Together, these two relationships indicated that, if Size grew so would firm Profits, but ROA would decrease. The final control variable measured the Number of Employees in the firm. This variable was significantly correlated ($p < 0.001$) and positive in all the regression models that used Profits to describe firm performance. In contrast, ROA was not significantly correlated to Number of Employees, preventing further analysis.

**Absorbed Slack,** (recall Equation 2) demonstrated significant beta ($\beta_i$) values across both performance measures. Against ROA, Absorbed Slack was negative, with a beta ($\beta_i$) value of -.078 in Model 6; however its non-linear (squared) coefficients in Models 9 and 11 were not significant. Thus, the beta ($\beta_i$) values from those models cannot be reported. Against Profits, the linear beta values were also significant ($p < 0.001$) and negative, the non-linear (squared) coefficients also being significant ($p < 0.05$). In
Model 11 for Profits the beta ($\beta_i$) values were -.348 for Absorbed Slack (p < 0.001) and .315 for Absorbed Slack Squared (p = 0.002). These observations indicated a U-shaped relationship between Absorbed Slack and construction firm Profits ($\cup$). Additionally, among all the slack variables, Absorbed Slack exhibited the strongest standardised correlation with Profits. In summary, increases in Absorbed Slack negatively impact construction firm ROA and has a U-shaped relationship with construction firm Profits ($\cup$), the latter supporting hypothesis 2b.

Unabsorbed Slack (recall Equation 3) demonstrated significant linear, and non-linear correlation with ROA; the only predictor variable to do so. Model 11 demonstrated first order correlations of Unabsorbed Slack and ROA of .278 (at p < 0.001) and second order correlations of -.209 (at p < 0.001). These results indicated an inverse U relationship between Unabsorbed Slack and ROA ($\cap$). Isolated correlations of individual linear predictors against Profits (Models 3, 6 and 8) were not significant; however, the inclusion of a non-linear term form produced significant correlations as follows. Model 11 correlated first-order Unabsorbed Slack against Profit at .146 (p < 0.001) and second-order at -.130 (p < 0.001). These results indicated an inverse-U shaped relationship between Unabsorbed Slack and Profits ($\cap$). In summary, increases in Unabsorbed Slack had an inverse-U shaped curvilinear relationship with construction firm ROA and Profits ($\cap$), supporting both hypothesis 1a and 1b.

HR Slack, measured as the ratio of Number of Employees to Turnover in that year (recall Equation 4), demonstrated both significant and non-significant correlations. Against ROA, HR Slack correlations were consistently not significant preventing further analysis. When regressed against Profits, however, HR Slack was significant (p < 0.001) and negative. In Model 11, the first-order standardised correlation was -.270 and the second-order .143. This indicated a U-shaped relationship ($\cup$) between HR Slack and Profits.

The final slack variable, Financial Slack, was measured as the proportion of cash reserves to turnover of that year (recall Equation 5). Against ROA, Financial Slack beta ($\beta_i$) values were consistently not significant preventing further analysis. Model 10 however, was an exception to this as it provided significant correlation coefficients (albeit at the .05 level), with a positive first-order correlation of .161 and a negative second-order correlation of -.151, indicating an inverse-U shaped relationship. Like
Unabsorbed Slack, the correlations between Financial Slack and Profits were not significant in the majority of models. However, Model 11 produced significant results. Model 11 demonstrated significant first-order correlation coefficients of .187 (at p < 0.01) and second-order beta values of -.152 (at p < 0.05) for Financial Slack against Profits. Increases in Financial Slack therefore exhibited an inverse U-shaped curvilinear impact on construction firm and Profits (∩), supporting hypothesis 1b.

6.3 Analysis of Organisational slack against the Manufacturing context

The following presents application of the research protocol to the manufacturing context. This alternate context, previously explored by prior slack researchers, was chosen to provide a baseline against which the construction results could later be compared. As the analysis method was identical, any differences could be attributed to the studied context. The following section focuses solely on analysis of the manufacturing context, as it is considered good practice to analyse the data in its own right prior to a comparison between contexts. For a comparative analysis between the construction and manufacturing contexts, see Chapter 7.

6.3.1 Data Sample

The data for this sample was obtained as for the construction context. Firms were chosen based upon their two-digit SIC code to provide a cross-section of manufacturing sectors (Table 28).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Firm Type/Classification</th>
<th>SIC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics</td>
<td>Manufacture of machinery and equipment.</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Manufacture of motor vehicles, trailers and semi-trailers.</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Manufacture of other transport equipment.</td>
<td>30</td>
</tr>
<tr>
<td>Electronics</td>
<td>Manufacture of computer, electronic and optical products.</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Manufacture of electrical equipment.</td>
<td>27</td>
</tr>
<tr>
<td>Chemical</td>
<td>Manufacture of chemicals and chemical products.</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Manufacture of basic pharmaceutical products and pharmaceutical preparations.</td>
<td>21</td>
</tr>
<tr>
<td>Wholesale/ Retail</td>
<td>Wholesale and retail trade and repair of motor vehicles and motorcycles.</td>
<td>45</td>
</tr>
<tr>
<td>Media</td>
<td>Motion picture, video and television programme production, sound recording and music publishing activities.</td>
<td>59</td>
</tr>
</tbody>
</table>
Following the selection criteria applied to the construction context previously, the initial sample for the manufacturing industry was 4,816 (Table 29). This sample was later reduced using the analysis protocol (recall Figure 22) to identify and exclude outliers in the sample and improve its ability to meet the statistical assumption required for analysis (Field 2005). The final sample was 3,924 firms following the removal of outliers.

Table 29: F.A.M.E. selection procedure for the manufacturing context

<table>
<thead>
<tr>
<th>Description of Selection Criteria</th>
<th>Step result</th>
<th>Search result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All active companies (not in receivership nor dormant) and companies with unknown situation</td>
<td>3,137,208</td>
<td>3,137,208</td>
</tr>
<tr>
<td>2. Firm SIC codes included in Manufacturing Context</td>
<td>212,375</td>
<td>98,920</td>
</tr>
<tr>
<td>3. Return on Total Assets (%): All companies with a known value, 2012</td>
<td>266,721</td>
<td>10,834</td>
</tr>
<tr>
<td>4. Profit (Loss) before Tax: All companies with a known value, 2012</td>
<td>275,602</td>
<td>10,834</td>
</tr>
<tr>
<td>5. Turnover: All companies with a known value, 2012, 2011, 2010, for all the selected periods</td>
<td>172,939</td>
<td>7,507</td>
</tr>
<tr>
<td>6. Administration Expenses: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>230,454</td>
<td>7,355</td>
</tr>
<tr>
<td>7. Liquidity ratio (x): All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,408,331</td>
<td>7,253</td>
</tr>
<tr>
<td>8. Total Reserves: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,547,479</td>
<td>7,232</td>
</tr>
<tr>
<td>9. Number of Employees: 2011, 2010, min=10, for all the selected periods</td>
<td>59,666</td>
<td>4,820</td>
</tr>
<tr>
<td>10. Net assets: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,893,216</td>
<td>4,820</td>
</tr>
<tr>
<td>11. Turnover per employee (unit): All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>87,021</td>
<td>4,817</td>
</tr>
<tr>
<td>12. Incorporation date: to 07/07/2012</td>
<td>7,910,931</td>
<td>4,816</td>
</tr>
<tr>
<td>Total</td>
<td>4,816</td>
<td></td>
</tr>
</tbody>
</table>

6.3.2 Descriptive Statistics analysis

Table 30 details the descriptive statistics for the data in the manufacturing sample. Descriptive analysis was implemented as for construction firms. The composition of manufacturing firm types is of note: wholesale and retail firms made up over one third of the construction context sample, while media firms made up less than 5%.
6.3.3 Pearson’s Correlation Analysis

As with the construction context, a bivariate analysis determined the direction and degree of association between two variables. The following discusses the relationships between pairs of variables within the manufacturing context. The Pearson’s correlation tables for the manufacturing context are presented in Table 31 and Table 32 below.

Dependent variable relationship

Within manufacturing a strong, significant relationship between the Firm ROA and Profits was observed ($r = .600$, $p < 0.001$). The correlation of these variables indicates that both measures are associated with one another, which is to be expected as ROA is calculated using Net Income, which is derived from pre-tax Profits. Despite the strong correlation observed between these two variables in construction, it is argued that they remain independent and indicate different aspects of firm level performance. Although the relationship is strong it does not suggest collinearity between the variables (Field 2005). Therefore, both measures ROA and pre-tax Profits are maintained as distinct dependent variables.

Control variables

Age was not significantly correlated with ROA but was significantly correlated ($p < 0.001$) against firm Profits. However, Age has only a weak effect ($r = .051$) on
Profits (remembering section 6.2.3), indicating that older firms are only marginally more profitable than younger firms.

The Size of the firm, measured as Net Assets, was significantly correlated with firm Profits \( (p < 0.001) \) at both t-1 and t-2. At t-1, Size had a moderate effect on firm Profits \( (r = .357) \), which reduced only marginally in strength at the extended time lag, t-2 \( (r = .313) \). Size was non-significantly correlated against firm ROA \( (p > 0.05) \).

The final continuous control variable, Number of Employees, was correlated \( (p < 0.001) \) with both ROA and Profits at both t-1 and t-2. The Number of Employees had a weak to moderate, positive effect on firm Profits at t-1 \( (r = .244) \), but a very weak, negative effect on firm ROA \( (r = -.087) \), at t-2 these values reduced in strength. Overall, increases in firm Size and Number of Employees were positively correlated with Profits, but weakly and negatively correlated with firm ROA.

**Independent linear**

All the linear slack variables and performance variables correlations at t-1 were significant \( (p < 0.01) \), but their correlation was consistently weak \( (r < .18) \).

*Absorbed Slack* was negatively correlated with both ROA and Profits, however its effect on Profits was weak \( (r = -.085) \) and weaker still against Profits at the extended time lag t-2 \( (r = -.066) \). *Unabsorbed Slack* had a positive correlation with both ROA \( (r = .109) \) and Profits \( (r = .09) \). The correlation strength decreased at the extended time lag t-2, ROA \( (r = .084) \) and Profits \( (r = .077) \).

*HR Slack*, like *Absorbed Slack*, was negatively correlated with both ROA and Profits and, like all slack variables, was only weakly correlated \( (r < 0.2) \) with Profits \( (r = -.161) \) and ROA \( (r = -.06) \). The effect of *HR Slack* on firm Performance deteriorated at the extended time lag; Profits \( (r = -.132) \) and ROA \( (r = -.035) \). The final slack variable, *Financial Slack*, was positively correlated with firm performance, having a weak-moderate effect \( (r = .145 \text{ for ROA and } r = .169 \text{ for Profits}) \).

As within the construction context, the manufacturing context examined the relationship between slack variables. Once again, the Pearson’s correlation analysis demonstrated that the slack variables were not strongly correlated against one another, but demonstrated significant correlations for the majority of \( r \) values within the manufacturing context. Like within the construction context the strongest correlation
demonstrated was between Unabsorbed Slack and Financial Slack ($r = .348, p < 0.01$). As with construction firms, the lack of correlation between slack variables indicates that the types of slack represented distinct pools of resources. Therefore, are suitable as distinct slack variables and further analysis.
Table 31: Pearson correlation table, manufacturing at t-1

<table>
<thead>
<tr>
<th></th>
<th>ROA</th>
<th>Profit</th>
<th>Electric</th>
<th>Chemical</th>
<th>Whols/Ret Media</th>
<th>Age</th>
<th>Size</th>
<th>No. Emp</th>
<th>Abs Slack</th>
<th>Unabs</th>
<th>Slack</th>
<th>HR Slack</th>
<th>Fin Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td>.600**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>.076**</td>
<td>.030</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical</td>
<td>.037*</td>
<td>.090**</td>
<td>-.207**</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholesale/Retail</td>
<td>-.167**</td>
<td>-.119**</td>
<td>-.379**</td>
<td>-.298**</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Media</td>
<td>-.031</td>
<td>-.045**</td>
<td>-.116**</td>
<td>-.091**</td>
<td>-.168**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-.027</td>
<td>.051**</td>
<td>-.041**</td>
<td>.046**</td>
<td>.033**</td>
<td>-.110**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>-.008</td>
<td>.357**</td>
<td>.048**</td>
<td>.100**</td>
<td>-.092**</td>
<td>-.023</td>
<td>.124**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Employees</td>
<td>-.087**</td>
<td>.244**</td>
<td>-.033*</td>
<td>-.020</td>
<td>.067**</td>
<td>-.039*</td>
<td>.090**</td>
<td>.454**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>-.048**</td>
<td>-.085**</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.037**</td>
<td>-.049**</td>
<td>.016</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>1.109</td>
<td>.090**</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.044**</td>
<td>.162**</td>
<td>-.065**</td>
<td>.052**</td>
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<tr>
<td>HR Slack</td>
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<td>-.161**</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>-.031</td>
<td>-.106**</td>
<td>.102**</td>
<td>.331**</td>
<td>.073**</td>
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<td></td>
</tr>
<tr>
<td>Financial Slack</td>
<td>1.145**</td>
<td>.169**</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.073**</td>
<td>.316**</td>
<td>-.007</td>
<td>.014</td>
<td>.348**</td>
<td>.120**</td>
<td>1</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 32: Pearson correlation table, manufacturing at t-2

<table>
<thead>
<tr>
<th></th>
<th>ROA</th>
<th>Profit</th>
<th>Electric</th>
<th>Chemical</th>
<th>Whols/Ret Media</th>
<th>Age</th>
<th>Size</th>
<th>No. Emp</th>
<th>Abs Slack</th>
<th>Unabs</th>
<th>Slack</th>
<th>HR Slack</th>
<th>Fin Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Profit</td>
<td>.600**</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>.076**</td>
<td>.030</td>
<td>1</td>
<td></td>
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** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).
6.3.4 Multiple Regression Analysis

As with the construction context, the following details the results of multiple regression analysis of manufacturing firms.

Table 33 and Table 34 present the multiple regression analysis results using ROA and pre-tax Profits as the dependent variable, at a time lag of one year (t-1). The results at the extended time lag and the complete statistical output are presented in Appendix 4. The same forced entry (or standard) method was used as it was for construction firms.
Table 33: Multiple regression results: ROA, manufacturing, t-1

<table>
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<tr>
<th>Independent Variables</th>
<th>Model 1</th>
<th>Model 2</th>
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Standardised Regression Coefficients

***p<.001; **p<.01; *p<.05
Table 34: Multiple regression results: Profits, manufacturing, t-1

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Standardised Regression Coefficients
***p<.001; **p<.01; *p<.05
ROA as a performance measure

The following examines the results of the multiple regression analysis when using ROA as a dependent variable in the manufacturing context

R²

Analysis of the goodness of fit of each model (R²) followed the same method of analysis as the examination of construction firms.

Absolute Values

As shown by Figure 28, the model proposed for analysis failed to achieve a high R² score and thus failed to explain a considerable amount of variation in firm ROA. Model 11 provided the greatest explanation, yet this model only explained 9.0% of the variation of ROA and required all 15 predictor variables to do so. The control model (Model 1) provided an R² of 3.9%. This indicated that the chosen slack variables were potentially a weak indicator of firm performance when measured against ROA within the manufacturing context due to the low R² score. However, the control variables selected were not far better.

![Figure 28: R² results from regression analysis against ROA, manufacturing, t-1](image)

Model improvements

Even though the absolute values of R² were low indicating a poor relationship between ROA and slack, by examining the improvement in R² scores as the models develop it demonstrates the ability of the slack variables to increase R² compared to Model 1. As the models became more complex, the R² result demonstrated notable improvement. An initial value of 3.9% in Model 1 (incorporating only control variables) was markedly improved upon by incorporating Financial Slack in Model 5 (R² = 6.1%). Furthermore,
Model 11, containing all the slack variables, was more than twice as accurate as the control model (Model 1). As such, quantifying slack in this context improved the predictability of ROA beyond that achieved with the control variables alone. Therefore slack, especially Financial Slack, was considered a good indicator of firm ROA when compared to the control variables of Age, Type, Size, and Number of Employees.

Validity of the model: F-ratio, Durbin Watson, VIF

The following tests the validity or the models using common determinants that demonstrate that the data, and results meet the statistical assumption for regression analysis (Field 2005). Model validity was determined in the same way as the analysis of construction firms: by examining: F-ratio, Durbin-Watson and VIF results.

**F-ratio**

Table 35 presents the F-ratio results with ROA as the performance measure. As with the construction firm analysis, calculated values of F for each model were compared with required values for significance at the .05 and .01 levels. As can be seen, each model far exceeded the minimum values of F required for validity. Some variation can be seen in the across the models. Model 5 provided the largest F-ratio result, which coincides with Figure 28 examining $R^2$ values. This means that the model had improved the predictability of ROA, more than the inaccuracy of the model.

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2</th>
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<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of Freedom</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>F-ratio result</td>
<td>22.56</td>
<td>20.79</td>
<td>25.53</td>
<td>21.14</td>
<td>32.02</td>
<td>23.99</td>
<td>31.95</td>
<td>28.36</td>
<td>27.28</td>
<td>26.29</td>
<td>25.83</td>
</tr>
<tr>
<td>Critical value</td>
<td>p &lt; 0.05</td>
<td>2.02</td>
<td>1.95</td>
<td>1.95</td>
<td>1.95</td>
<td>1.95</td>
<td>1.89</td>
<td>1.89</td>
<td>1.84</td>
<td>1.84</td>
<td>1.84</td>
</tr>
<tr>
<td></td>
<td>p &lt; 0.01</td>
<td>2.66</td>
<td>2.53</td>
<td>2.53</td>
<td>2.53</td>
<td>2.53</td>
<td>2.43</td>
<td>2.43</td>
<td>2.34</td>
<td>2.34</td>
<td>2.06</td>
</tr>
</tbody>
</table>

**Durbin-Watson**

The Durbin-Watson results were very good, with each model providing a score very close to the ideal of 2. The test results exceeded upper boundary requirements at the .01 level, confirming that there was no auto correlation of residuals in the models or in the sample.
Findings

Figure 29: Durbin-Watson statistic using ROA as a performance measure, manufacturing (t-1)

VIF

Table 36 shows that all the models containing linear variables (Models 1 to 8) are sufficiently below their critical VIF score (see Equation 12). This indicates that there was no multicollinearity within these models. Within Models 9, 10 and 11 however, as with construction, much larger VIF scores were demonstrated. Like in construction, this was expected due to the non-linear variables being products of their linear counterparts. Consequently the high VIF values are deemed acceptable as no multicollinearity existed within the models from which they were derived.

<table>
<thead>
<tr>
<th>Model</th>
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</tr>
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<tbody>
<tr>
<td>Average VIF</td>
<td>1.31</td>
<td>1.27</td>
<td>1.29</td>
<td>1.29</td>
<td>1.32</td>
<td>1.26</td>
<td>1.32</td>
<td>1.31</td>
<td>12.04</td>
<td>6.63</td>
<td>13.71</td>
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<tr>
<td>Degrees of Freedom</td>
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<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Critical VIF value</td>
<td>2.29</td>
<td>2.13</td>
<td>2.13</td>
<td>2.13</td>
<td>2.13</td>
<td>2.00</td>
<td>2.00</td>
<td>1.82</td>
<td>1.82</td>
<td>1.82</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Regression Coefficients

Similarly to the construction context, the beta ($\beta_i$) values for the control variables closely followed their Pearson correlation coefficients. Across Models 1, 2, 3, 4, 5 and 6, beta ($\beta_i$) for Age was not significant and only became significant at the .05 level in the remaining, more complex, models. Size was not significant in Models 1, 2, 3, 4, and 6, and was significant at the $p < 0.05$ level in the remaining models. Number of Employees was significant at the $p < .01$ level in Models 1, 2, 3, 4, 5 and 6 and the most influential of the control variables (Model 1 $\beta_i = -.085$).

The ($\beta_i$) values for Absorbed Slack were significant ($p < 0.01$) in all models apart from Model 8. Beta ($\beta_i$) values varied in strength and were consistently negative. Model 2, which added Absorbed Slack to the control variables, produced a beta ($\beta_i$) value of -.045.
Findings

(p < 0.01), indicating that a 22% increase in Absorbed Slack reduces firm ROA by 0.42% (see table 33). The beta (β_i) values for Absorbed Slack increased markedly in Models 9 and 11, which included the Absorbed Slack squared variable. In these models both the linear and non-linear beta (β_i) values were significant (p < 0.01). Model 11 the first order beta (β_i) value was -.394 for Absorbed Slack and the second order beta (β_i) value .363 for Absorbed Slack Squared. This indicated a U-shaped relationship (∪) between Absorbed Slack and Performance when measured as ROA, thus supporting Hypothesis 2a (H2a).

For Unabsorbed Slack, the significance of the beta (β_i) values was consistently positive and significant (p < 0.05). As with Absorbed Slack, the Unabsorbed Slack beta (β_i) values also varied in strength. The beta value (β_i = .111, p < .01) in Model 6 indicated that a 1.84 increase in Unabsorbed Slack would yield a 1.04% increase in firm ROA. In Model 11, both the linear and non-linear beta (β_i) values were significant (p <0.001) but, in contrast to Absorbed Slack, exhibited positive first order and a negative second order beta (β_i) values. In Model 11, the first order beta (β_i) values were .341 for Unabsorbed Slack, and the second order (non-linear) beta (β_i) value -.276 for Unabsorbed Slack Squared. The second order coefficient indicates an inverse U-shaped relationship (∩) between slack and performance, thus supporting Hypothesis 1a (H1a).

For HR Slack, the beta (β_i) values were negative and significant (p < 0.01) throughout the regression models. For example Models 4, 7 and 8 the beta (β_i) values ranged from -.053 to -.087, indicating that an increase in HR Slack of 4.59 would reduce firm ROA by between 0.50% and 0.81%. Akin to the above, in the latter models where squared terms were included (Models 10 and 11), the strength of the beta (β_i) values increased for the linear variables (β_i = -.129 and -.045 respectively) and maintained significance (p < 0.05). However, due to the lack of significance of the second order (HR Slack Squared) beta (β_i) coefficients, only a linear negative relationship between HR Slack and firm performance as ROA was supported, thus does not support any hypothesis.

Beta (β_i) values for Financial Slack against ROA were significant (p < 0.01) and positive in Models 5, 7 and 8, the beta (β_i) values also varied in strength. The these models beta (β_i) values were the strongest compared to other slack variables and significant (p <0.05). The beta (β_i) values for Financial Slack in Models 10 and 11 (which incorporated squared terms) increased in strength to β_i = .175 and .276 and were
significant (p < 0.01). Within these same models, however, the second order beta (β<sub>i</sub>) values which test for the non-linear relationship between Financial Slack Squared and ROA squared were not significant (p > 0.05). Therefore, does not support the hypotheses of a curvilinear relationship between slack and firm performance measured as ROA.

**Effect of extended time lag (t-2)**

The results of analysis at t-2 years can be found in Appendix 4. Overall, the impact of the extended time lag was considered slight. There were minor reductions in reported R<sup>2</sup> values and almost negligible variations in the validity of the models. The main impact of the extended time lag was on the statistical significance of the slack variable standardised beta (β<sub>i</sub>) coefficients. The confidence with which relationships between the slack variables and ROA reduced. Ultimately, the extended time lag has little impact on the analysis, where effects are seen the extended time lag is seen as detrimental to the validity of the analysis. These are not reported here as these detriments are not substantial, and do not impact the validity tests or the quality of the models to any reportable degree.

**Profits as a Performance Measure**

The following presents the regression models as above in the manufacturing context and when performance is measured using firm pre-tax Profits.

**R<sup>2**

The following examines the R<sup>2</sup> results obtained within the manufacturing context when using Profits as a dependent variable using multiple regression as a statistical analysis technique. The R<sup>2</sup> score of the model determines how well the independent variables are able to predict the dependent variable, in this case Profits.

**Absolute Values**

Figure 30 shows the R<sup>2</sup> results for the regression models using Profits as the performance measure. The models provided a moderate explanation for the variance in firm profits, by achieving R<sup>2</sup> values well above that of the models assess against ROA above. Model 11 achieved the largest R<sup>2</sup> value, explaining 19.8% of the observed variation in Profit. The control model (Model 1) accounted for the least amount of variance (14.9%). Although these values are not large, when considered against the innumerable unpredictable and unquantifiable influences on firm Profits (Capon et al.)
Findings

1990), they were considered a moderately good score. They indicated that the modelled slack variables are moderate indicators of firm performance when measured against Profits in the manufacturing context.

Figure 30: R² results from regression analysis against manufacturing firm Profits (t-1)

Model improvements

The inclusion of additional slack variables provided a notable improvement in the modelled predictability of firm Profits. Figure 30 illustrates that Model 1, the control model, achieved an R² value of 14.9%. Model 4, incorporating HR Slack, increased this to 17.0%. Similarly, Model 7 included Financial Slack and HR Slack to give an R² value of 18.4%; an improvement on the control model of 3.47%. Models 2, 3 and 5 however, were weak at explaining Profits variation, suggesting that Absorbed Slack, Unabsorbed Slack and Financial Slack are all weak predictors of firm Profits in the manufacturing context, providing almost negligible improvements over the control model. Models 10 and 11 incorporated non-linear predictor variables to give a comparatively good indicator of Profits in comparison to the control. Model 10 achieved a R² of 19.15% compared to the control’s 14.9%.

Validity of the model: F-ratio, Durbin Watson, VIF

The validity of the models explaining manufacturing firm Profits were characterised as before.

F-ratio

Table 37 presents the F-ratio results against critical values at a 5% and 1% confidence levels. Of note is that the F-ratio scores here exceeded those of the ROA models in the manufacturing context. Indicating that the models are better at predicting variation in
Findings

Profits than ROA. Each model far exceeded the minimum values required for validity, therefore is considered to be sufficiently valid, and prove that the results obtained from the regression analysis did not occur by chance.

Table 37: F-ratio results of validity using Manufacturing firm Profits as performance variable (t-1)

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
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<tr>
<td>Degrees of Freedom</td>
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<td>9</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>F-ratio result</td>
<td>98.15</td>
<td>89.47</td>
<td>87.67</td>
<td>100.6</td>
<td>90.66</td>
<td>81.48</td>
<td>98.02</td>
<td>81.33</td>
<td>70.78</td>
<td>84.26</td>
<td>64.27</td>
</tr>
<tr>
<td>Critical value</td>
<td>5%</td>
<td>2.02</td>
<td>1.95</td>
<td>1.95</td>
<td>1.95</td>
<td>1.95</td>
<td>1.89</td>
<td>1.89</td>
<td>1.84</td>
<td>1.84</td>
<td>1.68</td>
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<tr>
<td>Critical value</td>
<td>1%</td>
<td>2.66</td>
<td>2.53</td>
<td>2.53</td>
<td>2.53</td>
<td>2.53</td>
<td>2.43</td>
<td>2.43</td>
<td>2.34</td>
<td>2.34</td>
<td>2.06</td>
</tr>
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</table>

Durbin Watson

The Durbin Watson results were poorer than that for ROA (Figure 31) although they remained acceptable in determining the independence of residual error in the models and complied with Gujarati’s (2012) requirement as above. The results demonstrated are valid and meet the assumption of absent correlation between the regression residuals required for analysis.

![Figure 31: Durbin-Watson statistic using Profits as a performance measure (t-1)](image)

VIF

As with the manufacturing context, the test for VIF applies solely to the predictor (i.e. independent) variables, these values do not differ when the dependent variable is changed. The results for this validity test therefore are the same for the analysis of ROA and Profits, therefore, do not require further reporting.

Regression Coefficients

The beta ($\beta_i$) values for Age were not significant and were extremely weak (for instance the $\beta_i$ for Model 4 was -.003). Size was significant ($p < 0.01$) in all models, and positive in direction, and only slightly variable. In Model 1, for example, the beta ($\beta_i$) of .291
indicated that an increase in net assets (i.e. Size) by £13,500 would increase Profits by £440,000. Number of Employees was significant (p < 0.01) with consistent and positive β_i values, ranging from .117 in Model 1 to .203 in Model 11. Model 1, for example, indicated that an increase of 198 employees would increase Profits by £0.18 million.

The β_i values for linear Absorbed Slack were significant (p < 0.01) in all models except Model 8 and the strength of the beta (β_i) values varied but was consistently negative. For example, Model 2 exhibited a beta (β_i) value of -.073 (at p < 0.001) indicating that a 22% increase in Absorbed Slack would reduce Profits by c. £112,000. Beta (β_i) values for Absorbed Slack increased in Models 9 (-.471) and 11 (-.250) which explored the explanation provided by Absorbed Slack squared. In Model 9 the linear and non-linear beta (β_i) values were significant (p < 0.001) with negative first order (β_i = -.471) and a positive second (β_i = .395) order values. In Model 11 however, the Absorbed Slack (first order) and Absorbed Slack Squared (second order) beta (β_i) values were only significant at the p < .05 level. The second order beta (β_i) results from Model 9 and 11 indicated a U-shaped relationship between Slack and Profits, thus supporting Hypothesis 2b (H2b).

For Unabsorbed Slack, the beta (β_i) values were significant in all models predicting Profits, and were consistently positive. As elsewhere within the findings, the beta (β_i) values varied in strength, with a minima of 0.44 in Model 8 (p < 0.01). Model 3 (β_i = .053) predicted that an increase in Unabsorbed Slack (i.e. Quick Ratio) by 1.84 results in a c. £81,000 increase in Profits. Models 9 and 11 included second order beta (β_i) coefficients for Unabsorbed Slack Squared, to test for a non-linear relationship. In Model 9 the beta values were first order positive (β_i = .220) for Unabsorbed Slack and second order negative (β_i = -.174) for Unabsorbed Slack Squared. The negative second order coefficient indicates an inverse U-shaped relationship (∩) between slack and performance, in this case Profits, thus supporting hypothesis 1b (H1b).

HR Slack beta (β_i) values were negative and significant at the .01 level in Models 4, 7 and 8, ranging from -.172 to -.199. A beta (β_i) value of -.173 in Model 7 indicated that an increase of 4.55 employees per £1,000 of turnover (the calculation of HR Slack) would reduce Profits by roughly £138,000. In Model 10 the beta (β_i) value for linear HR Slack was -.337 while in Model 11 it was -.315 (p < 0.001). In Model 10 and 11, included second order beta (β_i) coefficients for HR Squared, to test for a non-linear relationship. The beta values for Model 10 were; first order negative (β_i = -.337, p <
Findings

0.001) for HR Slack and second order positive ($\beta_i =.172$, $p < 0.001$) for HR Slack Squared. The positive second order coefficients support a U-shaped relationship between HR Slack and Profits, thus supporting hypothesis 2b (H2b).

Financial slack was significantly ($p < 0.001$) and positively correlated with Profits in Models 5, 7 and 8, but was not in Models 10 and 11. In Model 5 the beta ($\beta_i$) value was only 0.090. Consistent with the predictors of Profit elsewhere, the beta ($\beta_i$) values for Financial Slack in Models 10 and 11 were not significant ($p > 0.05$). However, the second order beta ($\beta_i$) values for Financial Slack Squared in these models were significant ($p < 0.001$) and positive ($\beta_i = .234$ in Model 10 and .171 in Model 11). This indicates a U-shaped relationship ($\cup$) between Financial Slack and Profits, thus supporting Hypothesis 2b (H2b).

Effect of extended time lag (t-2)

The results of tests at t-2 are presented in Appendix 4. Overall, the impact of the extended time lag is somewhat negligible. Slight reductions in the $R^2$ scores are notes, and very minor changes to the validity tests of the models are demonstrated. The most critical impact is to the confidence level of the beta ($\beta_i$) coefficients of the slack variables, which are reduced at the extended time lag, but not to a degree that negates the results detailed above. Ultimately, the extended time lag has little impact on the analysis, where effects are seen the extended time lag is seen as detrimental to the validity of the analysis.

Summary of Slack in a Manufacturing Context

The following discussion compares regression model ability to predict firm performance when measured as ROA and Profits in the manufacturing sector.

$R^2$ Summary

$R^2$ results varied by the performance measure selected. The $R^2$ results using ROA as a dependent variable were much lower than those using Profits as a dependent variable. This indicates that the proposed models, and the variables within then, are better at predicting variation in firm Profits than firm ROA.

The improvements in $R^2$ score across models did not match across contexts. The $R^2$ scores for ROA did not exhibit the same patterns of change as the $R^2$ scores for Profits as a performance measure. Using as ROA the dependent variable, the addition of
Unabsorbed Slack and Financial Slack variables to the regression models provided the greatest increase in $R^2$ (recall Figure 28). When considering performance as Profits, however, HR Slack improved $R^2$ the most rather than other variables. This indicates that manufacturing firms generate ROA and profits from different pools of resources. HR Slack can predict profits, while ROA is more predictable using Unabsorbed and Financial Slack. A comparative analysis of the $R^2$ results is conducted in Chapter 7 (Section 7.2), examining how different models improve the predictability of variation in firm performance, and the discrepancies across contexts.

Model Validity
All the regression models were valid; satisfying Durbin-Watson, VIF and F-ratio requirements. Models predicting Profits far exceed the minimum critical values of F. Although lower values were demonstrated by ROA models, they were still valid by a considerable margin. For instance, Model 1 yielded an F statistic of 22.56; far exceeding the required minimum critical value of 2.66. All the models yielded Durbin-Watson statistics close to the optimum value of 2 and within the boundaries taken from Gujarati (2012). For models predicting Profits and those predicting ROA, VIF results were acceptable. In both situations, Models 1 to 8 maintained a VIF value below the maximum critical value. Models 9, 10 and 11 exhibited VIF values greatly in excess of this maximum value but this was determined the result of collinearity between squared slack variables and not the linear slack variables themselves. This VIF outcome was therefore rejected.

Coefficients Summary
The beta values produced within the regression analysis varied depending upon the performance variable measured, yet some commonalities could be found across the analysis.

Among the control variables, Age was demonstrated as generally having a non-significant relationship with both performance variables (ROA and Profits), preventing further analysis. Where significant beta ($\beta_i$) values were found, correlations were weak and negative in direction. Size had a significant, positive beta ($\beta_i$) value against firm Profits however against ROA, its beta value was not consistently significant and varied in direction from positive to negative. The final control variable, Number of Employees exhibited significant ($p < 0.001$) and positive beta ($\beta_i$) values across all regression
models in which Profits represented performance. On the other hand, for ROA the beta values for this variable were significant ($p < 0.001$) but negative.

**Absorbed Slack** had a negative, significant relationship ($P < 0.001$) with firm performance measured as either ROA or Profits. Beta ($\beta_i$) values for first order (linear) Absorbed Slack were consistently negative across all models when performance was measured by ROA or by Profits. Second order (non-linear) beta ($\beta_i$) coefficients were consistently positive across all models when performance was measured by ROA or by Profits. Significant second order beta ($\beta_i$) coefficients (Absorbed Slack Squared) support a U-shaped relationship ($\cup$) between Absorbed Slack and firm performance when measured by ROA and when measured by Profits. These results provide support for hypotheses 2a and 2b.

**Unabsorbed Slack**, demonstrated significant ($p < 0.001$), positive first order (linear) beta ($\beta_i$) values across all models for both ROA and Profits. For Profits, the role of Unabsorbed Slack was relatively weak compared to control variables like Size and Number of Employees yet, for ROA, the beta ($\beta_i$) values were comparatively strong. The second order (non-linear) beta ($\beta_i$) values (Unabsorbed Slack Squared) were consistently negative across all models for ROA and Profits. The latter relationships support an inverse-U shaped relationship ($\cap$) between Unabsorbed Slack and firm performance when measured by ROA and when measured by Profits. Thus, supporting hypotheses 1a and 1b.

**HR Slack** demonstrated consistently negative and significant ($p < 0.05$) beta ($\beta_i$) values against ROA and Profits. They were comparatively very strong compared to other slack variables against Profits, but weaker against ROA. The second order (non-linear) beta ($\beta_i$) values were consistently positive across all models and performance variables and significant ($p < 0.001$) against Profits but not significant against ROA. This supported a U-shaped relationship ($\cup$) between HR Slack and firm performance when measured by Profits, this supports hypothesis 2b.

**Financial Slack** exhibited consistently positive and significant ($p < 0.001$) beta ($\beta_i$) values for the first order coefficients. The second order (non-linear) beta ($\beta_i$) variables were consistently negative across all models and performance variables ($p < 0.05$ against Profits). These beta ($\beta_i$) values however, were non-significant ($p > 0.05$) against ROA, indicating a positive linear relationship between financial slack and firm ROA.
Against Profits, *Financial Slack Squared* provided significant, supporting beta ($\beta_i$) values ($p < 0.05$). This provides support for an inverse-U shaped relationship ($\cap$) between *Financial Slack* and firm Profits, supporting hypothesis 1b (H1b)

### 6.4 Conclusion

This chapter provided a detailed analysis of the data results generated from the statistical analysis of both the construction and manufacturing contexts, following the research design detailed in Chapter 5. This chapter examines the descriptive statistics, correlation analysis and finally the multiple regression analysis results, from which a number of conclusions can be drawn.

Within both contexts, the proposed multiple regression models were more capable of explaining the variation of firm Profits, than the variation of firm ROA. Within both the construction and manufacturing regression analysis larger R$^2$ scores were obtained for the models using Profits as a dependent variable. This indicates that the variables chosen were more suitable for the examination of Profits, and that there are other factors that explain the variation firm ROA that are not accounted for in the models. However, this does not indicate the extent to which ROA or Profits is more suitable as a proxy for innovation, only that the proposed models were able to explain more variation of firm Profits’ than firm ROA.

The multiple regression analysis of the construction context revealed highly statistically significant results, which support the slack-performance relationship, which is used as a proxy for the slack-innovation relationship. Using ROA as the dependent variable, the results demonstrated significant ($p <0.001$) negative second order (non-linear) standardised beta coefficients for unabsorbed slack. Which provides support for hypothesis 1a (H1a), by demonstrating an inverse U-shaped relationship between unabsorbed slack and firm performance ($\cap$). This was further replicated for *Financial Slack* as a predictor variable, which demonstrated significant ($p <0.05$) negative second order coefficients. The independent variable *Absorbed Slack* established significant ($p < 0.001$) negative first order (linear) standardised beta coefficients. This provides evidence for a negative relationship between *Absorbed Slack* and firm performance when measured as ROA. However, this does not provide support for either hypothesis (H1a or H2a), as only a linear relationship is established. *HR Slack* did not provide significant beta ($\beta_i$) values ($p > 0.05$); therefore do not support either hypothesis.
Using Profits as a dependent variable, the results also demonstrated statistical significant (p < 0.01) results. Both Absorbed Slack and HR Slack provided significant positive second order (non-linear) standardised beta coefficients. Which provides support for hypothesis 2b (H2b), by demonstrating a U-shaped relationship between slack and firm performance measured as Profits (∪). For variables Unabsorbed Slack and Financial Slack, significant (p < 0.01) negative second order (non-linear) standardised beta coefficients were generated. Which provides support for hypothesis one (H1b), by demonstrating an inverse U-shaped relationship between unabsorbed slack and firm performance when measured as Profits (∩).

While the focus was placed upon the construction context within this research, the manufacturing context was also examined to provide a baseline to examine compare the information gathered in the construction context against. The multiple regression analysis of the manufacturing context also revealed highly statistically significant results, which support the slack-performance relationship, which is used as a proxy for the slack-innovation relationship. Against both ROA and Profit as dependent variables, for Unabsorbed Slack the results demonstrated significant negative second order (non-linear) standardised beta (βi) coefficients. Which provides support for hypotheses proposed in this thesis (H1a and H1b), by demonstrating an inverse U-shaped relationship between unabsorbed slack and firm performance (∩). Contrary with this Absorbed Slack provided significant (p < 0.01) positive second order (non-linear) standardised beta (βi) coefficients. Which provides support for hypothesis 2a and 2b (H2a and H2b), by demonstrating a U-shaped relationship between slack and firm performance (∪) for both ROA and Profits. HR Slack reveals a U-shaped relationship (∪) with Firm Profits demonstrating significant positive second order (non-linear) standardised beta (βi) coefficients with Profits as a performance variable, supporting hypothesis 2b (H2b). Finally, Financial Slack demonstrates a negative second order coefficient against firm Profits supporting Hypothesis 1b (H1b).

The control variables; Age, Size, number of employees and firm type were also seen to impact firm performance. Age is seen to be statistically significant (p < 0.05) and negative predictor of both firm ROA and Profits’ in construction; however, is non-significant in the manufacturing context. The size of the firm demonstrated significant (p < 0.001) positive standardised beta (βi) coefficients against firm Profits, but not
against ROA for both construction and manufacturing. The number of employees in the firm established highly significant a positive relationship with firm profits for both contexts, but for ROA was non-significant in construction and negative in manufacturing. Finally firm type did not provide any significant relationship against Profits as a dependent variable within the construction, but demonstrated that the type of firm does dictate firm ROA within the construction context.

This part of the research included ‘peripheral’ construction firms within the construction sector sample. Whilst it could be argued that this might detract from the suitability of the results to ‘core construction’ firms, it is maintained that ‘construction’ cannot continue to be defined so narrowly to include only ‘core construction’ firms. This research sought to test the slack-innovation outcome relationship on a broader array of firms in not just ‘core construction’ firms, but also firms that support and develop construction innovations. The broader conceptualisation of the construction sector used as population for this study followed BIS (2012) an economic analysis of the construction sector. As noted within this thesis academics support broadening constructions’ boundaries for example; Barrett et al. (2007) and (Reichstein et al. 2005).

The results for the construction context apply to not only the core construction firms, but also products and service firms as dictated in Appendix 1. The inclusion of what might be considered ‘peripheral’ firms also adds to the construction sample quantity surveying and design activities which are an essential part of construction (Reichstein et al. 2005). The firms included within the sample are firms that interact, and form the ‘construction sector’ (see Section 1.3.) and are therefore, relevant to construction as a whole.
Chapter 7. Analysis Study 1

7.1 Introduction

Within the previous chapter, an extensive analysis was conducted in the construction and manufacturing contexts following identical research designs. This analysis examined the data using several statistical techniques, most importantly multiple regression in order to test the relationship between the presence of slack and firm performance. The results for each context, indicating the quality of the models, comprised the strength and direction of the relationship between slack types and firm performance, as an indicator for innovation outcomes.

This chapter provides a comparative analysis of these results to extract a more detailed understanding of their meaning and importance. The discussion uses the manufacturing context as a baseline against which results in the construction context are compared. Differences in the results previously indicated that construction and manufacturing firms generate performance from differing slack resource profiles. Finally, the regression coefficients achieved are compared against each other and relevant literature.

7.2 Comparison of Regression Model Quality

The following section discusses the quality of the regression models in terms of their ability to predict variation in the observed measures of performance. To build on the prior analysis, the following compares results obtained in the manufacturing and construction contexts.

The $R^2$ results reveal how much of the variance observed in the dependent variable is explained by the regression model. When comparing models, $R^2$ values can indicate the extent to which revisions to model structure improves the ability of the model to predict the variation in the dependent variable, in this case performance. By comparing the $R^2$ results of an individual model when applied in manufacturing and construction contexts, the researcher can gain insight into model validity in each context. With this in mind, Figure 32 and Figure 33 illustrate the $R^2$ results of the regression analysis in the manufacturing and construction contexts for performance variables ROA and Profits respectively.
The figures illustrate that the $R^2$ results for the manufacturing context were consistently well above those of the construction context. $R^2$ values from the control model (Model 1) through all of the subsequently more complex models which included linear and non-linear variables (Models 2-11) shows that these models were consistently more accurate at predicting the performance of manufacturing firms than construction firms. This was a critical insight as it indicated that the models, and possibly the analytical approaches within them, were more suitable for analysing manufacturing firms than construction firms. Additionally, by also indicating the extent to which slack dictates firm performance, and consequently innovation as the underlying driver of firm performance, these models suggested that the influence of slack is not as prominent in construction firms as it is in manufacturing firms. Therefore, it could be argued that, within a construction context, a different approach must be taken to examine slack in construction. Research into identifying more appropriate slack predictor variables might be necessary to ensure higher quality models. On the other than this discrepancy might be explained the functions of slack not operating in the same manner in construction as they do in manufacturing. Further insight revealed that variance in Profits could be predicted with more accuracy than ROA. Therefore, it can be asserted that the regression models are more appropriate for examining variance in firm Profits than firm ROA.

![Figure 32: Comparison of $R^2$ results, Profits](image_url)
Improvements in the $R^2$ results as models became more complicated were of further interest, as were variations in $R^2$ results between model contexts. Figure 32 illustrates the results for Profits. It demonstrates that larger $R^2$ results occur with the same steps in model complexity in the construction context as in the manufacturing context. This is most evident in Models 4, 7 and 8. Specifically, this indicates that construction and manufacturing firms must generate Profits using the same resource profile, namely by using predominantly HR Slack (Model 4, 7 and 8 all include HR Slack).

In contrast, the $R^2$ results for ROA (Figure 33) do not emulate each other in the construction and manufacturing contexts. The manufacturing context demonstrates larger $R^2$ results in Model 3 and Model 5: models that added Unabsorbed Slack and Financial Slack respectively. However, this was not replicated in the construction context. Instead, in construction, the largest $R^2$ results are in Model 6 when Absorbed Slack and Unabsorbed Slack variables were added alongside each other.

In summary, the lack of commonality in the slack variables found to be driving ROA between construction and manufacturing implies that firms in these contexts draw upon different types of slack resources to generate performance. However, when generating Profits specifically, both industries consumed similar slack resources in, to the extent visible to an econometric analysis at least, similar ways. It is contended that construction firms generate firm profits through a combination of Absorbed and HR Slack, while ROA is generated through a combinations of Absorbed and Unabsorbed Slack. Which indicates that there is reliance upon absorbed slack to improve performance, while the dependence on other resources is dependent upon the manner of improvement in question.
The fact that the regression models explained a lower extent of the variance present in both ROA and in Profits in construction than they did in manufacturing suggested that the econometric approach of the preceding chapter might not be as suited to characterising the relationship between slack and performance in construction as it is in manufacturing. What can be clearly ascertained, however, is that the impact of slack on firm Profits is more apparent than on ROA irrespective of the sector examined. Furthermore, the construction firm’s ability to generate higher ROA differs from that of manufacturing firms, drawing upon different resource profiles. However, both contexts generate Profits in comparable ways, drawing upon similar resource Profiles. Thus, much of the finding that might be generated regarding the impact of slack largely is reliant upon the correct dependent variables being selected.

7.3 Comparison of Regression Coefficients results

Thus far, this chapter has compared the quality (represented as their ability to explain variance in dependent variables) of the model results between the manufacturing and construction contexts. It has also compared these results to the literature. This section addresses the regression analysis results to compare the beta coefficients (β) values obtained between the manufacturing and construction contexts. These values represent the effect and direction of the independent variables on the dependent variable. The following discusses the direction and shape of the relationships revealed between the predictor slack variables and the predicted performance variables of Profits and ROA.

Table 38 and Table 39 summarise the multiple regression results and the role of Models 9, 10 and 11 in supporting (or otherwise) the hypotheses. The strength of the beta (β) values for the variables are not reported within the tables, as their values varied between models and strength between contexts. Moreover these strength of the effect is less critical than the significance and direction, the hypotheses seek to test the shaped and existence of a relationship between slack and performance, not the strength of this relationship. The following provides a brief summary of the results within the construction context, prior to supporting the relationship with the manufacturing results and matching the results to existing literature demonstrating similar relationships between the slack variables and the dependent variable performance.

The results demonstrated a large number of statistically significant relationships. Table 38 and Table 39 show that Absorbed Slack and Unabsorbed Slack demonstrated
significant ($p < 0.001$) standardised beta coefficients ($\beta_i$) across both ROA and Profits, except for *Absorbed Slack* for ROA ($p < 0.01$) and *Unabsorbed Slack* for Profits (n.s.). More importantly in terms of the study hypotheses, the relationships between predictor slack variables (in their non-linear form) and Profits were of the same type for construction and manufacturing firms, although the confidence levels were higher in most cases for manufacturing. Significant relationships with non-linear slack variables were generally absent when attempting to predict performance as ROA, excluding *Unabsorbed Slack* in construction firms ($p < 0.001$) and *Unabsorbed Slack* and *Absorbed Slack* in manufacturing firms ($p < 0.001$ and $p < 0.01$, respectively).

Table 38: Summary of beta coefficients from regression analysis, construction

<table>
<thead>
<tr>
<th>Variable</th>
<th>ROA</th>
<th>Profits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+/- Significance</td>
<td>Relationship</td>
</tr>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Size</td>
<td>-ve</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>No of Employees</td>
<td>-ve</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>Models 2-8</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>-ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>+ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>HR Slack</td>
<td>-ve</td>
<td>n.s.</td>
</tr>
<tr>
<td>Financial Slack</td>
<td>+ve</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>Models 9-11</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed Slack$^2$</td>
<td>+ve</td>
<td>n.s.</td>
</tr>
<tr>
<td>Unabsorbed Slack$^2$</td>
<td>-ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>HR Slack$^2$</td>
<td>+ve</td>
<td>n.s.</td>
</tr>
<tr>
<td>Financial Slack$^2$</td>
<td>-ve</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Table 39: Summary of beta coefficients from regression analysis, manufacturing

<table>
<thead>
<tr>
<th>Variable</th>
<th>ROA</th>
<th>Profits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+/- Significance</td>
<td>Relationship</td>
</tr>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-ve</td>
<td>n.s.</td>
</tr>
<tr>
<td>Size</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>No of Employees</td>
<td>-ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td><strong>Models 2-8</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>-ve</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>+ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>HR Slack</td>
<td>-ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Financial Slack</td>
<td>+ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td><strong>Models 9-11</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed Slack$^2$</td>
<td>+ve</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Unabsorbed Slack$^2$</td>
<td>-ve</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>HR Slack$^2$</td>
<td>+ve</td>
<td>n.s.</td>
</tr>
<tr>
<td>Financial Slack$^2$</td>
<td>-ve</td>
<td>n.s.</td>
</tr>
</tbody>
</table>
Within the construction context, when predicting ROA as the dependent variable, the results (recall previous chapter) established that *Unabsorbed Slack* shares an inverse U-shaped relationship (∩) with ROA, demonstrating significant (p < 0.001) positive first order ($\beta_i = .278$) and negative second order ($\beta_i = -.209$). The significant negative second order coefficient demonstrated an inverse U-shaped relationship (∩), thus supporting Hypothesis 1a. *Absorbed Slack* also demonstrated a significant (p < 0.001) and negative first order ($\beta_i = -.078$) coefficient. Its second order coefficient was not significant.

As *HR Slack* and *Financial Slack* did not provide a significant relationship or an improvement in model quality, they were considered to be inappropriate for examining ROA in the construction context and were therefore rejected from further analysis using ROA as a performance variable.

Using Profits as the dependent variable in construction firms, the results demonstrated that all slack variables provided a significant curvilinear relationship. *Unabsorbed Slack* and *Financial Slack* demonstrated an inverse U-shaped relationship (∩) with a significant (p < 0.001 and p < 0.01 respectively) negative second order coefficients ($\beta_i = -.130$ and -.152 respectively). This supports Hypothesis 1b. *Absorbed Slack* and *HR Slack* demonstrated a U-shaped relationship (∪) with Profits, demonstrating a significant positive second order coefficients ($\beta_i= .315$ and .145), supporting Hypothesis 2b.

Within the manufacturing context, comparable relationships to those within the construction context were demonstrated. As within construction, *Unabsorbed Slack* demonstrated significant (p< 0.001) negative second order coefficients ($\beta_i= -.276$). Therefore, supporting an inverse U-Shaped relationship with ROA, and supporting Hypothesis 1a. Absorbed Slack demonstrated significant positive second order coefficients ($\beta_i = .363$, p < 0.01) against ROA in the manufacturing context, supporting Hypothesis 2a. This relationship was not demonstrated in construction. *HR Slack* and *Financial Slack* did not provide a significant curvilinear relationship against ROA.

When using Profits as the dependent variable in manufacturing firms, the results demonstrated were comparable to those within the construction context, with all slack variables providing a significant curvilinear relationship. *Unabsorbed Slack* demonstrated an inverse U-shaped relationship (∩) with a significant (p < 0.001)
negative second order coefficients ($\beta_i = -0.130$). This supports Hypothesis 1b. *Absorbed Slack* and *HR Slack* demonstrated a U-shaped relationship (∪) with Profits, demonstrating a significant ($p < 0.001$) positive second order coefficients ($\beta_i = 0.224$ and $-0.160$), supporting Hypothesis 2b. These matching coefficient results across contexts, using profits as a dependent variable, coincide with the matching of the $R^2$ results in Section 7.2. In contrast to the findings in constructions, financial slack demonstrated significant ($p < 0.01$) positive second order coefficients within the manufacturing context. Which supports a U-shaped relationship, and thus Hypothesis 2b, however, this is at odds with the findings from the construction context. The results from the regression analysis is summarised further in Table 40 below. As discussed above, the results indicate a number of shared relationships between slack and performance across contexts. It can be clearly seen below that similar relationships are demonstrated across contexts when using Profits as a dependent variable.

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Construction</th>
<th>Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ROA</td>
<td>Profits</td>
</tr>
<tr>
<td>Absorbed Slack</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>Positive</td>
<td>-</td>
</tr>
<tr>
<td>HR Slack</td>
<td>-</td>
<td>Negative</td>
</tr>
<tr>
<td>Financial Slack</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

$Absorbed Slack^2$ - $\cup (H2b)$ $\cup (H2a)$ $\cup (H2b)$

$Unabsorbed Slack^2$ - $\cap (H1a)$ $\cap (H1b)$ $\cap (H1a)$ $\cap (H1b)$

$HR Slack^2$ - $\cup (H2b)$ - $\cup (H2b)$

$Financial Slack^2$ - $\cap (H1b)$ - $\cup (H2b)$

7.4 - Chapter Summary

This chapter engaged with a comparative analysis of the results from the construction and manufacturing contexts, and a comparison of results to prior literature.

This chapter provided evidence that constructions firms draw from the same resource base as manufacturing firms in order to support Profits, evidenced by increases in the $R^2$ results in corresponding models. This however, was not replicated when using ROA as the dependent variable. Despite some low $R^2$ results, the results within this research matched with prior literature, and were accepted as being able to explain a satisfactory
amount of variation in performance. This chapter reveals that the research method within this thesis provides higher quality models for manufacturing firms than for construction firms. Although this was proposed that this gap difference (based upon $R^2$ values) was because the research method was unsuitable for the construction context. It was revealed this gap difference was the result of failure of the control variables to explain variation in firm performance, as opposed to the failure of the slack variables, resulting in a difference in $R^2$ between construction and manufacturing.

This chapter also examined the coefficient of the slack variables across contexts and against existing literature. Using ROA as the dependent variable, negative second order (non-linear) standardised beta coefficients for *Unabsorbed Slack*. Which provides support for Hypothesis 1a (H1a), by demonstrating an inverse U-shaped relationship between *Unabsorbed Slack* and firm performance ($\cap$). No other significant curvilinear relationship was established.

Using Profits as a dependent variable, the results also demonstrated statistically significant results. Both absorbed slack and human resource slack provided significant negative first order (linear) and positive second order (non-linear) standardised beta coefficients. Which provides support for Hypothesis 2b (H2b), by demonstrating a U-shaped relationship between slack and firm performance ($\cup$). For variables unabsorbed slack and financial slack, significant positive first order (linear) and negative second order (non-linear) standardised beta coefficients were generated. Which provides support for Hypothesis 1b (H1), by demonstrating an inverse U-shaped relationship between unabsorbed slack and firm performance ($\cap$).

Ultimately, this research has established support for Hypotheses 1a, 1b and 2b within the construction context; this is supported by the replication of the coefficients within the manufacturing context, and existing literature that also suggests conflicting results. Therefore, the results are inconclusive to some degree. However, it is maintained that *Unabsorbed* and *Financial Slack* validate an inverse U-shaped relationship between slack and firm performance ($\cap$), while *Absorbed* and *HR Slack* established a U-shaped relationship between slack and firm performance ($\cup$).
Chapter 8. Analysis Study 2: Inductive Research

8.1 Introduction
This chapter presents the analysis of Study 2, which followed the inductive research approach to collect primary source data. The data was collected through transcribed semi-structured interviews; each interviewee represented a firm type within the construction sector. In addition to the interviews, small amount of firm data is provided to distinguish each interviewee.

8.2 Data
The semi-structured interviews were conducted to be used as the primary means for data analysis for the inductive research strategy in Study 2, alongside the econometric investigation for Study 1 detailed in Chapter 5. The interviewees each represented a type of firm within the construction sector: Construction, Civil Engineering, Specialists, Service or Products, as defined in Chapter 1 using SIC (O.N.S 2007) and BIS (2013). In addition to the semi-structured interviews that followed the prompt sheet in Appendix 4, information about each interviewee was gathered in order to obtain the years respondents have worked within construction, their current role and their years with their current employer. In order to understand the environments of the interviewees further, a range of informative data was gathered for each firm. This included information on the size and turnover of the firm. This information is provided below in Table 40.

8.3 Respondent Relevance
Each interviewee was identified as a key member of the management staff within their own firm. As such, they were considered heavily involved within the management structure, aware of many facets of the firm, and where possible directly involved with initiatives associated with innovation. Furthermore, their positions are likely suitable for assessing and measuring the amount (or lack) of slack within the organisational system. Although speculation of the level of slack within the entirety of the firm might not be possible for some of the larger firms, understanding of the sub-unit in which respondents are involved was considered sufficient.
8.4 Analysis technique

Interviews were collected, recorded and transcribed *verbatim*, while a semi-structured interview style was used. The interviews were conducted over telephone with participants. To aid the direction of the conversation and ensure that the correct concepts were discussed a question prompt sheet was developed and given to participants prior to the interview process (Appendix 4). Following the transcription of the interviews, the data was examined using a coding system (Appendix 5) and then analysed. This system was used to identify the propositions made by the interviewees, and then interpreted and developed for analysis. The coding was not used as a form of quantitative analysis, simply as a means of labelling key features of the discussion.
## Table 41: Interview Respondent Information

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Industry Represented</th>
<th>Firm Role</th>
<th>Role within firm</th>
<th>Years in Industry</th>
<th>Years in Firm</th>
<th>Interview Length (min)</th>
<th>Firm Turnover</th>
<th>Firm Size (Number of Employees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction</td>
<td>Construction and Property Service</td>
<td>Pre-Construction Director</td>
<td>26</td>
<td>20</td>
<td>45</td>
<td>£500-600 million</td>
<td>1,800</td>
</tr>
<tr>
<td>2</td>
<td>Civil Engineering</td>
<td>Civil Engineering and Building Contractor</td>
<td>Building Director</td>
<td>40</td>
<td>8</td>
<td>50</td>
<td>£15 million</td>
<td>60-65</td>
</tr>
<tr>
<td>3</td>
<td>Specialist</td>
<td>Insulation Specialist</td>
<td>Product Development Manager</td>
<td>3</td>
<td>3</td>
<td>60</td>
<td>£120 million</td>
<td>380-400</td>
</tr>
<tr>
<td>4</td>
<td>Services</td>
<td>Steel Fabricator</td>
<td>Quality, HR and Safety Director</td>
<td>4</td>
<td>3</td>
<td>42</td>
<td>£6 million</td>
<td>50-55</td>
</tr>
<tr>
<td>5</td>
<td>Products</td>
<td>Exterior Lighting</td>
<td>Technical Director</td>
<td>19</td>
<td>11</td>
<td>64</td>
<td>£20-24 million</td>
<td>190-200</td>
</tr>
</tbody>
</table>
8.5 Analysis

The following details the responses of interview respondents relating to the key areas discussed within the thesis; Innovation, Organisational slack and Firm Performance. Participants were questions about their understanding and knowledge of the above topics, and furthermore how they associate the concepts to one another.

Discussions regarding innovation were used to support the assumptions within the thesis used in order to generate the econometric analysis in Study 1. The opportunity to discuss the concept of slack directly with practitioners also allowed for a brief examination of their environment and the resonance of the concept of slack. The following section breaks down the interviews based upon the topics discussed and positions adopted within the thesis to allow corresponding comments from respondents to be compared and critiqued.

8.5.1 Innovation in construction

Defining the concept of ‘innovation’ and its resonance with respondents

Each interviewee was questioned on their understanding and interpretation of the concept of ‘innovation’. Using the adopted definition within this thesis, respondents were questioned about the definition’s suitability to their interpretations, and amendments they would make. Overall, each respondent found that the selected definition of innovation matched their own and their firms view of innovation. Thus, demonstrating that the selected definition of innovation from Barrett & Sexton (2006) resonates within construction firms therefore is a valid representation of innovation for use within this thesis. Although this might be considered a cursory inquiry, it was necessary to ensure a shared interpretation of innovation between the researcher and respondents. Respondent 3 offered an alternative, but very similar interpretation of the concept of innovation, where innovation is represented by both the adoption and generation of new ideas:

“So if the innovation is internal or external is immaterial...A lot of people think of innovation like something extremely new which has been done before. But in this, if it is new for a company, then the company itself has to change it doesn’t matter if it is an adoption of an existing process out there as it’s in innovation for the company itself” (Respondent 3)
Further to this, the respondent also maintained the firm view of innovation, and the firm as a boundary for analysis, based upon his environment.

“In a job environment I would go with the company view” (Respondent 3)

This follows closely to the work summarised in Chapter 2 Section 2.4, when discussing the boundary of novelty in the definition of innovation. The evidence within this research demonstrated that practitioners agree with the selected definition and interpretation of firm level innovation. This provides further support for the selected definition. Additionally this also supports the examination of innovation at the firm level, as practitioners operate and perceive their environment from the firm perspective as indicated by Respondent 3 above.

➢ Approaches innovation in construction

Firms were questioned regarding the firm level approaches to innovation and how the firm engages with innovative activities. This gave the researcher insight into the mechanisms of innovation within each of the firms. The respondents provided varied perspectives to one another, where innovative activities were idiosyncratic to the firm, and the nature of their specialisation.

Respondent 1 and Respondent 5, both members of larger firms, were shown to have task forces and “rainbow meetings” to support innovation, which supports the generation of bottom-up information flow, in order to address problem solving. The respondents encouraged innovative behaviour from individuals, by allowing and demonstrating changes that could occur. Smaller firms, such as those represented by Respondent 2 and 4, were described by themselves as being less or non-innovative, where innovation and change was not a frequently desired objective. Despite this, Respondent 2’s answers were insightful, reasoning that to some degree innovation occurs consistently in construction, due to the novelty of every project:

“I always describe construction as a problem-solving activity anyway; rarely do you do a job where you not are confronted by something you have not done before” (Respondent 2)

Like Respondent 2, other respondents saw problem solving as their predominant form of innovation. Respondent 5, looked to innovation as “identifying problems within the
business and then fixing those”, while Respondent 1 used task forces to address “problems we have encountered across a number of projects or product types.”

**The Purpose of innovation**

Chapter 2 of this thesis characterised construction firms as innovation adopting organisations that utilised innovation as a means to support further organisational goals. Chapter 4 extended this perspective to propose firm performance as a suitable proxy measure of innovation outcomes in light of an inability to measure innovation in the construction context. To further investigate and test these assumption respondents were asked for their perspective on the purpose of innovation for the firm, and the measurement of innovation.

Overall respondents identified that the purpose and driver of innovation was that it represented a means of ensuring competitiveness and survival of the firm within the marketplace. This was voiced clearly by Respondent 1 below:

“In a competitive market if you do things that we did yesterday you will be out of business in five weeks flat.” (Respondent 1)

And repeated by Respondent 5

“If you’re standing still you’re going backwards... it’s the sort of Formula One - type attitude. Everybody else is moving forward and you have to move forwards too.” (Respondent 5)

Each respondent saw innovation as essential to his or her business, and something that if not maintained would jeopardise firm survival, indicating an innate want to innovate when necessary. However, beneath this desire for survival, firms were motivated to innovation from different sources. Respondent 4, a member of a steel fabrication firm, perceived the firm as “non-innovative”, due to the nature of their work. The discussion illustrated and environment where innovation was heavily client led, and reactive to client demands. Similarly, Respondent 2, a civil engineering contractor, presented a similar perspective on innovation within the firm. However, both respondents were willing to innovate in terms of new products and processes for a contract. Remarking on the firms’ approach to innovation, Respondents 4 and 2 said:
“We make what the people want…We make what the customer wants, so that’s where our innovation DOESN’T come from…innovation isn’t really one of our major things.” (Respondent 4)

“I think you tend to respond to it [new ideas], because someone asked for it [new ideas]” (Respondent 2)

Measuring Innovation

A central issue to this thesis as discussed in Section 4.7 was that innovation could not be accurately measured or represented within the construction context. Traditional measures such as R&D expenditure and Patents were argued to be ineffective indicators of innovative activities, innovation or the impact of innovation. This was reasoned to be, in part, due to the complexity of innovation (Damanpour et al. 1989) and its incommensurability on some level, preventing innovation to be quantified (Smith 2004). In addition, innovation in construction is typically ‘hidden’ from standard measures due to its incremental nature (Barrett et al. 2007; Harris & Halkett 2007). This proposition led to the development of firm performance (ROA and Profits) as a proxy measure for innovation outcomes.

Coinciding with the discussion above, respondents were asked how their firm measured innovation and its outcomes. Overall respondents did not measure innovation directly, if at all, instead looked to outcome or peripheral changes that might occur as a result of a change. This was summarised by Respondent 1, a director of a major Construction firm, when discussing change to safety regulation as an example of innovation:

“I don’t think we have any metrics that reliably tell me the impact of any one innovation… the most sophisticated we get is we introduced X new procedure into our safety manual at such date and what factors that had on our statistics… I don’t think we do anything doing anything more sophisticated that outside core business KPIs.” (Respondent 1)

Respondent 5 was also directly asked about the firms’ use of patents, as a firm specialising in exterior lighting products. The respondent specified the following:

“We don’t use patents. If you are going to have a patent… then the conclusion is that people won’t break it or they will break. If they WILL break it you’ve got to
decide whether you willing to fight the hundred thousand pound court case to stop them using it. Our decision was: no we never can take people to court! So then you wonder why spending £2,000 a year on patents.” (Respondent 5)

This demonstrates that patents are not suitable for measuring innovation in construction, supporting the arguments in section 4.7. Where measures were used, the approaches revealed by respondents were based upon changes to productivity levels (Respondents 4 and 5), or based upon outcomes such as turnover, profitability and Return on Investment (ROI) (Respondents 4 and 5). Respondent 3, a Product Development Manager of a major insulation specialist stated that there were in fact no innovation measurements in place at his firm upon his arrival.

This information indicates that practitioners themselves do not measure innovation using traditional measures such as R&D or Patents, instead look towards the outcome of innovation as an indicator. To measure these outcomes, as presented within the thesis at a firm level, respondents chose to identify firm level performance measures. This indicates that the unsuitability of traditional innovation measures as discussed within the thesis is a valid representation of how firms themselves go about assessing innovation, and its outcomes. This further supports the measurement of innovation outcomes using proxy measures as demonstrated in Study 1.

8.5.2 Organisational Slack

- Resonance of the concept of Organisational Slack

Organisational slack is presented within this thesis as an overlooked concept with regard to innovation in the construction context. Organisational slack is thought to offer an explanation for the discrepancies between the rates of innovation of construction firms. However, organisational slack is still to be explored and tested within the construction context. Organisational slack was defined as “the pool of resources in an organisation in excess of the minimum necessary to produce a given level of organisational output" (Nohria and Gulati 1997:604). This investigation sought to examine the resonance of the concept with practitioners within the construction context.

Respondents were questioned about their knowledge of the concept of slack, be it from literature, or personal experience and application. Further to this, they were questioned about its function as a whole with the firm, in order to test the suitability of its
application to the construction context. Respondents were either aware of the concept, or able to interpret a working understanding of what it entails. Respondents related the concept of organisational slack to “capacity” (Respondent 1 and Respondent 2), “Spare money...spare time...spare people” (Respondent 5), and “Where we’ve got too much stuff” (Respondent 4). The only exception to this understanding of organisational slack was Respondent 3, though this was due to a translation issue that prevented the respondent from providing his own insight without extensive explanation from the researcher. Respondent 1 appeared well versed in the subject, identifying both the availability of people in order to have spare capacity, and also the availability of cash resources to deal with unforeseen problems.

Respondents were also able to identify the importance of slack in the general function of the firm. Slack was seen to be a necessary component of both delivering a high standard of service and innovation. Respondents 2 and 5 saw slack as means to ensure investment in machinery and tooling required to remain competitive. Similarly as stated by Respondent 2:

“I think if you’re committed to delivering service, which is not easy in terms of as perceived by the client then you do need some slack. Because...otherwise, you just can’t respond.” (Respondent 2)

Of critical interest were the statements of Respondent 1, who deliberated about the negative consequences of the presence of slack. Indicating a resonance of both the positive and negative attributes associated with slack. This perspective was shared with Respondent 4, who saw slack as a potential overhead that could price a firm out of the market

“You can’t afford to have dead resources in most cases... does make me think that you need to be careful because too much slack can make you fat lazy and inefficient.” (Respondent 1)

“We are in a competitive market anyway, 1 or 2% [increase in overhead] of can make the difference in winning the losing a job” (Respondent 4)
Exploring the impact of changes in the environment. i.e. Presence of slack or excess resources

This research offered the opportunity to question practitioners directly regarding the presence of organisational slack in their environment, as opposed to relying upon secondary data sources as is Study 1. This research adapted the slack research of Nohria & Gulati (1996) and Troilo et al. (2014), adopting questions from their studies to examine the respondents’ environment in relation to slack and innovation. Prior studies measured a perceived level of slack against a perceived rate of innovation, here the study simply sought to understand how respondents perceived their environment in relation to slack.

Respondents were asked four questions about their environment; firstly the impact of a 10% reduction in staff time, now related to unconnected activities; secondly the impact of a 10% reduction in budget; thirdly the presence of a pool of resources within the firm; and finally the impact of increased profits on innovation.

The perceived impact of changes to the respondents’ environment was typically quite high. Respondents reported from 5% to over 10% change in a special case. The first and second questions were adopted to examine the firms’ capacity or HR slack, and the latter the level cash or financial slack within the firm. Nevertheless, several firms perceived both changes in relation of staff overheads, where reductions in budgets had a large impact than reducing staff time. Respondent 4 reflected on a 10% reduction in budget stating that:

“If we reduce the financial input by 10%, it would definitely be affected. For one thing, we’d have to reduce wages, or lose staff... that 10% reduction would have to be matched by weight reduction or redundancies. “(Respondent 4)

This was an opinion shared by Respondent 2 and 5, who both saw a budget reduction as affecting their overheads, which is predominantly is made up of wage costs. This association as opposed to separation of budget and human resources is likely to be the result of a difference in the nature of industries from where the questions were developed. Construction remains a highly labour intensive activity, which translates to high wage costs for the employers. Therefore, reducing their overall budget was seen to have an equal or greater impact on output than reducing staff time.
The size of the firm, even within this small sample was seen to have an impact on the level of slack within the firm. Smaller firms within the sample, as demonstrated above, perceived changes as affecting the firm more heavily than the larger firms. Respondent 1, with a firm consisting of around 1,800 people, reported only a 5% (or less) reduction in output in the face of either 10% reduction in staff time or budget. This indicates the presence of higher levels of slack, which contradicts the discussion with Respondent 1 who described their firm as a “tight ship”, i.e. efficient. This provides some evidence that larger firms might have a higher level of slack than smaller firms might.

Comparably, Respondent 3 reported that a 10% reduction in budget would have little to no effect on his level of output. This was in part due to the following:

“10% fluctuation in people coming and going is anyway quite normal and it gets hidden in the noise.” (Respondent 3)

Within the discussion of slack throughout this thesis, resources (especially those relating to human resources) are treated collectively and considered homogenous across a firm or organisation within a certain resource type, i.e. all human resources are the same. However, the respondents identified a differentiation within the firm, and the individuals employed and their interaction with slack. This highlights the importance of individuals to managers within the firm. Respondents 3 and 5 both discussed how different employees, despite holding similar roles to their colleagues functioned in a different manner. While some employees work well with freedom, others are less productive. As recognised in the quote below, Respondent 3 saw that

“I have a few people in my team if I were to allow them to do one day or half a day a week... I’m betting the performance from them and the team they work on would actually improve. So I’m definitely a fan of this, however, it is maybe 4 from 20 people.”(Respondent 3)

Similarly, Respondent 2 saw that the resource demand of different projects, and based upon different types of resources, the firm would be impacted differently by changes in slack.

“We have quite a bit of slack in our site management arm, but everyone else’s running round like a scalded cat.” (Respondent 2)
The final question about organisational slack, asked respondents if a sudden increase in profits, would translate into higher levels of reinvestment and innovation. Respondent 5 maintained that the firm was willing to, and had demonstrated investment into innovation, even prior to profits being generated. The respondent went on to describe how investment in the technical department from a pool of resources, led to dramatically increased profits over a period of several years. Respondent 1 indicated a desire to re-invest profits back into the firm to support innovation:

“If we were able to increase our margin on an ongoing basis that would start recycling that back into innovative activities to again improve margin. However, this would be to a point, as the environment we working is a very low margin industry anyway.”

8.5.3 Firm Level Performance

- Measuring Firm Level Performance

As stated within the above sections, firm performance was incorporated as a proxy measure of innovation outcomes. In section 5.10 of the research design for Study 1, the research critiqued a range of possible performance measures. Performance management systems (PMS) such as the Balanced Scorecard (BSC), were identified as popular means of measuring performance (Kaplan & Norton 1992). However, it was argued that PMS are unsuitable for Study 1 due to the variability of measures preventing meaningful cross firm comparisons, and further that the purpose of PMS are to improve business and ultimately maximise profits (Ahmad-Latiffi 2012). Consequently, the study chose ROA and pre-tax Profits as measures of firm performance. To ensure that these were appropriate measures of firm outcomes participants were first questioned about the purpose of innovation (discussed in Section 8.5.1), and later how their firm measures firm level performance.

The respondents typically referred to the use of financial metrics as their main source when measuring firm level performance. Some also suggested the use of project level measures such as program and quality/defects, client satisfaction, however, these were seen to feed back into the desire to generate and maintain a level of profitability. The quotes below taken from each respondent reflect their approaches to firm performance measurement:
“None of them will surprise you things like: profit being the main one I guess, turnover for the volume of business.” (Respondent 1)

“At the end of the day the financial imperative is the most significant” (Respondent 2)

“The only real measurement that is happening within this firm are financial measures” (Respondent 3)

“Bottom line of measurement is financial performance, on a contract by contract basis... There are other peripheral measurements that we do, but there are linked back to the bottom line.” (Respondent 4)

“Overall we measure it as profitability and turnover.” (Respondent 5)

Respondents who indicated the use of alternate forms of performance measurement systems beyond financial, consistently linked their use back to financial performance. For example, Respondent 2, a civil engineering contractor, saw finishing on program as an imperative part of the firm’s reputation and client satisfaction, but also one that gave the firm the best chance of making a profit. In addition to this, whilst the respondents interviewed sought to generate turnover and profits, predominantly each respondent also looked towards long-term profit maximisation and survival, over short-term profit maximisation.

“It’s about being in business next year, in 10 years’ time, in a hundred years’ time. The focus is that not “let’s make a big profit”.

The only exception to this was Respondent 4, a steel fabrication firm, which dealt on a contract-by-contract basis and therefore had slightly shorter outlook on a contract-to-contact basis. However, they too maintained some form of long-term projection.

➢ Associating slack, innovation and performance

The use of semi-structured interviews as a data collection method, offered the researcher an opportunity to strengthen the association between slack, innovation and firm performance by testing how respondents thought the concepts were associated. Respondents were directly asked how slack and innovation impacted the firm.
As with the responses regarding the purpose of innovation, respondents saw innovation as beneficial in supporting firm performance. Respondent 1 thought that innovation plays a “massive role” in supporting firm level performance. Once again respondents articulated a mentality of moving forward with innovation to remain competitive. Respondent 2 stated:

“I think the best phrase really is “you can’t stand still”. You are either going forwards you are going backwards”. (Respondent 2)

Slack was linked to innovation and performance in general terms throughout each interview, where resources (either cash or human) were seen to be part of the innovation discussion. Respondent 4 was clear in indicating the importance of slack to firm performance. The respondent recognised that slack support investment and change within the firm, associated within innovation, which in turn is essential to remain competitive.

“It [Slack] allows reinvestment, which is important... If you don’t reinvest in machinery and people in that kind of thing then your costs will go up and up and up. If your competitors are investing their costs are going down and down... So you price yourself out of the market.”(Respondent 4)

Respondent 5 was wary of the association between slack and the firm, largely due to the nature of the industry and the firm work. The following excerpt from Respondent 5’s interview demonstrates further resonance with the subject of organisational slack, yet also warns of its unsuitability to the construction context, from its origins:

“I think if we were Google, I would really like this idea of creating non-business downtime. To both broaden peoples understanding of the world the market and their technical knowledge. Like creative writing course for engineers would be brilliant, they need to know how to tell a story in a report, and a skill that you need to learn that you don’t learn in engineering. Think those broaden skills help you then do your job. It’s a concept are very much like the theory of, however in the business I’m in, I’m not convinced it would show that there is a benefit of from it” (Respondent 5)
Chapter 9. Discussion

9.1 Introduction

This chapter critically examines the findings of both research studies against the state of previous literature and the understanding of the relationship between slack and innovation. The first two sections address the econometric analysis of Study 1, and seeks to establish consistency with regards to the direction or shape of the slack-innovation outcome relationship. These sections also incorporate the results of the manufacturing analysis to support the rational. Following this, Section 9.4 addresses Study 2 the interview based inductive research. This study is assessed against literature used to support the claims made within the thesis in order to develop Study 1’s Research Design. Following this, the chapter reflects upon the research objectives of this research project, and debates the extent to which these have been satisfied. The results of the two studies are also compared in order to understand the similarities and differences between the results on the perceptions of slack and the quantitative measurement of slack, and innovation.

9.2 Study 1: Matching R² results with literature

The lack of literature and prior research on organisational slack in construction firms provided no base upon which the econometric analysis results could be compared. Therefore, the researcher compares the R² results with traditional slack literature in the manufacturing context.

Within this research project, of note are the low R² results obtained for ROA. The results for construction ranged from 2.3% to 4.3% and for manufacturing from 3.9% to 9.0%. Although the low values from Model 1 were initially a concern, similar results can be found for control models in the literature. For example, Chiu & Liaw (2009) demonstrated R² = 8.9% in a more complex control model incorporating size, age, industry profitability, firm type, and two measures of the firm environment. Although much larger R² values (45.5% - 47.2%) are demonstrated in Tan (2003) in models predicting ROA, however, the author argues that this is the result of strongly correlated variables, which can be identified in the Pearson correlation analysis (Tan 2003:746). This evidence is rejected due to the high level of correlation between variables, inflating the R² results, and failing to meet the underlying statistical assumptions for statistical
analysis (Field 2005). This result therefore is rejected by the author as being valid, and furthermore not comparable to this research.

Further, more complex models incorporating additional slack variables to the control Model 1 considerably improved the $R^2$ results in both contexts for ROA, demonstrating the ability of the slack variable to predict ROA. The $R^2$ values were maximal in Model 11 in both contexts, indicating that organisational slack – when fully characterised by Absorbed, Unabsorbed, HR and Financial Slack – plays an integral role in predicting firm performance, improving the $R^2$ result. For example using ROA as a performance measure within the construction context the $R^2$ results from 2.26% in Model 1 to 4.31% in Model 11, which doubles the $R^2$ result. Similar increases in $R^2$ values are seen in Chiu & Liaw (2009:332), where application of linear and non-linear (squared) slack variables doubled the ability to predict variation an ROA.

Larger $R^2$ values were obtained when predicting Profit as a performance (and dependent) variable. Construction firm $R^2$ values ranged from 7.7% to 11.1% and manufacturing firm values ranged from 14.9% to 19.8%. As with ROA, the $R^2$ results for the regression models of Profits improved as models incorporated additional slack variables. From the literature, comparable results were found. Tan & Peng (2003) also examined pre-tax profits as a performance variable. They produced an $R^2$ value of 69.8% in their complete model incorporating all predictor variables (consisting of Absorbed and Unabsorbed Slack, Size and Age). This unique result however, is due to the predictor variables strongly correlated against the dependent variable (Tan & Peng 2003:1259), and not due to an established theoretical relationship. Therefore, the regression results obtained are inflated, due to high correlation between the variables.

Despite differing from the results of Tan & Peng (2003), this research did not contain highly correlated variables, therefore ensuring the quality of the models. Second, the results using profits as a dependent variable exceed the results using ROA, which are supported in the above. Therefore, the results obtained in this study are considered valid.

Further literature conducting a cross-sectional analysis using Profits as a dependent variable could not be found to link these results to literature. As demonstrated Appendix 2, the majority of studies using Profits as a dependent variable, use panel data analysis, which does not produce $R^2$ values, but an alternative but not comparable statistic.
Although the $R^2$ results are different between the two contexts studied, for Profits it is contended that this is largely due to the difference in the control model (Model 1) across contexts and not the effect of slack variables. Figure 32 illustrates the difference in $R^2$ results between manufacturing and construction firms for each model using firm Profits as the dependent variable. Across all the models the gap difference in $R^2$ values between contexts there is a gap difference from 7.2% to 8.7% between contexts. However, this gap does not vary across models, as different models are used there is only +1.5% variation in the gap difference of $R^2$ result between contexts. This indicates that an $R^2$ gap difference of 7.2% is the result of the difference between the control models (models 1), and no other additional variables. Although the purpose of the comparisons above were initially used to indicate that construction firms and manufacturing firm generate Profits from the same resource profiles. Due to the lack of variation or change in the difference between $R^2$ results across contexts. This also indicates that the entire difference in $R^2$ across contexts is the result of the inability of control variables (Type, Age, Size and Number of Employees), rather than the inability of studied slack variables, to explain variation in Profits in a construction context. Therefore, weakness in the construction regression models in comparison to manufacturing are not due to slack measures but the control variables.

This is not the same as arguing that firms draw from the same or different resource profiles. This conclusion concerns the selected variable measures and the suitability of the incorporated control variables. The conclusion above substantiates the approach taken concerning the slack variables selected and measures as suitable in both a construction and manufacturing context when examining variation in firm Profits. This, however, is not demonstrated when using ROA as a dependent variable. Recalling Figure 33 it can be seen that the trend lines for each context diverge from one another. This indicates that the proposed models are able to predict more variation in ROA in manufacturing than construction, providing further evidence that construction and manufacturing firm generate ROA differently.

### 9.3 Study 1: Matching Coefficient Results with Literature

From Section 7.3, it is clear that there is a large amount of variation between the significance and direction of the relationship between slack and innovation outcomes (measured as firm performance), contingent not only on the slack measure but also on the dependent variable in question. In general, across both contexts, *Absorbed* and *HR*
Slack were seen to support a U-shaped relationship (∪), while Unabsorbed and Financial Slack support an inverse U-shaped relationship (∩).

The following discussion compares these results against literature incorporating the same or comparable measures. The comparisons focus upon prior literature that has adopted the same or comparable measures of slack. It must be noted that the measures used within this research have been used by prior research, but under different variable labels. For example, the quick ratio used here to measure unabsorbed slack, might also be labelled ‘available slack’ for instance in prior literature in (Geiger & Makri 2006).

9.3.1 Absorbed slack

The measure of Absorbed Slack presented in Equation 2 was taken from Love & Nohria (2005) following its extensive use elsewhere (Sadorsky 2006; Kim et al. 2008; Wefald et al. 2010).

This research found that within the construction context Absorbed Slack demonstrated significant coefficients against both ROA and Profits. Against ROA, Absorbed slack demonstrated a negative first order coefficient, and a negative relationship, against Profits. Absorbed slack demonstrated significant positive second order (βi= .315) beta (βi) coefficients within Model 11. Absorbed Slack provided significant improvement the predictability of the variation in firm ROA, and moderate improvements in the predictability of firm Profits, demonstrated by increases in in R². This research also found that within the manufacturing context Absorbed Slack demonstrated a U shaped relationship (∪) with both ROA and Profits. Against both dependent variables, Absorbed Slack provided significant negative first order and positive second order coefficients.

Wefald et al. (2010), who adopted the same measure of absorbed slack, demonstrated a significant positive relationship between ROA and Absorbed Slack. This is in conflict with the findings of this research. However, Wefald et al. (2010) were only able to provide this result when firm type was not controlled, more complex models provided only non-significant (p > 0.05) beta (βi) coefficients between Absorbed Slack and ROA.

Chiu & Liaw (2009) also adopted this measure of Absorbed Slack (which they referred to as Recoverable Slack) and examined its relationship to firm ROA. They found a significant (p < 0.001) U-shaped relationship (∪) between Absorbed Slack and ROA.
They were also able to represent significant ($p < 0.001$) U-shaped relationships ($\cup$) between Absorbed Slack and other performance variables: Return on Equity (ROE) and Return on Invested Capital (ROIC).

Geiger & Makri (2006) also used the same measure to represent Recoverable Slack when examining firm level innovation. They demonstrated that independent increases in Absorbed Slack are positively associated with measures quantity of firm innovation (patent counts) and innovation citation intensity. Indicating that Absorbed Slack is positively associated within firm level innovation. This corresponds with the results of this thesis, which use performance measures as an indicator of innovation outcomes.

This research supports U-shaped relationship ($\cup$) between Absorbed slack and performance (measured as Profits), used as a proxy for firm level innovation, within both the manufacturing and construction contexts. For this thesis, the results regarding Absorbed Slack support Hypothesis 2b. The literature demonstrates the same relationship. This relationship indicates that moderate levels of Absorbed Slack are detrimental to firm performance (and, therefore, innovation), whereas maintaining higher and lower levels of slack are actually beneficial to the firm, performance and theoretically innovation. This indicates that the cost of moderate level of slack reduced returns to the firm, while lower levels of absorbed slack makes the firm more efficient, and higher levels allows the firm to pursue aggressive strategies.

### 9.3.2 Unabsorbed slack

Unabsorbed Slack, was measured using the quick ratio (recall Equation 3) and taken from Herold et al. (2006). Like the above, this measure has been used extensively within existing literature and has been used as a measure of Unabsorbed Slack and Available Slack (see, for example, (Geiger & Cashen 2002; Geiger & Makri 2006; Herold et al. 2006; Kim et al. 2008)).

This research found that, within the construction context, Unabsorbed Slack demonstrated an inverse U-shaped relationship ($\cap$) with both ROA and Profits. These relationships provide support for Hypothesis 1a and Hypothesis 1b. Within the manufacturing context, Unabsorbed Slack replicated the same inverse U-shaped relationship ($\cap$) with both ROA and Profits. This is argued to indicate evidence that
Unabsorbed Slack functions in the same manner within the construction and manufacturing context.

Luan et al. (2013) demonstrated that reductions in *Unabsorbed Slack* (measured as Current Ratio) negatively impacts firm performance measured as ROA. Therefore, Lee (2011) established a positive linear relationship between Unabsorbed Slack and firm performance (measured as ROA). This linear relationship however, does not relate to the hypotheses within the literature nor the relationships established in this research. Therefore, does not provide support for the results.

Geiger & Cashen (2002) adopted the Quick Ratio as a measure of available slack, in their study of innovation in *Fortune 500* firms. They were able to demonstrate a significant inverse U-shaped relationship (∩) between *Unabsorbed Slack* and innovation. Similarly, Geiger & Makri (2006) demonstrated a positive linear relationship between the same measure and citation intensity of patents. Once again however, this does not relate to the hypotheses within the literature nor the relationships established in their research. Therefore, does not provide support for the results.

This research has found an inverse U-shaped relationship (∩) between *Unabsorbed Slack* and performance when measured as the quick ratio. The results regarding *Unabsorbed Slack* support both Hypothesis 1a and 1b in construction firms when performance is measured as both ROA and as Profits. These relationships are further supported by the findings of this study in the manufacturing context and in relevant literature. A U-shaped relationship indicates that moderate levels of *Unabsorbed Slack* are the most beneficial to firm innovation and performance, and that maintaining higher and lower levels of slack limits innovation and consequently reduces firm performance.

**9.3.3 HR slack**

The measure of *HR Slack* was taken from Mishina et al. (2004) and presented in Equation 4.

In the construction context, second order *HR Slack* demonstrated a significant (p < 0.001) U-shaped relationship (∪) with firm Profits. Against ROA, *HR Slack* failed to support any significant relationship. *HR Slack* was a strong predictor of variation in Profits but a poor predictor of variation in ROA. Thus relationship provides support for Hypothesis 2b. The manufacturing context results replicate these relationships. In this
sector, *HR Slack* exhibited a U-shaped relationship (∪) with Profits, supporting the relationship and the function of slack within the construction context.

Mousa & Chowdhury (2014), who adopted the same measure of *HR Slack*, examined the effects of slack on innovation intensity in publically traded US firms. They demonstrated a significant (p < 0.001) relationship between slack and innovation intensity. However, this does not relate to the hypotheses regarding the curvilinear relationships between slack and performance, nor the relationship established in this research. Therefore, does not provide support for the results.

The only other instance of *HR Slack* as a predictor variable was provided by Mishina *et al.* (2004); the measure source. These authors examined the impact of *HR Slack* on short-term sales growth, finding it to be positively related. They also found that *HR Slack* had a strong moderating effect on market expansion and sales growth. This final paper however, also did demonstrate a curvilinear relationship, and does not support the results within this work.

The positive impact of *HR Slack* on the firm established within existing literature does not support the results within this work. This research indicates a negative and or U-shaped relationship (∪) between *HR Slack* and performance (as Profits). For this thesis, the results regarding *HR Slack* support Hypothesis 2b, indicating that its presence in moderate levels is detrimental to firm performance (and, therefore, innovation), whereas maintaining higher and lower levels of *HR Slack* are beneficial to the firm, and its performance.

### 9.3.4 Financial Slack

The cash reserves, the measure of *Financial Slack* (recall Equation 5) was taken from Voss *et al.* (2008).

This research found that, within the construction context, *Financial Slack* demonstrated a significant inverse U-shaped relationship (∩) with Profits in Model 10 and Model 11 which incorporated *Financial Slack Squared* (non-linear) as a variable. In the majority of models, *Financial Slack* did not demonstrate a significant relationship with ROA.

Evidence from manufacturing supported a U-shaped relationship (∪) with Profits above, exhibiting significant positive second order coefficients. This contrasts the
Discussion

evidence from the construction context. No significant curvilinear relationship was found between Financial Slack and ROA in the manufacturing context.

Bradley et al. (2011) used cash reserves of the firm to measure Financial Slack when examining firm performance (as Profit) in tough environments. Tough environments being once of scarce resources, or highly dynamic. Bradley et al. (2011) provided significant (p < 0.05) negative second order coefficients also supporting an inverse U-relationship. This evidence supports the relationship demonstrated between Financial Slack and Profits within this research.

Cash reserves were also adopted by George (2005) in an investigation into the performance of privately held firms. In this study, a positive linear relationship between cash reserves and firm performance (gross profits) was established. This therefore does not relate to the hypotheses, and the curvilinear relationships within this research.

The results of this research regarding Financial Slack initially support Hypothesis 1b. Evidence from literature generally only supports a linear positive relationship between Financial Slack and firm outcomes, and cannot be related to the curvilinear relationship in this research. An inverse U-shaped relationship illustrates that moderate levels of Financial Slack are the most beneficial to firm innovation and performance, and that maintaining higher and lower levels of slack limits innovation and consequently reduces firm performance.

9.4 Study 2: Support of Assumptions

This section deals exclusively with the data collected through the use of semi structured interviews in Study 2 (see Chapter 8). The following associates the statements and considerations of interview participants with the claims made within the thesis, which were used to develop the research design for Study 1. This section focuses upon four key areas: First the function of slack within the firm; Second the purpose of innovation and determining firm performance as a suitable proxy for innovation outcomes; Third slack’s resonance as a determinate of innovation and firm performance.

The interviewees were selected at random from a sample of firms within UK construction following a selection process similar to Study 1; five interviews were conducted in total. Respondents represented key personnel within the firm involved in innovative and strategic decision within their firm, each representing a classification of
The central theme of this thesis is the proposed relationship between organisational slack and innovation. Although explored extensively within general management literature, thus far organisational slack has not been seen as a significant factor in determining firm level innovation. It is argued within this thesis that the varied functions slack within the firm (Lin et al. 2009) underpin the managerial actions identified by Hartmann (2006) which support innovation. The participants of Study 2 identified slack in relation to spare capacity, time, and financial resources; key characterisations of resources identified within this thesis. Study 1 used Human Resource slack as a measure of excess capacity, and cash reserves as a measure of excess financial resources.

Respondents were also able to recognise the impact of changes to their level of slack would affect their performance output. Questions designed by Nohria & Gulati (1996) Troilo et al. (2014) were used to examine the respondents reaction to changes in staff time and budget. Reductions in these areas were perceived by respondents to negatively affect the performance of the firm, which is considered by the research to indicate support for a positive linear relationship between slack and the firm (see Section 3.7.1). The positive relationship slack is argued within this thesis to provide excess resources that enable the firm to take advantage of opportunities (Mishina et al. 2004; Lin et al. 2009); legitimises experimentation (Nohria & Gulati 1997); allows for inducement and
rewards (Bourgeois 1981); and provides a cushion against turbulence in the firm’s environment (Sharfman et al. 1988; Tan 2003).

However, respondents also provided exceptions to this based upon the attributes of individuals within the firm. Respondents stated that some individuals would perform better, or not be affected at all. This demonstrated support for the negative relationship between higher levels of slack and performance. Potentially this demonstrates the complexity of the concept of slack and the conflicting perspective of its presence within the firm.

A respondent also identified a curvilinear relationship between slack and the benefit derived by the firm (see Section 3.7.3). This relationship first proposed by Bourgeois (1981) argues that as well as low levels of slack, excessive levels of slack also diminish the benefit to the firm. High levels of slack lead sub-optimal behaviours (such as empire building) (Nohria and Gulati 1997) or as stated by Respondent 1 “fat lazy and inefficient”. Despite this assertion, the Respondents perceptions indicated a positive association between slack and the benefits derived by the firm, and recognised its use in reinvestment, and an important component for innovation. This curvilinear relationship formed the basis for the hypotheses used to test the slack-innovation outcome relationship in Study 1.

9.4.2 Measuring innovation outcomes using firm performance

A major assumption with this thesis is the inability to measure firm level innovation in construction using patents or R&D expenditure. This led the research to propose firm financial performance as a viable measure of innovation outcomes. This proposal allowed the researcher to conduct the econometric analysis of Study 1. However, the association between innovation and performance as a proxy has only been supported by theoretical discussion, and no evidence suggesting this as a suitable choice was provided.

Study 2 offered the opportunity to directly question practitioners on the measurement and purpose of innovation, in order to determine if the researcher’s proposals were sound and resonated in practice. Participants of Study 2 perceived that the assumption of the research were sound in their development. Respondents forwarded that the purpose of innovation was to support further organisational goal, and these goals were typically in line with generating and maintaining firm financial performance and
survival. This follows the proposal of the thesis that construction firms act as innovation adopting organisations as seen in Damanpour & Wischnevsky (2006) and Gambatese & Hallowell (2011a). The respondents indicated that there were few if any direct measures of innovation, or innovation outcomes per se within their environment. Instead, indicating that the firm used common measures to indicate improvements such as production level, turnover and profit, which relate to the general operations of the firm.

Respondent 5 directly rejected the use of patents within the firm, and discussed its limitations of use to the firm in general, not only as a measure of innovation. This discussion lends support to the rejection of patents as a viable measure, paralleling the discussion of the work of Smith (2004) and Knott (2012).

These insights from practitioners provide support for the assumptions made within the thesis (see Chapter 4) in the development of the research design for Study 1 (see Chapter 5). Practitioners were clear about not measuring innovation directly, instead focusing on outcomes where possible, and further detached metrics in terms of financial performance. Therefore, the use of financial performance measures as a proxy for innovation outcomes in Study 1 is considered justified and supported by Study 2.

9.4.3 Slack as a determinant of innovation and performance in construction

The second assumption within this thesis is that slack is a viable determinant of innovation in construction, which is based upon prior evidence from outside the construction sector. However, there is little to no evidence prior to this thesis supporting the use of slack within the construction context, or arguments supporting that the presence of slack supports either innovation or performance. Although the purpose of Study 1 was to test a slack-innovation outcome relationship within the construction context, it was also vital to obtain the perspectives of practitioners on the slack-innovation relationship.

Overall practitioners from the construction sector within Study 2 saw slack as an essential component to not only innovation but also firm performance. Respondents perceived that slack resources enabled investment in plant and machinery relating to innovation, support training and development, and allow innovation to occur. Slack was also seen by respondents to ensure that levels of productivity and quality were maintained, ensuring the financial performance of the firm.
This thesis has aimed to establish slack as a determinant of innovation within the construction context. It is argued that the functions of the firm require some form of slack in order to operate effectively, and a level of slack is required in order to fund innovative activities (Cyert & March 1963). The responses of those interviewed within Study 2 provide support for this association between slack, innovation and performance proposed within the thesis.

Respondents indicated that they were hesitant about the concept of slack, due the complexity of the market, and the competitively of the market where small increases in overheads might price a company out of the market place. Only one respondent rejected the notion of slack, largely based upon the contextual issues and an overemphasis of the function of unused spare capacity within the firm. More work could have been done within the study to understand the mechanisms by which slack functions within construction firms to understand if they are similar or not to those presented in prior slack research.

9.5 Reflection of the research problem

The thesis began by arguing for and highlighting the research problem and a number of specific research objectives. It is to these objectives and research problem that the next sections will address and scrutinise. The intention is to explore and highlight the extent to which the research has addressed the problem and met the objectives. This section also outlines the contributions made by the research.

9.5.1 Research Objective 1 (RO1)

RO1. Define innovation and analyse the factors that determine firm level innovation in construction firms.

The first aim of the research (RO1) was achieved through an extensive literature review of innovation from both construction and mainstream management. Chapter 2 critiqued multiple definitions of innovation and distinguished it from change, invention and imitation. This research contributed to innovation research in construction, by making a clear distinction between innovation and other concepts, such as inventions and change. Ultimately innovation was defined as Thus innovation is defined as “the effective generation and implementation of a new idea, which enhances overall organizational performance” (Barrett & Sexton 2006). Within Study 2 this definition was found to
Discussion

resonate with construction practitioners, who saw it as an appropriate representation of their firms view of innovation.

Whilst, project based factors and the nature of construction have an impact on the direction and potential for innovation within construction as a whole, they do not explain difference between innovative and non-innovative firms within construction. This research identified firm culture and leadership within the firm as factors to explain the discrepancy between innovative and non-innovative firms. Culture was seen to be made of two interdependent components the *ability* and *willingness* of the firm to innovate, which was argued to be dependent upon firm level resources. Focusing upon this resource dependency the researcher identified and positioned excess resources, or ‘slack’, as an unexplored factor of a firm’s ability and willingness to innovation and by extension, firm level innovation in construction.

9.5.2 Research Objective 2 and 3 (RO2 and RO3)

RO2. Develop a broad theoretical understanding of the concept of organisational slack.

RO3. Develop theoretical linkages to position organisational slack as a determinant of innovation in construction firms.

Chapter 3 established organisational slack as a pivotal determinant of innovation and firm performance. However, the chapter highlights that organisational slack had not been theoretically and empirically explored in the UK construction industry. This research therefore extended “slack research” by arguing for and constructing an alternative typology (see Section 3.5.5), which built upon theoretical developments of Sharfman *et al.* (1988), and connecting this with slack metrics (see Figure 9).
Following the development of the typology above, the research examined the functions that are argued to manifest through the presence of slack within the firm. Examining the functions of slack within the firm, it was seen that slack might be both beneficial and detrimental to the firm. It was contended that both a positive and negative position regarding the level of slack within the firm could be maintained. To resolve these conflicting perspectives the slack-benefit to the firm relationship was forwarded as curvilinear, either U-shaped (∪) or an inverse-U-shaped (∩). This compromised the positive and negative linear arguments into a single model. This enabled the development of the hypotheses in the following chapter (Chapter 4), to allow for this relationship to be tested.

In meeting RO3, connections were made between the concept of organisational slack and the firm level determinants of innovation within Chapter 4. Drawing upon resource dependency of ability and willingness of the firm, these determinants were theoretically associated with the functions of slack. The development of these linkages is argued to establish the level of organisational slack as a determinant of innovation in construction. This was argued to allow for the transposition of slack to the constructions context, and the slack-innovation relationship to be tested.

Due to the failure of traditional measures of innovation to capture innovation in construction, performance was proposed as a proxy measure of innovation. Although this detached from the original approach of examining innovation, it offered the author
the ability to test the relationship between slack and the firm, and thus test the theoretical slack-innovation relationship, which would not be possible if measuring innovation directly.

9.5.3 Research Objective 4 and 5 (RO4-5)

RO4. Develop hypotheses and test the relationship between slack and innovation outcomes

RO5. Analyse the findings in order to determine the validity of the theoretical links in RO3.

RO6. Draw conclusions from, limitations of, and recommendations for the research.

Hypotheses for the slack-innovation outcome relationship (performance acting as a proxy for innovation), were forwarded in Chapter 4, which met part RO4.

RO4 was satisfied through both the literature review and studies 1 and 2. Chapter 4 developed initial hypotheses to testing the relationship between slack and innovation outcomes. The hypotheses related to testing the shape of the slack-innovation outcome relationship (∩ or ∪), discussed in Chapter 3. These hypotheses were further divided in relation to two measures for firm level performance, which was forwarded as a proxy for innovation in construction firms, the two measures chosen were ROA and Profits (see Section 5.10). H1a and H1a predicted an inverse U-shaped relationship (∩) between the level of slack and ROA or Profits respectively, H2a and H2a predicted a U-shaped relationship (∪) between the level of slack and ROA or Profits respectively. To test the above hypotheses Chapter 5 provided a detailed research design which was used to test the relationship between firm performance (as a proxy for innovation) and the level of organisational slack within construction firms. The slack-performance relationship was tested using multiple regression analysis, which allowed the researcher to assess the extent to which performance might be predicted by a set of independent variables, thus satisfying RO4. The development of the hypothesis for RO4 was further met by Study 2, which used semi-structured interviews to further explore and test the association between the organisational slack and innovation. Evidence was found supporting the assumption that innovation could not be measured directly, participants in the study revealed, as proposed within the thesis, that financial performance measures were a more commonly used metric for innovation outcomes. Therefore, this supported
the use of financial performance measures (ROA and Profits) as proxy measures for innovation outcome in Study 1’s econometric analysis.

To meet RO5, the findings for study one of research were analysed in Chapters 6 and 7. The results support a relationship between slack and the proxy for innovation, firm performance. The results of the statistical analysis which established an association between slack and firm performance were both; statistically significant, indicating a high level of confidence, and developed within statistically sound regression models that met the necessary assumptions to avoid statistical bias in accordance with the research design. The slack variables were demonstrated as being able to predict variation in firm level performance, confirming a relationship between the two concepts. Also therefore, a relationship between slack and the underlying firm level innovation. Study 2 provided further support for the theoretical links between organisational slack, innovation and performance, which were used to build Study 1, again satisfying RO5. Respondents identified slack as a critical determinant of both innovation and performance, and saw innovation as a critical component of firm financial performance and survival.

Section 10.5 within the following chapter satisfies RO6. This section states the conclusions that may be drawn from this research project, and reflects upon the limitations of the research project, and forwards a number of suggestions for possible future research addressing slack within construction.

9.5.4 Research Problem

RP1. Construction firms require innovation to continue to function within the marketplace. Organisational Slack offers an explanation for the difference between high, and low innovating firms within construction. Whilst Organisational Slack has been theoretically and empirically explored and developed in other industries, this concept has not been expanded to involve the construction context. The problem therefore, is first explore and understand how Organisational Slack benefits the firm and its ability to innovate, and also empirically test if organisational slack is a viable explanation for variation in firm level innovation within the construction context.

Throughout this thesis, the research problem above has been continually reflected upon and addressed in the theoretical developments and the research. This thesis develops a
greater understanding of firm level determinants of innovation, specifically organisational slack, and its interaction with the firm. To date, no construction research could be found that focuses on testing a relationship with organisational slack. This thesis is the first to test a relationship with organisational slack within the construction context. This research project therefore, offers a significant contribution to the understanding of firm level determinants of innovation. Despite the regression analysis providing varied, if not conflicting results regarding the shape of the slack-performance relationship (supporting hypotheses 1a, 1b and 2b), this research is able to establish slack as a determinant of firm level performance, and the underlying firm level innovation. Therefore, this research is able to address the research problem presented in Chapter 1, by establishing slack as a viable explanation for firm level innovation.
Chapter 10. Reflections on research, Conclusions, Limitations and Recommendations

10.1 Introduction
This chapter critically examines the research objectives, and contributions made by the research specifically in defining innovation, positioning slack as a firm level determinant of innovation in construction, and the development of a new typology of slack. Following this, a discussion further examines the research project as a whole, against research criteria discussed in Chapter 5 (see also Buckley et al. 1976). Such critical examinations reflect the cautious realist ontological position laid out in the methodology.

The chapter reinforces the findings of the statistical analysis, and the conclusions drawn out from these findings and how they relate to the hypotheses developed in Chapter 4. Scrutinising the research design, findings and conclusions also leads to a discussion of the research limitations. After further reflection, a number of recommendations for future research are provided to strengthen and deepen our understanding of organisational slack and innovation within construction firms. The chapter concludes by reflecting upon the broad implications of the research in highlighting the importance of organisational slack within construction firms.

10.2 Satisfying Research Criteria
With Chapter 5, the position of the cautious realist was chosen to reflect the researcher’s ontological stance. As such, it was argued that it is necessary for the researcher to be critical of the choices and approach to the research. This critical perspective was demonstrated within the research design for Study 1 (see Section 5.11) and this project’s ability to meet the research objectives (see Section 9.4). The following applies this critical perspective to the research project as a whole in accordance with Buckley et al. (1976:28), who provided conditions which distinguish ‘research’ from other investigations.

1) An orderly investigation of a defined problem – This project provides an orderly structure through Chapters 5 to 9, testing the slack-innovation outcome relationship (as a proxy for innovation). Chapter 5 details two complete research designs for
Studies 1 and 2, both critically select measures and the approaches to testing the hypotheses, and exploring the understanding of slack respectively. Chapter 6, 7 and 8 provide a detailed and orderly examination of the results from both studies allowing for conclusions and contributions to be drawn from the research project.

2) **Use of appropriate scientific methods** – Chapter 5 forwards a number of research methods for this project, and were critically analysed. Ultimately, selecting two methods to create a mixed method research project, using both Archival analysis and interviews as research methods that avoids ‘gross miss fit’ (Yin 2009). The choice of archival analysis, and the subsequent statistical analysis using econometrics, follows closely to the traditions of prior organisational slack research. The use of interviews allowed the researcher to provide primary data support for the assumptions that built the econometric analysis. Although a number research methods and statistical techniques were considered, they were deemed inappropriate for this research. The statistical techniques used within the research design for Study 1 (for example Pearson’s $r$, and Multiple Regression analysis) are well documented within slack research, and appropriate for examining the research problem. Thus, satisfying this criterion.

3) **Gather adequate and representative evidence** – To provide representative evidence for this research had to ensure that data is gathered within the construction sector which is representative of the constructs being tested; innovation, firm level performance, and slack. For Study 1 the data gathered relied upon the F.A.M.E database as a secondary source of annual report data to measure performance and slack. This research recognised that although secondary data sources are not research problem specific possibly preventing the data from being adequate (Blumberg et al. 2005), the research design ensured that suitable data was gathered by selected measures were representative of the variables being measures (Boyd et al. 2013). Further to this, the statistical analysis tested the relationship between the level of slack in the firm, and firm level performance (acting as a proxy for innovation) within the construction context, using the representative evidence. Therefore, is argued to provide adequate and representative evidence.

For Study 2 each participant was selected as a representative of different firm types from within the constructions sector, based upon SIC classification relating to
Appendix 1. This ensured that any data gathered on the participants views were representative to some degree of construction practitioners. Five interviews were conducted lasting roughly 1 hour each to ensure that all topics were discussed and sufficient information was gathered.

4) **Draw conclusions based on evidence, logical reasoning and void of bias** – The conclusions drawn within this thesis, presented below in Section 10.4.1, draw upon the findings of the Study 1 (chapter 6) and the comparative analysis of these findings (Chapter 7), and analysis of Study 2 (chapter 8). The conclusions from Study 1 were fully developed within the prior chapters, and based upon the statistical confidence of the results and logical reasoning to their values. The use of statistical analysis is argued to void bias to a large extent, being only able to report and present the results obtained. For Study 2 the conclusions support the assumption made within the thesis regarding the connections between the concepts of slack, innovation and firm performance.

5) **Demonstrate validity of conclusions drawn** – The conclusions drawn from the statistical analysis demonstrated significant relationships at high confidence intervals (p< 0.05, p <0.01 and p < 0.001). Further to this, the multiple regression analysis results were subject to several validity tests these ensured that the assumptions for multiple regression analysis were met. Chapter 6 demonstrates that all the results gathered met the statistical assumptions and were thus considered valid. Evidence that did not meet the significant confidence interval (p > 0.05) was not carried forward, for instance the relationship between financial slack and ROA in the construction context.

6) **Ensure results may be replicated under similar conditions** – This criterion was satisfied within the complete and exhaustive research designs presented in Section 5.10 and 5.11. The research design for Study 1 detailed the chosen measures of variables, the data collection protocol, and the statistical techniques adopted within the analysis. Further to this, in order to replicate this study, the researcher developed a data generation and analysis protocol for this study (see Figure 22). This protocol details the steps taken to develop the results within this thesis, so that they may be replicated in similar conditions.
The research design for study 2 is detailed in Section 5.11 and discusses the questions posed to participants of the semi structured interview. The research is also replicable using the interview prompt sheet provided in Appendix 4, which was used during the interviews.

10.3 Contribution to Research Design
Section 5.10 and Section 5.11 of this thesis presents detailed research designs, including a rational for the variable, sample, data source and analytical techniques used to test a relationship between slack and construction firms within Study 1 and Study 2.

The first study in this thesis contributes to Research Design by demonstrating how a construction researcher might test through the use of econometrics a relationship using organisational slack. The research design in its entirety is laid out for the reader, including interpretation of the statistical analysis. Whilst the research design is built upon prior slack research, the selection of four slack measures, and examination of two contexts is considered unique to slack research, and one that contributes to the investigation of slack.

Further to this, this research provides evidence that the size, age and type of firm within construction research play little to no role in determining the performance of the firm, used to indicate innovation outcomes. Providing further legitimacy to the assertions of Reichstein et al. (2008) that size is inconsequential when considering innovation in construction.

The second study within this research project, which adopted interviews as a research method, provides a foundation for the examination of organisational slack through this approach. Providing a framework for a questionnaire sheet to understand the relationship between innovation and slack. This also further contributes to slack research in general due to the lack of interview based research, where slack research predominantly used questionnaire and econometric analysis.

10.4 Contribution to Practice
This thesis contributes to practice by demonstrating the importance of organisational slack, and the impact it has on the firm, which previously had not been considered or demonstrated within the construction context. (Hardie & Newell 2011) demonstrated previously that practitioners ranked firm resources below project conditions, the
regulatory climate and industry networks. However, this demonstrates that slack resources can have definitive impact on the firm and therefore is worth of greater consideration.

This thesis is argued to contribute to practice by demonstrating a relationship between the amount of resources within the firm, and innovation outcomes. While there have been prior suggestions to the importance of resources (Kissi 2012), this had previously not been demonstrated. Furthermore, this research demonstrates that the slack-innovation relationship is different of various forms of slack. Therefore, practitioners must be aware of this when accumulating or removing resources within the firm. They must think critically about the impact of slack, and the effect it might have within the firm as it is not a straightforward solution.

10.5 Conclusions, limitations and recommendations (RO5)

10.5.1 Conclusions
The key conclusion that can be drawn from this thesis can be summarised simply as: the level of slack impacts the firm within construction firms. This is essential, as it was previously unknown, regardless of direction i.e. positive or negative, or outcome (innovation or performance), if the level of excess resources (slack) played a role within construction firms. The fundamental conclusion that is drawn from this research project is that slack is a viable construct within the construction context. In that, the level of slack has an influence on firm level performance via innovation outcomes, and therefore, must be considered within future research. As demonstrated within Chapters 6, 7 and 8, the level of slack within construction firms influences innovation outcomes which therefore is argued influence the underlying firm level innovation.

Study 2 provides significant support for the use of financial performance measures as proxies for direct measures of innovation outcomes. Participants accepted the proposed definition, and provided a consensus that financial measures are typically used in practice to measure innovation outcomes. In using performance as a measure for innovation outcomes in Study 1, it is conceded that inferences cannot be made regarding the exact slack-innovation relationship, however due to slacks impact on performance as a measure of innovation outcomes, it must also be inferred that slack influences innovation.
Whilst it is maintained that slack determines firm performance within the construction and manufacturing contexts, identified in Section 7.2. It is also concluded that the ability of slack to predict firm performance is weaker within construction than manufacturing context. This was demonstrated by lower $R^2$ scores within the construction context, compared to identical models in the manufacturing context. This indicated that the research designs, or at least the selected measures, are less capable of determining variation in performance, and therefore innovation, within the construction context. Therefore, an augmented research design, supported by further research might generate a stronger relationship when testing slack within construction.

When ROA was used as a dependent, the gap difference in the $R^2$ scores was argued to be the result of differences between the contexts and their resource consumption in generating ROA. The regression models failed to explain the same about of variation performance within the construction context, as compared to the manufacturing context. Contrary to this, the gap difference when using Profits as a dependent variable was the result of the control variables failure, and not the slack variables’ ability to predict variation in firm Profits. This indicates that the commonly accepted control variables Size, Age and Number of Employees, do not determine firm performance within construction to the same extent as manufacturing. Therefore, indicates that construction firms are different from manufacturing firms in their ability to convert resources into performance, and that the research design used within this research is more applicable to manufacturing than construction.

This research project also concludes that the shape and direction of the slack-performance relationship, and consequently the underlying slack-innovation relationship is dependent upon first the type of slack in question; and second the performance measure being used. The relationship between slack and performance was seen to differ depending upon the slack resource in questions, some demonstrated inverse U-shaped relationships ($\cap$), while others demonstrated U shaped relationship ($\cup$). H1a/H1b both proposed an inverse U-shaped relationship ($\cap$) between organisational slack and firm performance (ROA and pre-tax Profits). *Unabsorbed Slack* demonstrated the only viable curvilinear relationship against ROA, supporting Hypothesis 1a (H1a). *Unabsorbed Slack* and *Financial Slack* supported Hypothesis 1b (H1b) by demonstrating a curvilinear relationship with pre-tax Profits. These relationships were supported further within the analysis of the manufacturing context,
where the same relationships were demonstrated. This suggested that construction firms must balance their levels of unabsorbed and financial slack, in order reap the greatest benefit. Furthermore, firms must ensure that their levels of slack do not diminish too greatly, nor increase too much, and reduce the benefit derived by the firm. Higher levels of *Unabsorbed Slack* and *Financial Slack* would be too costly to maintain, and diminish performance, while lower levels might restrict the capabilities and funding that the firm might provide.

A U-shaped relationship (∪) between slack and performance was tested using H2a/H2b. Due to non-significant coefficients, Hypothesis 2a (H2a) could not be supported within the construction context, failing to demonstrate a U-shaped relationship between slack and ROA. Hypothesis 2b (H2b) proposed a U-shaped relationship (∪) between slack and pre-tax profits, *Absorbed and HR Slack* supported this hypothesis. Once again, these conclusions were further supported by the findings within the manufacturing context, which replicated the relationships above. This implies that firms must seek to avoid moderate levels of *Absorbed and HR Slack*, and seek either low levels of slack to improve efficiency, or higher levels to allow for the pursuit of risky strategies. This is opposite to *Unabsorbed Slack* and *Financial Slack* discussed above, demonstrating a distinction between different resource types.

Although the results are technically inconclusive regarding the shaped of the slack-performance relationship, as conflicting hypotheses were supported, this is consistent with established research. Existing slack research does not provide a consensus as to the shape of the slack-performance, or slack-innovation relationship (Chiu & Liaw 2009; Lin et al. 2009; Mousa & Reed 2013). This is important as it indicates that shape of the relationship between slack and the firm is dependent upon the type of resource in question. This means that firms must identify how the accumulation of excess resource types aids or diminishes the firms’ capabilities, as opposed to having a blanket perspective of the impact of slack as beneficial or detrimental (excess resources).

Based upon the impact of different slack variables in predicting performance variation, this research can further conclude that firms within both construction and manufacturing contexts generate Profits from the same resource profile conversely, ROA is generated differently, from dissimilar resource profiles within construction firms than manufacturing firms. Construction firms are argued to generate Profits through a
combination of \textit{Absorbed} and \textit{HR Slack}, while ROA is generated through a combination of \textit{Absorbed} and \textit{Unabsorbed Slack}. This further indicates that there is a distinction between manufacturing and construction firms, at least in regards to the accumulation and consumption of slack resources. In practice this means that different resources impact different firm types in unique ways, and that the approach to measuring the impact of slack is not necessarily universal. While some resources might impact the firm in similar ways across contexts, in this case in relation to Profits. The researcher must be aware of differences between firm types, and the appropriateness of the relationship between independent and dependent variables (in this case ROA).

Further to these developments from Study 1, Study 2 provided additional conclusions from to drawn from the research. Primarily that innovation is not directly measured within the sample firms, rather firms choose to measure outcomes of changes within the firm, typically in terms of financial and firm level measures. Secondly, that the concept of slack can be recognised by practitioners and that they are capable of assessing changes in their environment in relation to a change in slack. The typical perspective from practitioners is that a reduction in slack leads to a reduction in performance, which follows the positive linear relationship demonstrated in Section 3.7.1. However, exceptions were also present based upon the individual, and practitioners were also able to contemplate the duality of the slack-firm relationship as being. Finally, the views of participants of the study agreed with the perspectives of this study, identifying slack and a determinant of innovation and firm level performance.

\textbf{10.5.2 Limitations of the research}

Reflecting upon the research conducted within this thesis the author has sought to critically examine the work and present what are considered limitations to this research. These limitations are as follows

1. As identified in Bourgeois (1981), the use of annual reports as a single source of data within the Research Design provides the researcher with limited information, providing only a “snapshot” of the firm. The use of annual reports within this research demonstrates the research of levels of resources within the firm at a specific point in time, and tell little of how these levels might have fluctuated throughout the year or been manipulated for the purpose of the report. Richard \textit{et al.} (2009) warns that short and medium term measures can be misleading, and
influenced by random fluctuations in the environment. As such, these criticisms limit the research findings, and must be taken into consideration.

2. A second limitation is that the slack concept is transferred largely based upon the assumption of common resource dependency within firms, which to some degree ignores possible contextual differences. Hillebrandt (1985) argued that while a number of the characteristics of construction are not unique, the combination of these characteristics makes construction unique. Subsequently the ways in which annual reports and accounts are presented are different from other sectors (Halpin & Senior 2011). Attempts were made to ensure that the measures used within this research were representative of the variables adopted; yet it remains unclear if measures that are more suitable might be found specifically for construction. There remains the possibility that the measures selected within this research, were unsuitable for the analysis of the construction context, and not representative of slack within the firm.

3. A key limitation to this research is the detachment from the original purpose of the research to examine firm level innovation. This research began with positioning the level of slack within the firm as a determinant of firm level innovation. However, due to the inability of traditional measures of innovation to capture innovation within the construction context (or any context for that matter), innovation could not be accurately measured. Firm level performance was adopted as a proxy measure to indicate underlying innovation. Although theoretical links were established between the concepts of slack, innovation and performance, the research detached from a direct measure of innovation. Consequently, the results relate to firm level performance, and cannot guarantee the same relationships with the underlying firm level innovation.

4. The fourth limitation is the use of single financial measures to represent firm level performance. Whilst pre-tax Profits and firm ROA are frequently used performance measures within slack research, there are limitations to their adoption to represent firm performance. Primarily, firm performance is variable and cannot truly be constrained to a single metric. There are a number of alternative financial or accounting measures that also might indicate firm performance (Richard et al. 2009). Moreover, were performance not defined as financial returns, there are a
number of non-financial measures which might also be considered that reflect broader stakeholder interests (Love & Holt 2000). In practice the performance of construction firms is generally measured through a combination of both financial (e.g. ROA or Profits) and non-financial (e.g. productivity or quality) performance measures. As a result, the use of ROA and pre-tax profits represents a narrowing of focus by the researcher from a broader conceptualisation of the concept of firm performance, therefore is a limitation to this research.

5. The final limitation concerns the development of the theoretical framework associating firm level innovation with the level of slack within construction firms, specifically the resource based view of the firm (RBV). The resource-based view of the firm has faced criticisms for its representation of the firm. Priem & Butler (2001) have argued that the theory is fundamentally tautological, in that the reasoning of the RBV, valuable resources generate value is argued to be self-verifying and redundant. In reply to this criticism, Barney (2001) argues that to some degree all strategic management theories are tautological, depending upon how they are stated. To deal with this limitation, the Research Design specified a time lag between the measurement of the independent and dependent variables. If performance was measured at time “t”, slack was measured at “t-1”, to ensure that changes in performance were dictated by prior levels of slack. The researcher recognises that there are limitations to all frameworks, and indeed those used to understand the firm, therefore differing perspectives and critiques of positions must be respected and recognised.

10.5.3 Recommendations for further research
Once again reflecting upon the research conducted within this thesis the author posits a number of recommendations for future research. These recommendations are as follows:

1. The primary recommendation is that future research develops construction specific econometric measures of slack. Following Tan (2003), further research should begin with developing construction specific measures of slack through interviews with construction practitioners. Thus, developing measures that construction practitioners themselves recognise as demonstrating slack within the firm, and therefore are more representative of the accumulation of slack in construction. These can then be
compared to commonly adopted measures, and indicate if construction is unique in its measurement of slack.

2. The second recommendation is for further slack research within construction, to diverge from the research methods chosen here, and conduct further qualitative research using case studies or survey responses, focusing upon slack and innovation. Recalling Section 3.8.2 and Table 6, there is a tradition within slack literature to survey firms to self-assess their level of slack. Alternatively, through the use of a case study the research might be able to bridge gaps between existing case study research on innovation and the understanding of slack in construction firms.

3. A final recommendation is to determine if there is a genuine lack of slack within construction firms, in comparison to firms from other contexts or industries. Hardie & Newell (2011) have suggested that construction firms lack the necessary slack to innovative readily. This also represents a gap in knowledge, which must be understood. Although it is recognised that the Small to Medium firms (SMEs) dominate the construction sector (Barrett & Sexton 2006), SMEs are considered to have access to comparably less resources that larger counterparts (Terziovski 2010). Indicating that the ‘lack’ of slack within is due to the dominant firm size within the sector, as opposed to some unique difference between sectors. Research must identify if, and possibly why, a lack of slack within the construction context exists, and if this limits innovation within the sector.

10.6 Implications of understanding of organisational slack

It is argued that the detailed examination of the concept of organisational slack, and the subsequent research, provides a foundation for slack research within the construction context. Furthermore, the research offers grounds for greater understanding of the impact of slack on innovation, and the firm.

The concept of organisational slack offers an overlooked perspective within construction research, as an unexplored determinant of firm level innovation. The concept of slack offers an alternative perspective to those focused upon project level and industry level differences previously identified within construction research, focusing upon the firm as the innovator, and the functions afforded by higher levels of slack (excess resources), and restraints by lower levels of slack. The following
speculates to the broader implications of the concept of slack in relation to innovation in construction.

10.6.1 Calls for change within the sector

Within the construction sector, government regulation and initiatives can play a significant role in dictating the direction and extent of change within construction. However, to date these ‘initiatives’ are argued to fail to consider innovation in construction in relation to the level of slack within the firm. The evidence provided within this research indicates that the level of slack has an impact on firm level performance, and theoretically firm level innovation.

Whilst there are calls for change within the construction sector from policy makers and academics research, the prescribed changes might fail to resonate with practitioners unless the level of slack within the sector is considered. A possible lack of slack to fund innovation within construction firms has the potential to cripple any hopes of successful change within the construction sector. For instance, house builders who might lack slack are not likely to drive towards environment sustainability, unless they have the funds to support such innovative activities. As noted in research by Barrett & Sexton 2006 and Hardie & Newell (2011), construction firms are often too busy trying to survive let alone invest in new administrative or technological innovations. By recognising slack as a determinant of innovation and performance, government initiatives can investigate how decisions and initiatives impact the level of slack within the firm. Possibly allow firms to move focus away from the practice of “firefighting”, i.e. attempting to survive (Voss et al. 2008; Hardie & Newell 2011), allowing construction firms to focus upon expansive thing, risk taking and innovative ventures (Voss et al. 2008), and consequently enabling more innovation within the sector.

10.6.2 Slack and project level analysis

The implications of the functions of organisational slack extend beyond the firm as a unit of analysis. Slack is argued by the author to be applicable to the project level within the construction context. Although slack is predominantly examined at the firm level within broader management literature, by approaching construction project team as a temporary organisations (Blayse and Manley 2004), it is argued that the functions of slack may be applied to the project level in construction. This is supported by DeMarco (2001), who considers the concept of slack from a project based perspective, although
predominantly within a software engineering context. While this might not perfectly emulate the project level within construction, the issues and functions are argued to remain the similar, dealing with variability and unpredictability of projects. Additionally Lawson (2001) discusses the importance of time as a resource, indicating the mistakes and errors often occur due to a lack of slack time. To what extent are health and safety issues on projects related to a lack of slack, and the rush to complete work to a deadline. Research by Davey & Powell (2004) within construction found that poor design on a project, in part, can arise from insufficient time and resources at the tendering process. Again, identify resources as a project level issue within construction.

Construction projects, although temporary couplings of sub-units from multiple firms, exist as a temporary organisation, and are thus likely to be subject to the same if not heightened issues found within mainstream management literature discussing project management and innovation. Blayse & Manley (2004) discuss that conflict often arises on construction projects due to conflicting goals by units engaged on project, which do not necessarily align with the main contractor. Reductions or elimination of slack could lead poor project performance, mistakes, poor quality or even accidents (Lawson 2001), or increase conflict between firms as competing firms vie for resources on site. Conversely, would too much slack drive up the cost of projects, and dampen the desire to improve, reducing the quality of projects (Leibenstein 1969). As such, research must extend within the construction context, to address the presence or lack of slack at the project level.

10.6.3 Nature of construction

The nature of construction products, has often been espoused as both a differentiating factor that distinguishes construction from other sectors (Hillebrandt 1985), but also as barrier, preventing innovation in construction (Blayse & Manley 2004; Thorpe et al. 2008). The temporary nature of construction projects and the inter-firm relationship they generate, longevity, cost and complexity of the construction product, all dampen the construction sector as a whole from innovating as readily as other sectors. However, it is argued that it is this nature of construction that demands the presence of slack within the firm. Further the characteristics of construction firms indicate a lack of slack. It is speculated that construction environment might be less adversarial, less risk adverse and more innovative if firms had more slack.
If one considered a firm with a low level of slack, it would not have the necessary funds to support innovation, forcing the adoption of innovation from its external environment, likely to be adversarial due to a lack of funds to alleviate conflict, and likely to avoid risk and not pursue innovation in a general sense. All these describe the features of the typical construction firm found within construction literature (Egbu et al. 1998; Blayse & Manley 2004; Thorpe et al. 2009). Koskela & Vrijhoef (2001) argue that the construction process is incredibly uncertain, in addition to this Davey & Powell (2004) notes the variability of workload and virtually handmade nature of construction projects. As such, it is argued that construction firms require slack to tackle the intrinsically variable and complex construction process, without which firms would be unable to cope and would fail to meet demands or fail to survive. Of further note within the nature of construction is that is that the construction environment is both highly fragmented, adversarial, and avoid risk (Blayse & Manley 2004; Davey & Powell 2004). This might be due to a lack of slack within the firm, due to the dominance of small firms within the construction context (Terziovski 2010).


References


References


REFERENCES


APPENDICES
Appendix 1 – SIC CODES

Construction Sector

CONSTRUCTION

41 Construction of buildings
41.1 Development of building projects
41.10 Development of building projects
41.2 Construction of residential and non-residential buildings
41.20 Construction of residential and non-residential buildings
41.20/1 Construction of commercial buildings
41.20/2 Construction of domestic buildings

CIVIL ENGINEERING

42 Civil engineering
42.1 Construction of roads and railways
42.11 Construction of roads and motorways
42.12 Construction of railways and underground railways
42.13 Construction of bridges and tunnels
42.2 Construction of utility projects
42.21 Construction of utility projects for fluids
42.22 Construction of utility projects for electricity and telecommunications
42.9 Construction of other civil engineering projects
42.91 Construction of water projects
42.99 Construction of other civil engineering projects n.e.c.

SPECIALIST

43 Specialised construction activities
43.1 Demolition and site preparation
43.11 Demolition
43.12 Site preparation
43.13 Test drilling and boring
43.2 Electrical, plumbing and other construction installation activities
43.21 Electrical installation
43.22 Plumbing, heat and air-conditioning installation
43.29 Other construction installation
43.3 Building completion and finishing
43.31 Plastering
43.32 Joinery installation
43.33 Floor and wall covering
43.34 Painting and glazing
43.34/1 Painting
43.34/2 Glazing
43.39 Other building completion and finishing
43.9 Other specialised construction activities
43.91 Roofing activities
43.99 Other specialised construction activities n.e.c.
Appendix 1

43.99/1 Scaffold erection
43.99/9 Specialised construction activities (other than scaffold erection) n.e.c.

**SERVICES**

46.13 Agents involved in the sale of timber and building materials
46.73 Wholesale of wood, construction and materials and sanitary equipment
46.74 Wholesale of hardware, plumbing and heating equipment and supplies
77.32 Renting and leasing of construction and civil engineering machinery and equipment
71.11 Architectural activities
74.90/2 Quantity surveying activities

**PRODUCTS**

08.11 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate
08.12 Operation of gravel and sand pits; mining of clays and kaolin
09.9 Support activities for other mining and quarrying
16.1 Sawmilling and planing of wood
16.21 Manufacture of veneer sheets and wood-based panels
16.22 Manufacture of assembled parquet floors
16.23 Manufacture of other builders carpentry and joinery
22.23 Manufacture of builders' ware of plastic
23.11 Manufacture of flat glass
23.12 Shaping and processing of flat glass
23.31 Manufacture of ceramic tiles and flags
23.32 Manufacture of bricks, tiles and construction products, in baked clay
23.42 Manufacture of ceramic sanitary fixtures
23.51 Manufacture of cement
23.52 Manufacture of lime and plaster
23.61 Manufacture of concrete products for construction purposes
23.62 Manufacture of plaster products for construction purposes
23.63 Manufacture of ready-mixed concrete
23.64 Manufacture of mortars
23.65 Manufacture of fibre cement
23.69 Manufacture of other articles of concrete, plaster and cement
23.7 Cutting, shaping and finishing of stone
23.99 Manufacture of other non-metallic mineral products n.e.c
25.11 Manufacture of metal structures and parts of structures
25.12 Manufacture of doors and windows of metal
25.21 Manufacture of central heating radiators and boilers
25.72 Manufacture of locks and hinges
27.33 Manufacture of wiring devices
27.4 Manufacture of electric lighting equipment
28.14 Manufacture of other taps and valves
28.25 Manufacture of non-domestic cooling and ventilation equipment
33.11 Repair of fabricated metal products
Manufacturing Sector

MECHANICAL

28 Manufacture of machinery and equipment n.e.c.
28.1 Manufacture of general purpose machinery
28.11 Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
28.12 Manufacture of fluid power equipment
28.13 Manufacture of other pumps and compressors
28.14 Manufacture of other taps and valves
28.15 Manufacture of bearings, gears, gearing and driving elements

28.2 Manufacture of other general-purpose machinery
28.21 Manufacture of ovens, furnaces and furnace burners
28.22 Manufacture of lifting and handling equipment
28.23 Manufacture of office machinery and equipment (except computers and peripheral equipment)
28.24 Manufacture of power-driven hand tools
28.25 Manufacture of non-domestic cooling and ventilation equipment
28.29 Manufacture of other general-purpose machinery n.e.c.

28.3 Manufacture of agricultural and forestry machinery
28.30 Manufacture of agricultural and forestry machinery

28.4 Manufacture of metal forming machinery and machine tools
28.41 Manufacture of metal forming machinery
28.49 Manufacture of other machine tools

28.9 Manufacture of other special-purpose machinery
28.91 Manufacture of machinery for metallurgy
28.92 Manufacture of machinery for mining, quarrying and construction
28.93 Manufacture of machinery for food, beverage and tobacco processing
28.94 Manufacture of machinery for textile, apparel and leather production
28.95 Manufacture of machinery for paper and paperboard production
28.96 Manufacture of plastics and rubber machinery
28.99 Manufacture of other special-purpose machinery n.e.c.

29 Manufacture of motor vehicles, trailers and semi-trailers
29.1 Manufacture of motor vehicles
29.2 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
29.20 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
29.3 Manufacture of parts and accessories for motor vehicles
29.31 Manufacture of electrical and electronic equipment for motor vehicles
29.32 Manufacture of other parts and accessories for motor vehicles
ELECTRONICS

26 Manufacture of computer, electronic and optical products
26.1 Manufacture of electronic components and boards
26.11 Manufacture of electronic components
26.12 Manufacture of loaded electronic boards
26.2 Manufacture of computers and peripheral equipment
26.20 Manufacture of computers and peripheral equipment
26.3 Manufacture of communication equipment
26.30 Manufacture of communication equipment
26.4 Manufacture of consumer electronics
26.40 Manufacture of consumer electronics
26.5 Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks
26.51 Manufacture of instruments and appliances for measuring, testing and navigation
26.52 Manufacture of watches and clocks
26.6 Manufacture of irradiation, electromedical and electrotherapeutic equipment
26.60 Manufacture of irradiation, electromedical and electrotherapeutic equipment
26.7 Manufacture of optical instruments and photographic equipment
26.70 Manufacture of optical instruments and photographic equipment
26.8 Manufacture of magnetic and optical media
26.80 Manufacture of magnetic and optical media

27 Manufacture of electrical equipment
27.1 Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
27.12 Manufacture of electricity distribution and control apparatus
27.2 Manufacture of batteries and accumulators
27.20 Manufacture of batteries and accumulators
27.3 Manufacture of wiring and wiring devices
27.31 Manufacture of fibre optic cables
27.32 Manufacture of other electronic and electric wires and cables
27.33 Manufacture of wiring devices
27.4 Manufacture of electric lighting equipment
27.40 Manufacture of electric lighting equipment
27.5 Manufacture of domestic appliances
27.51 Manufacture of electric domestic appliances
27.52 Manufacture of non-electric domestic appliances
27.9 Manufacture of other electrical equipment
27.90 Manufacture of other electrical equipment

Chemical/Pharmaceutical

20 Manufacture of chemicals and chemical products
20.1 Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms
20.11 Manufacture of industrial gases
20.12 Manufacture of dyes and pigments
20.13 Manufacture of other inorganic basic chemicals
20.14 Manufacture of other organic basic chemicals
20.15 Manufacture of fertilisers and nitrogen compounds
20.17 Manufacture of synthetic rubber in primary forms
20.2 Manufacture of pesticides and other agrochemical products
20.20 Manufacture of pesticides and other agrochemical products
20.3 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
20.30 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
20.4 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
20.41 Manufacture of soap and detergents, cleaning and polishing preparations
20.42 Manufacture of perfumes and toilet preparations
20.5 Manufacture of other chemical products
20.51 Manufacture of explosives
20.52 Manufacture of glues
20.53 Manufacture of essential oils
20.59 Manufacture of other chemical products n.e.c.
20.6 Manufacture of man-made fibres
20.60 Manufacture of man-made fibres

21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
21.1 Manufacture of basic pharmaceutical products
21.10 Manufacture of basic pharmaceutical products
21.2 Manufacture of pharmaceutical preparations
21.20 Manufacture of pharmaceutical preparations

    Wholesale and Retail
45 Wholesale and retail trade and repair of motor vehicles and motorcycles
45.1 Sale of motor vehicles
45.11 Sale of cars and light motor vehicles
45.19 Sale of other motor vehicles
45.2 Maintenance and repair of motor vehicles
45.20 Maintenance and repair of motor vehicles
45.3 Sale of motor vehicle parts and accessories
45.31 Wholesale trade of motor vehicle parts and accessories
45.32 Retail trade of motor vehicle parts and accessories
45.4 Sale, maintenance and repair of motorcycles and related parts and accessories
45.40 Sale, maintenance and repair of motorcycles and related parts and accessories

    Media
59 Motion picture, video and television programme production, sound recording and music publishing
Activities
59.1 Motion picture, video and television programme activities
59.11 Motion picture, video and television programme production activities
59.12 Motion picture, video and television programme post-production activities
59.13 Motion picture, video and television programme distribution activities
59.14 Motion picture projection activities
59.2 Sound recording and music publishing activities
59.20 Sound recording and music publishing activities
## Appendix 2 – Slack Research Papers

<table>
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<td>Salge &amp; Vera (2013)</td>
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<td>Mallidou <em>et al.</em> (2011)</td>
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<td>Survey</td>
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(Gross Profits – Net Profits)
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- 334 -
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Appendix 3 – Data Manipulation

The following section details the manipulation of the data sample, from its raw form to a final sample suitable to engage with the analysis detailed in the research design. The process of converting the data from its raw to final state is illustrated in previously in Figure 24. Figure 24 is a flow chart illustrating the research protocol used as a systematic process of data manipulation to produce a final workable sample.

The data manipulation process was applied identically to both the construction and manufacturing contexts in order to remove bias that might be applied to either context. For ease, the following details only manipulation of the data within the construction context, the same process applied to the manufacturing sector.

**STEP 1: Gather Data**

Following the Research Design and the data collection procedure detailed in Chapter 6, an initial sample of 4,299 cases were collected for analysis from the construction context based upon the availability of the data. The selection procedure and the search results produce by F.A.M.E can be seen below in Table 16. The table illustrates that the size of the potential sample based upon the availability of the desired data at the time of the study.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Step result</th>
<th>Search result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All active companies (not in receivership nor dormant) and companies with unknown situation</td>
<td>3,137,208</td>
<td>3,137,208</td>
</tr>
<tr>
<td>2.</td>
<td>Firm SIC codes included in Construction Context</td>
<td>666,050</td>
<td>281,283</td>
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<tr>
<td>3.</td>
<td>Return on Total Assets (%): All companies with a known value, 2012</td>
<td>266,721</td>
<td>21,619</td>
</tr>
<tr>
<td>4.</td>
<td>Profit (Loss) before Tax: All companies with a known value, 2012</td>
<td>275,602</td>
<td>21,619</td>
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<tr>
<td>5.</td>
<td>Turnover: All companies with a known value, 2012, 2011, 2010, for all the selected periods</td>
<td>172,939</td>
<td>12,380</td>
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<td>6.</td>
<td>Administration Expenses: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>230,454</td>
<td>11,954</td>
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<tr>
<td>7.</td>
<td>Liquidity ratio (x): All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,408,331</td>
<td>11,693</td>
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<td>8.</td>
<td>Total Reserves: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,547,479</td>
<td>11,617</td>
</tr>
<tr>
<td>9.</td>
<td>Number of Employees: 2011, 2010, min=10, for all the selected periods</td>
<td>59,666</td>
<td>4,299</td>
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<tr>
<td>10.</td>
<td>Net assets: All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>1,893,216</td>
<td>4,299</td>
</tr>
<tr>
<td>11.</td>
<td>Turnover per employee (unit): All companies with a known value, 2011, 2010, for all the selected periods</td>
<td>87,021</td>
<td>4,299</td>
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<tr>
<td>12.</td>
<td>Incorporation date: to 30/12/2012</td>
<td>8,148,228</td>
<td>4,299</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>4,299</td>
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</table>
Although an initial sample of 4,299 firms was collected, this sample demonstrated distributions of variables which failed to meet the normality assumptions necessary to conduct a valid regression analysis of the sample, thus in their current state were unsuitable for analysis. The following details the data manipulations that were conducted in accordance with the research protocol in Figure 24, and illustrates the changes these manipulations make on the sample at each step of the process.

**STEP 3: Initial examination of sample**

In order to meet the basic assumptions required for regression analysis Field (2005) states that the dependent variables (in this thesis innovation outcomes measured using performance) should be normally (or close to normally) distributed, to allow for the correct measurement of residuals. If the residuals are incorrect, this can limit the validity of the results. In order to determine the normality of distributions of the dependent (in this research: performance) variables, the descriptive statistics, histogram plots and p-p plots were generated for analysis. The distributions and normality that were produced by performance variables ROA and Profits are illustrated below in Figures 37 and 38. Finally, Table 42 demonstrates the descriptive statistics for these variables in the initial sample.

![Figure 35: (a) Histogram and (b) Normality plot for construction firm ROA](image-url)
What can be seen in the figures above is that the dependent variables of the raw sample were not normally distributed. The histograms demonstrate extreme values outside the norm, highlighted by red circles. Likewise, the normality plots illustrate extreme values, highlighted in red, which distort the analysis for the sake of a few cases. Table 42 further illustrates this in the extreme skew and kurtosis statistics for the variables. The Profits distribution was the most non-normal, and was extremely peaked with a kurtosis statistic of 694.77. This value indicates an extremely non-normally distribution, where values cluster tightly around the mean value. This would have prevented the use of the selected statistical analysis technique, and resulted in extreme errors in the results. As illustrated below, ROA was also non-normally distributed.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
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</thead>
<tbody>
<tr>
<td>ROA (%)</td>
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<td>-581</td>
<td>397</td>
<td>3.47</td>
<td>22.90</td>
<td>-6.73</td>
<td>186.32</td>
</tr>
<tr>
<td>Profit (£000’s)</td>
<td>4299</td>
<td>-1134000</td>
<td>780000</td>
<td>2211.75</td>
<td>29309.93</td>
<td>-5.26</td>
<td>694.77</td>
</tr>
</tbody>
</table>

Throughout this data manipulation, section histograms will be generated along with the descriptive statistics as a reference point to demonstrate the improvement of the normality of the variables, relative to Table 42 above. The purpose of the data manipulation is to return the dependent variables to a suitable distribution as close to normally distributed as possible, in order to meet the statistical assumptions necessary to analyse the sample. In reference to the above, the descriptive statistics above the variables should have a skew and kurtosis value closer to 0, the normality plot of the
data should be linear, following the illustrated line, and finally the histogram should follow the normally distribution plot on the figure.

What can be seen in Figure 33 and 34 is not only that the distributions are non-normally distributed, but also that there are some extreme values distorting the sample indicated in red. These extreme values, distort the sample, and prevent normal distribution of the variables, and the excessive skew and kurtosis statistics of the data.

Therefore, manipulation of the data was required in order to reduce these statistics, through removal of data or through transformation. As seen in the above, some of sample cases are extreme compared to the majority of the sample. For instance from the raw data sample, the largest Profits values were almost 5 times larger than the 20th largest value and 18 times larger than the 50th. These values are demonstrated below in Table 43. Similarly, to the data below, extreme cases also existed within the performance variable ROA, which were disproportionately larger than other values within the sample. In order to identify and extract the cases causing the distortion of the sample, the research applied Process 1: outlier-labelling rule to identify and extract the extreme cases from the sample. This process is detailed within the following sub-section

<table>
<thead>
<tr>
<th>Firm Name</th>
<th>Sector</th>
<th>Position</th>
<th>Profits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Rail Infrastructure Ltd</td>
<td>41100</td>
<td>1st</td>
<td>780,000</td>
</tr>
<tr>
<td>Taylor Wimpey UK Ltd</td>
<td>41100</td>
<td>20th</td>
<td>156,891</td>
</tr>
<tr>
<td>SIG Plc</td>
<td>43290</td>
<td>50th</td>
<td>43,700</td>
</tr>
</tbody>
</table>

**STEP 4 and STEP 5: Outlier labelling rule**

In order to normalise the dependent variable distribution the outlier labelling rule formulated by (Hoaglin & Iglewicz 1987) was used. The outlier-labelling rule allows for the identification of extreme values, uncharacteristic of the sample to be identified and consequently removed from a given sample. Outlier results are those that do not fit with the rest of the sample, presenting extreme cases which distort the distribution of the sample results and are not representative of the data as a whole. The application of the outlier labelling rule on the raw sample identified cases existing outside an upper and lower boundary. The boundaries were calculated using the range between the 25th and 75th percentile, multiplied by a factor of 2.2 (confidence interval of 10%), which was then added to the 75th percentile (upper boundary), or removed from the 25th
percentile (lower boundary) in accordance with (Hoaglin & Iglewicz 1987). The calculation for these boundaries is demonstrated below, prior to Table 47 indicating the values for the outlier labelling rule:

\[
Upper \ Boundary = Q_3 + k \times (Q_3 - Q_1)
\]

\[
Lower \ Boundary = Q_1 - k \times (Q_3 - Q_1)
\]

Where \( k = 2.2 \)

Table 45: Outlier labelling rule application to performance variables in construction context

<table>
<thead>
<tr>
<th>Variable</th>
<th>q1</th>
<th>q3</th>
<th>q3-q1</th>
<th>Lower (q1-g')</th>
<th>Upper (q3+g')</th>
<th>Bottom Cases</th>
<th>Top cases</th>
<th>B%</th>
<th>T%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA (%)</td>
<td>0.416</td>
<td>8.975</td>
<td>8.56</td>
<td>-18.42 £</td>
<td>27.8 £</td>
<td>192</td>
<td>147</td>
<td>5.1%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Profit (£000's)</td>
<td>24.73</td>
<td>1068.85</td>
<td>1044.12</td>
<td>-2,272.3 £</td>
<td>3,365.9 £</td>
<td>189</td>
<td>439</td>
<td>5.1%</td>
<td>11.8%</td>
</tr>
</tbody>
</table>

Table 44 above illustrates the results from the application of the outlier labelling rule on the performance variables within the raw sample, identifying the upper and lower boundaries and the number of cases that existed outside these parameters. Outliers within the sample were identified sequentially, prior to removal of the selected cases in order to prevent over correction and the unnecessary removal of cases. Within the data set the extreme cases for ROA and Profits were first identified, then removed, so not to remove more cases than necessary. The removal of these outlier cases ultimately resulted in a 22% reduction in the sample size to provide an adjusted sample of 3,340 cases. Although it was recognised that the removal of a sizable portion of sample, and what were the highest (and some of the lowest) performing firms might distort the results, it was considered necessary in order to meet the statistical assumptions and provide a statistical analysis that was valid.

**STEP 6: Examination of reduced Sample**

In order to determine the extent of the improvements made by the application of the outlier labelling rule in STEP 3, an analysis of the dependent variables was repeated. This analysis generated descriptive statistics, histograms and normality plots for each dependent variable, as in STEP 2. The results of this analysis are illustrated in Figure 37, Figure 38 and Table 45 below.
As can be seen by the figures above and the descriptive statistics below, significant improvements were made to the normality of the performance variables distributions. Visually from the histograms and normality plots in Figure 37 and Figure 38, it can be seen that the application of the outlier-labelling rule removed a significant proportion of extreme values. As a result the distributions of the variables were more normally distributed. Furthermore, removing these outliers has provided a clearer indication of how the data is distributed, previously not possible due to outlier cases which distorted the generated plots. Improvements were also identified within the normality plots, which were also far more linear that within the raw sample, suggesting a normal distribution, which was suitable for regression analysis.

Table 46: Descriptive statistics of performance variables from reduced sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA (%)</td>
<td>3465</td>
<td>-18</td>
<td>28</td>
<td>4.59</td>
<td>7.120</td>
<td>.273</td>
<td>1.150</td>
</tr>
<tr>
<td>Profit (£000’s)</td>
<td>3465</td>
<td>-2226</td>
<td>3353</td>
<td>475.01</td>
<td>797.117</td>
<td>.912</td>
<td>2.037</td>
</tr>
</tbody>
</table>
Table 45 above illustrates the descriptive statistics of the performance variables within the reduced sample following the application of the outlier-labelling rule on the raw sample. As can be seen above, in comparison to the raw sample the skewness and kurtosis statistics are considerably reduced. A skewness statistic of -6.73 for ROA was reduced to only .273 within the reduced sample, which is considered by the researcher to be within the acceptable range of +/-1. Despite requirements to provide a normal distribution, Field (2005) does not provide guidelines for what is considered a suitable distribution of data for analysis. Nevertheless, it is proposed that the application of the outlier labelling rule was sufficient in reducing the skewness and kurtosis statistics for all performance variables within the sample, making them valid for statistical analysis. For both ROA and Profits within the reduced samples these variables demonstrated skew below a 1, and a sufficiently low value for kurtosis. Therefore further manipulation of the performance variables was not carried out for this study.

**STEP 7: Compute Ratios**

Following the removal of outliers within the dependent variables ROA and Profits, the subsequent step of the data manipulation was to generate the slack ratios from the raw data. The slack ratios, which will be later used to generate the slack variables for analysis, are the direct measures of slack resources as dictated within the Research Design. Slack ratios are the absolute values of the slack variables, prior to further manipulation in Steps 7 and 9; where outliers are removed (step 7), and the values are centred relative to industry means (step 9). The calculations used for the slack ratios were as follows:

Expense ratio used to calculate Absorbed Slack = \( \frac{SG&A \, expenses}{Turnover} \)

Quick ratio later used to calculate Unabsorbed Slack = \( \frac{Current \, assets-\, inventories}{Current \, liabilities} \)

HR ratio later used to calculate Human Resource Slack = \( \frac{firm \, employees}{Turnover} \)

Cash ratio later used to calculate Financial Slack = \( \frac{Cash \, reserves}{Turnover} \)
STEP 8: Examination of Slack Ratios

As in the above, it was considered necessary to perform an initial analysis of the slack ratios in order to reveal any possible irregularities in the collected data which might distort future analysis. As with the performance variable in Steps 3 and 4, the descriptive statistics and histogram plots were collected. Unlike the dependent variables, the independent or predictor variables are not required to be normally distributed to satisfy assumptions for statistical analysis (Field 2005). Therefore the histogram plots below were used solely to identify extreme cases which might distort the results, and reduce the generalizability of the conclusions. In Figure 39 below each ratio’s histogram indicates that there are extreme values within the sample.

Figure 39: Histograms of Slack ratios from reduced sample (a) Expense Ratio (b) Quick Ratio (c) HR Ratio (d) Cash Ratio

As illustrated in Figure 39 above, the slack ratios were plagued by extreme values much like that with the performance variables previously. Although this is not as serious an issue as that seen within the raw sample for the performance variables, this was still a
cause for concern as prior to analysis it cannot be ascertained the extent to which particular cases might be errors in measurement or true outliers. Similarly, to the figures above, Table 46 illustrates the descriptive statistics for the slack ratios at t-1 (2011). It can be seen that the levels of skewness and kurtosis vary across the ratios, and in some cases are very large. The following section seeks to identify and remove extreme values from the sample based upon outlier within the slack ratio distribution. This was done not to improve the normality of the slack ratios distribution, but to remove cases with potential to distort the analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expense Ratio</td>
<td>3465</td>
<td>.00</td>
<td>60.40</td>
<td>.2574</td>
<td>1.05711</td>
<td>53.291</td>
<td>3026.369</td>
</tr>
<tr>
<td>Quick Ratio</td>
<td>3465</td>
<td>.004</td>
<td>48.804</td>
<td>1.527</td>
<td>1.809</td>
<td>12.426</td>
<td>264.299</td>
</tr>
<tr>
<td>HR Ratio</td>
<td>3465</td>
<td>.17</td>
<td>666.67</td>
<td>7.8939</td>
<td>14.01492</td>
<td>32.183</td>
<td>1430.928</td>
</tr>
<tr>
<td>Cash Ratio</td>
<td>3465</td>
<td>-118.57</td>
<td>213.04</td>
<td>.4079</td>
<td>4.99759</td>
<td>18.899</td>
<td>1096.445</td>
</tr>
</tbody>
</table>

**STEP 9 & 10: Identification and removal of outliers, and subsequent analysis**

As can be seen in Figure 39 above, each slack variable indicates cases in extreme to the rest of the sample. For instance, the largest value in the expense ratio (60.4%) is more than 12 times larger than the next value (4.9%). The data gathered from F.A.M.E is considered to be accurate therefore, so are the values of extreme cases, however, cases such as this were checked for validity to ensure the accuracy of the overall sample. However, in spite of the accuracy of some extreme cases this cannot be confirmed for every extreme case. Moreover, it is argued that their inclusion prevents an appropriate analysis of the sample, as extreme cases are not representative of the sample, therefore must be removed.
Table 48: Identifying extreme cases in slack ratios for reduced sample (t-1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Company Name</th>
<th>TYPE</th>
<th>RANK</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expense Ratio 2011</td>
<td>Ben Bailey Homes Limited</td>
<td>Construction</td>
<td>1</td>
<td>60.40</td>
</tr>
<tr>
<td></td>
<td>Axa Real Estate Investment Managers Limited</td>
<td>Construction</td>
<td>2</td>
<td>4.89</td>
</tr>
<tr>
<td></td>
<td>Blackburns (Harleston) Limited</td>
<td>Construction</td>
<td>20</td>
<td>1.10</td>
</tr>
<tr>
<td>Quick Ratio 2011</td>
<td>Rock Fall Company Limited</td>
<td>Specialist</td>
<td>1</td>
<td>48.80</td>
</tr>
<tr>
<td></td>
<td>Evans Management Limited</td>
<td>Construction</td>
<td>10</td>
<td>20.52</td>
</tr>
<tr>
<td></td>
<td>Sydenhams Timber Engineering Limited</td>
<td>Construction</td>
<td>20</td>
<td>9.99</td>
</tr>
<tr>
<td>HR Ratio 2011</td>
<td>Ben Bailey Homes Limited</td>
<td>Construction</td>
<td>1</td>
<td>666.67</td>
</tr>
<tr>
<td></td>
<td>Cumbrian Industrials Limited</td>
<td>Civil Engineering</td>
<td>2</td>
<td>187.82</td>
</tr>
<tr>
<td></td>
<td>Harry Fairclough Limited</td>
<td>Construction</td>
<td>20</td>
<td>46.69</td>
</tr>
<tr>
<td>Cash Ratio 2011</td>
<td>Ben Bailey Homes Limited</td>
<td>Construction</td>
<td>1</td>
<td>213.04</td>
</tr>
<tr>
<td></td>
<td>Ackroyd &amp; Abbott Limited</td>
<td>Construction</td>
<td>2</td>
<td>78.89</td>
</tr>
<tr>
<td></td>
<td>Luff Group Limited</td>
<td>Construction</td>
<td>20</td>
<td>7.39</td>
</tr>
</tbody>
</table>

The researcher removed the most extreme cases for each variable in order to remove cases that might distort the distributions, in order improve the clarity and interpretability of the results. In order to remove bias that might occur through visual or discriminative selection of extreme cases, both the highest and lowest five cases of each slack ratio were highlighted for removal from the sample. Both the highest and lowest cases were removed to maintain balance in the distribution and remove bias against low or high values. The number of removed cases was based on the minimum necessary to find values that corresponded to the sample and were not so extreme as those indicated in red above.

These cases were subsequently removed and saved outside of the main data set. This process was also repeated for the highest and lowest three cases for the control variables size and number of employees. Although the application of the outlier labelling rule was considered, this process was thought to remove too much of the remaining data, and was furthermore considered unnecessary for application on data that would be used to generate the predictor variables. The process of identifying and removing outliers from the sample reduced the sample size from 3340 to 3407.

The following figures and table illustrate the histograms and descriptive statistics from Step 8 in the research protocol, following the removal of the identified outlier within the slack ratios. Although some extreme cases do remain in the sample of these variables, it
is argued that there is sufficient distribution of cases to allow for these values to remain in the sample. Moreover, a perfectly normal distribution is not necessary for the predictor variables as it is for the dependent variables (Field 2005).

![Histograms of Slack ratios following Step 7](image)

**Figure 40: Histograms of Slack ratios following Step 7** (a) Expense Ratio (b) Quick Ratio (c) HR Ratio (d) Cash Ratio

As can be seen in Table 48 below, the removal of the identified outlier has significantly improved the skewness and kurtosis statistics for these variables. For instance Expense ratio, HR ratio and Cash Ratio previously had kurtosis statistics in the thousands, as can be seen this was reduced to a value of 12.01 for the Expense ratio.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expense Ratio</td>
<td>3416</td>
<td>0</td>
<td>3</td>
<td>.23</td>
<td>.214</td>
<td>2.816</td>
<td>11.555</td>
</tr>
</tbody>
</table>

Table 49: Descriptive statistics of Slack ratios from reduced sample (t-1)
STEP 11 & 12: Generation of slack variables via mean cantering, and subsequent analysis

Following the removal of outliers within the slack ratios in Step 7, the next data manipulation step in the research protocol is to generate the slack variables. These are created using the slack ratios seen above and are used in the final data set for used for the regression analysis.

As detailed in the research design, in order to control for the difference between firms such as resource heterogeneity (Richard et al. 2009) slack researchers often mean correct slack ratios using industry averages (Love & Nohria 2005; Bradley, Wiklund, et al. 2011; Mishina et al. 2004). Mean centring is the process by which values for a measure are centred to a mean of 0.0 (Dalal & Zickar 2012). This aid the interpretability and comparability of variables. The Slack variables were calculated as the slack ratio value minus the industry mean value. For example absorbed slack was calculated using the following equation:

\[ \text{Absorbed Slack} = \text{Expense ratio} - \text{Industrial Average Expense ratio} \]

Where Expense ratio = \( \frac{\text{SG&A Expenses}}{\text{Turnover}} \)

This form of calculation was applied to the generation of all slack variables, distinguishing cases based upon their industry classification as detailed in the research design. The process of mean centring was done not only to control for differences between firms, but also to aid interpretability of results. By zero centring values by using means the research can identify high slack firms by positive values and lower slack firms by negative values (Mishina et al. 2004).

Following the mean centring of the data, a descriptive analysis was conducted in accordance with Step 12 of the research protocol. Figure 41 illustrates histograms of the new slack variables generated from the previous slack ratios. Similarly Table 52 illustrated the descriptive statistics that were generated by the slack variables. Although
the mean centring of the slack variables caused some distortion in terms of skewness, kurtosis and standard deviation statistics for each slack type, these changes were all considered minor, and insignificant compared to improving the interpretability of the final results. The data set containing the slack variables were then saved, concluding stage 3 of the data manipulation.

![Histograms of Slack variables following Step 9](https://via.placeholder.com/150)

(a) Absorbed Slack (b) Unabsorbed Slack (c) Human Resource Slack (d) Financial Slack

**Figure 41: Histograms of Slack variables following Step 9**

(a) Absorbed Slack (b) Unabsorbed Slack (c) Human Resource Slack (d) Financial Slack

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbed Slack</td>
<td>3407</td>
<td>-0.27</td>
<td>2.40</td>
<td>0.000</td>
<td>0.210</td>
<td>3.01</td>
<td>13.22</td>
</tr>
<tr>
<td>Unabsorbed Slack</td>
<td>3407</td>
<td>-1.53</td>
<td>16.29</td>
<td>0.000</td>
<td>1.281</td>
<td>4.80</td>
<td>37.20</td>
</tr>
<tr>
<td>Human Resource Slack</td>
<td>3407</td>
<td>-8.01</td>
<td>60.89</td>
<td>0.000</td>
<td>5.492</td>
<td>3.20</td>
<td>19.45</td>
</tr>
<tr>
<td>Financial Slack</td>
<td>3407</td>
<td>-7.01</td>
<td>19.27</td>
<td>0.000</td>
<td>0.886</td>
<td>8.64</td>
<td>128.76</td>
</tr>
</tbody>
</table>

Table 50: Descriptive statistics of Slack variables from reduced sample (t-1)
STEP 13 & 14: Generation of non-linear slack variables and Dummy Variables

At this stage the research protocol had removed the outlier cases from the performance variables, removed of extreme cases from the slack ratios and completed the generation of the slack variables. However, both Hypothesis 1 and Hypothesis 2 predict a non-linear relationship between organisational slack and performance. Thus, as detailed in the research design in Chapter 5, in order to establish non-linear relationships within a regression analysis, non-linear variables were generated by raising existing variables to a higher power (Tabachnick & Fidell 2001), based upon the algebraic regression equation. Within existing slack research linear variables are squared to provide an additional variable, and a quadratic equation to demonstrate a non-linear relationship within the regression analysis (see Tan & Peng, 2003).

The theoretical basis of the non-linear relationship is that is a resolution between two conflicting perspective of linear relationships, seen in Section 3.7.3. Presently, slack research does not explore the impact of slack beyond a parabolic (i.e. squared) functions, thus this research does not seek to extend to a cubed power, and focuses solely on the first order (linear) and second order (squared) coefficients.

Due to the mean centring of the slack variable, a number of cases have negative values for slack; therefore squaring these terms would result in errors in the distribution. In order to correct for this, following the transformation laid out by Field (2005) was performed. A Value of +1 was added to each case so that the minimum case was always at least 1, allowing this to be squared without causing error in the calculation. This was then squared to create a non-linear variable, and then once again zero-centred using the mean of the sample to indicate firms with high and low levels of slack. The calculations were as follows

\[
\text{slack non-linear} = (\text{slack variable} + \text{minimum} + 1)^2
\]

\[
\text{slack squared} = (\text{slack nonlinear}) - \text{meanslack nonlinear}
\]

Following the generation of the generation of the non-linear slack variables, the descriptive statistics were produced to ensure that the variables maintained a mean of 0.00, these statistics are illustrated in Table 53 below.
The final step in the research protocol prior to the analysis of the final sample was the generation of the dummy variables in order to analyse firm type. To this point firm type exists as a categorical variable, with arbitrarily assigned codes to aid the researcher in their analysis. However, these codes cannot be meaningfully applied within a regression analysis. Dummy coding is a means by which groups may be represented in order to include their influence in a statistical analysis (Field 2005). Due to the analysis covering a large range of firm types, it was considered appropriate to ensure differences between these firms in terms of performance be controlled. This practice is often found within slack research where dummy variables are used to represent firm types against a baseline firm (see Bradley). In this instance constructing firms were used as a baseline for the distinction of the dummy variable. This can be seen in Table 51, which illustrates the applied dummy variables in reference to the firm type, BIS and SIC code classification. Following the generation of the dummy variables a final data set was produced so that Steps 13, 14 and 15 could be conducted.

Table 51: Descriptive statistics of Slack variables from reduced sample (t-1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbed Slack squared</td>
<td>3407</td>
<td>-6.7</td>
<td>11.83</td>
<td>.0000</td>
<td>.678</td>
<td>4.67</td>
<td>42.39</td>
</tr>
<tr>
<td>Unabsorbed Slack squared</td>
<td>3407</td>
<td>-7.04</td>
<td>346.00</td>
<td>.0000</td>
<td>15.80</td>
<td>11.76</td>
<td>189.82</td>
</tr>
<tr>
<td>Human Resource Slack squared</td>
<td>3407</td>
<td>-110.36</td>
<td>4775.26</td>
<td>.0000</td>
<td>219.90</td>
<td>9.83</td>
<td>137.25</td>
</tr>
<tr>
<td>Financial Slack squared</td>
<td>3407</td>
<td>-63.90</td>
<td>679.09</td>
<td>.0000</td>
<td>21.77</td>
<td>15.90</td>
<td>373.24</td>
</tr>
</tbody>
</table>

Table 52: Firm type dummy variables for construction context

<table>
<thead>
<tr>
<th>Firm Type/Classification</th>
<th>BIS classification</th>
<th>SIC code</th>
<th>CODE</th>
<th>Dummy 1</th>
<th>Dummy 2</th>
<th>Dummy 3</th>
<th>Dummy 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contracting</td>
<td></td>
<td>1</td>
<td>41</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td></td>
<td>1</td>
<td>42</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Specialist</td>
<td></td>
<td>1</td>
<td>43</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Service</td>
<td></td>
<td>2</td>
<td>Various</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Product</td>
<td></td>
<td>3</td>
<td>Various</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
## Table 53: Semi Structured Interview Question Prompt Sheet

<table>
<thead>
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<th>Nº</th>
<th>Innovation</th>
<th>Organisational Slack</th>
<th>Firm Performance</th>
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<td>1</td>
<td>Researchers have defined innovation as: “the effective generation or adoption, and implementation of a new idea, which enhances overall organizational performance” Does this definition resonate with your or the firm's view of innovation?</td>
<td>What is your understanding of organisational slack? Does the firm have a pool of excess resources; human, cash or otherwise?</td>
<td>How does the firm measure performance?</td>
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<tr>
<td>2</td>
<td>How do you define innovation?</td>
<td>Assume that due to some sudden development, 10% of the time of all people has to be spent on work unconnected with normally activities. How seriously will your output be affected over the next year?</td>
<td>How vital is financial performance to the firm?</td>
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<tr>
<td>3</td>
<td>How does the firm engage with innovation activities? Research, problem solving?</td>
<td>Assume that due to an unforeseen development, your departments or firms annual operating budget is reduced by 10%. How significantly will your work be affected over the next year?</td>
<td>What is more important short-term or long-term profit maximisation?</td>
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<tr>
<td>4</td>
<td>Has the firm had any notable innovations in the last year? (either through adoption of generation)</td>
<td>The firm have a necessary pool of financial resources that can be used on a discretionary basis for strategic initiatives?”</td>
<td>What role does innovation play in firm performance?</td>
</tr>
</tbody>
</table>
| 5 | a) What is the purpose of the firm to innovate?  
b) How would the firm measure a given innovation? | If the firm had an increase in profits, would this improve its ability to innovate? | Does/would the availability of excess resources (slack) allow for improved overall performance? |
| 6 | What are the key determinates of innovation in the firm? | Does the role of slack function within construction firms? |   |
| 7 | What role do firm level resources, both tangible and intangible play in the firm’s ability to innovate? | Is there a lack of resources within construction to support the potential level of innovation? |   |
# Appendix 5 - Transcription codes

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<th>Sub-topic</th>
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### Construction Market

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Appendix 6 – Extended time lag Multiple regression Models

Table 56: Multiple regression Table of results, ROA, Construction, t-2
Table 57: Multiple regression Table of results, Pre-Tax Profits, Construction, t-2
Table 58: Multiple regression Table of results, ROA, Manufacturing, t-2
Table 59: Multiple regression Table of results, Pre-Tax Profits, Manufacturing, t-2
### Table 54: Multiple regression Table of results, ROA, Construction, t-2

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**.Absorbed Slack**²

**Unabsorbed Slack**²

**HR Slack**³

**Financial Slack**³

| Number of Observations | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 | 3407 |
| Degrees of Freedom    | 7    | 8    | 8    | 8    | 8    | 9    | 9    | 11   | 11   | 11   | 15   |
| R²                    | 2.41% | 2.55% | 2.61% | 2.43% | 2.40% | 2.79% | 2.40% | 2.81% | 3.71% | 2.47% | 3.73% |
| Adjusted R²           | 2.21% | 2.32% | 2.38% | 2.20% | 2.20% | 2.50% | 2.17% | 2.49% | 3.40% | 2.15% | 3.31% |
| F-test or Wald x      | 12.01 | 11.11 | 11.38 | 10.57 | 10.52 | 10.85 | 9.40 | 8.91 | 11.88 | 7.82 | 8.77 |
| Durbin-Watson         | 1.95 | 1.95 | 1.95 | 1.96 | 1.95 | 1.95 | 1.96 | 1.95 | 1.95 | 1.95 | 1.95 |
| Average VIF           | 1.27 | 1.24 | 1.25 | 1.26 | 1.35 | 1.32 | 1.36 | 1.34 | 13.68 | 4.76 | 13.60 |

***p<.001; **p<.01; *p<.05
Table 55: Multiple regression Table of results, Pre-Tax Profits, construction, t-2

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<td>8</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>15</td>
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<tr>
<td>R2</td>
<td>6.52%</td>
<td>6.80%</td>
<td>6.52%</td>
<td>8.20%</td>
<td>6.52%</td>
<td>6.87%</td>
<td>8.30%</td>
<td>8.39%</td>
<td>7.57%</td>
<td>8.89%</td>
<td>9.32%</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>6.32%</td>
<td>6.63%</td>
<td>6.30%</td>
<td>8.03%</td>
<td>6.30%</td>
<td>6.60%</td>
<td>8.10%</td>
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<td>7.27%</td>
<td>8.60%</td>
<td>8.92%</td>
</tr>
<tr>
<td>F-test or Wald x</td>
<td>33.84</td>
<td>31.22</td>
<td>29.63</td>
<td>38.15</td>
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<td>27.84</td>
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<td>28.27</td>
<td>25.28</td>
<td>30.12</td>
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</tr>
<tr>
<td>Durbin-Watson</td>
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<td>1.78</td>
<td>1.78</td>
<td>1.80</td>
<td>1.78</td>
<td>1.79</td>
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<td>1.81</td>
<td>1.79</td>
<td>1.82</td>
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</tr>
<tr>
<td>Average VIF</td>
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<td>1.24</td>
<td>1.25</td>
<td>1.26</td>
<td>1.35</td>
<td>1.22</td>
<td>1.36</td>
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<td>13.68</td>
<td>4.76</td>
</tr>
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***p<.001; **p<.01; *p<.05
### Table 56: Multiple regression Table of results, ROA, Manufacturing, t-2

<table>
<thead>
<tr>
<th>Independent Variables</th>
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<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
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<th>M9</th>
<th>M10</th>
<th>M11</th>
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</thead>
<tbody>
<tr>
<td>Civil Eng.</td>
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<td>-0.11</td>
<td>-0.10</td>
<td>-0.11</td>
<td>-0.09</td>
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<td>-0.27</td>
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| Products              | -0.184| -0.184| -0.186| -0.185| -0.188| -0.187| -0.190| -0.191| -0.192| -0.191| -0.197|***
| Services              | -0.071| -0.071| -0.071| -0.072| -0.071| -0.072| -0.072| -0.055| -0.073| -0.058| -0.058|***
| Age                   | -0.020| -0.019| -0.024| -0.021| -0.025| -0.023| -0.027| -0.028| -0.030| -0.026| -0.033| *
| Size                  | 0.003| 0.000| -0.020| -0.003| -0.058| -0.024| -0.073| -0.081| -0.038| -0.076| -0.090|***
| No of Employees       | -0.083| -0.082| -0.066| -0.078| -0.054| -0.064| -0.042| -0.034| -0.054| -0.039| -0.026|
| Absorbed Slack        | 0.029| -0.035| -0.019| 0.046| 0.049| 0.053| 0.285| 0.239| 0.239| 0.239| 0.239|***
| Unabsorbed Slack      | 0.084| -0.087| -0.053| 0.285| 0.239| 0.239| 0.239| 0.239| 0.239| 0.239| 0.239|***
| HR Slack              | -0.03| -0.059| -0.057| -0.091| -0.085| 0.171| 0.218| 0.218| 0.218| 0.218| 0.218|***
| Financial Slack       | 0.140| 0.153| 0.153| 0.136| 0.071| 0.171| 0.218| 0.218| 0.218| 0.218| 0.218|***

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<tr>
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<td>Degrees of Freedom</td>
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<td>8</td>
</tr>
<tr>
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<td>Adjusted R2</td>
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<td>1.91</td>
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<td>1.32</td>
<td>1.28</td>
<td>1.30</td>
<td>1.29</td>
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</table>

***p<.001; **p<.01; *p<.05
## Table 57: Multiple regression Table of results, Pre-Tax Profits, Manufacturing, t-2

<table>
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<tr>
<th>Independent Variables</th>
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</tr>
<tr>
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<td>12.55%</td>
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<td>12.80%</td>
<td>14.75%</td>
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<td>15.50%</td>
<td>15.75%</td>
</tr>
<tr>
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<td>70.84</td>
<td>79.06</td>
<td>73.02</td>
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<td>1.83</td>
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<td>1.84</td>
<td>1.85</td>
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<td>1.89</td>
<td>1.90</td>
</tr>
<tr>
<td>Average VIF</td>
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<td>1.28</td>
<td>1.30</td>
<td>1.29</td>
<td>1.33</td>
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<td>1.32</td>
<td>1.32</td>
<td>6.07</td>
<td>6.76</td>
<td>9.16</td>
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</tbody>
</table>

\*\*\* p < .001; \*\* p < .01; \* p < .05
Appendix 7 – Raw Multiple Regression results example

### Variables included in Model Regression

<table>
<thead>
<tr>
<th>Model</th>
<th>Variables Entered</th>
<th>Variables Removed</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F.SQ.Cor.11, Civils, NoEMP.11, AGE, Service, Abs.SQ.Cor.11, HR.SQ.Cor.11, Products, UNAbs.SLACK.11, SIZE.11, Special, HR.SLACK.11, UNAbs.SQ.Cor.11, F.SLACK.11, Abs.SLACK.11</td>
<td>.</td>
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</tr>
</tbody>
</table>

a. Dependent Variable: PROFIT.TH  
b. All requested variables entered.

### Model Quality and Validity

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Durbin-Watson</th>
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<td>.107</td>
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a. Predictors: (Constant), F.SQ.Cor.11, Civils, NoEMP.11, AGE, Service, Abs.SQ.Cor.11, HR.SQ.Cor.11, Products, UNAbs.SLACK.11, SIZE.11, Special, HR.SLACK.11, UNAbs.SQ.Cor.11, F.SLACK.11, Abs.SLACK.11  
b. Dependent Variable: PROFIT.TH

### ANOVA

<table>
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<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
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</table>

a. Dependent Variable: PROFIT.TH  
b. Predictors: (Constant), F.SQ.Cor.11, Civils, NoEMP.11, AGE, Service, Abs.SQ.Cor.11, HR.SQ.Cor.11, Products, UNAbs.SLACK.11, SIZE.11, Special, HR.SLACK.11, UNAbs.SQ.Cor.11, F.SLACK.11, Abs.SLACK.11

### Coefficient Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
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</tr>
<tr>
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<tr>
<td>Special</td>
<td>4.481</td>
<td>35.615</td>
<td>.003</td>
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<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Mean</td>
</tr>
<tr>
<td>----------</td>
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<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>Predicted Value</td>
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</tr>
<tr>
<td>Residual</td>
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<td>Std. Predicted Value</td>
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<td>Std. Residual</td>
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</table>

a. Dependent Variable: PROFIT.TH
Charts

Histogram
Dependent Variable: PROFIT.TH

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: PROFIT.TH
Appendix 7

Scatterplot

Dependent Variable: PROFIT.TH
Appendix 8 – Interview Sample

Interview 1 – Construction

Firm specialisation – Pre-Construction and property services

Position – Pre-Construction Director

Interview Length: 50 minutes

Researchers have defined innovation as: “the effective generation or adoption, and implementation of a new idea, which enhances overall organizational performance” Does this definition resonate with your or the firms view of innovation?

I think it’s interesting that we often in construction think of innovation in a slightly narrower definition. I think your definition there probably fits with what I would define innovation as. We are a little bit of a traditional industry. And if someone decided they were going to make bricks in a different way that will be seen as innovation. I don’t necessarily think a lot of the things we do around quantitatively changing and improving management processes and business processes are seen as innovation in its true sense. So if a customer is asking us to explain our innovation, or give us examples of how we have been innovative. We would have a much narrower definition of that [innovation], when we think about that was the client. So I like your definition I think it’s correct, I think the organisation sees it a little narrower around the production of the products rather than the processes involved.

Do you think construction firm should be really looking and recognising the fact that there are other forms of innovation that are quite important?

I think would be enormously beneficial. I think in reality we do, a lot of firms do, but they’ll probably define them more as change programmes rather than innovation.

How does Wates go about engaging with innovation activities? Is a lot of research and development and terms of formal activities, teams devoted teams devoted to innovation, or is it more on site problem-solving?

I would say there’s a range of approaches. We will have little task forces set up by the business to address particular problems we have encountered across a number of projects or product types. So if we found something gone wrong once or twice, then a little group will be formed to think about how we’ll tackle that problem. That would then be rolled out as a new mandated procedure or approach. So it might be simple as don’t use this particular product, or if you are using this particular product you need to use this to stick together.
Then there is… As an organisation we encourage individuals to show the new thinking on whatever it might be. So typically around a process or procedure in terms of how we do business, and that is encouraged through a employee… Champion…Champion of the month…Award. I think they now call it employee excellence, where there is an annual dinner and people are nominated by the managers or team leaders, and anything particularly innovative in that year and there awarded with certificates and awards.

The other way we do it is by engaging with third-party specialists. So a lot of what we do is done by subcontractors or third-party suppliers. So we are in constant dialogue with them around how we tackle each individual project and most efficient way. I wouldn’t necessarily say it’s innovation but it’s all about doing business and building buildings in the most efficient way in terms of relationships with suppliers and subcontractors.

Could you highlight any specific innovations that have occurred within the last 12 months? Any specific products they’ve used on projects anything that really stands out? Even some administrative organisational changes that might have occurred been quite impactful?

I’ll give you two examples

the first is we have started doing a lot more residential work. The construction market particularly around London there is a big increase in the amount of residential projects. We found that building bathrooms in those buildings is a particular challenge. So we have started adopting off-site bathrooms made in a factory and brought to site as a unit. We think that is innovation, even though that technology has been around 30 years. But for us it’s innovation because we have always previously built bathrooms on site. I think it’s sort of innovative first doing on a large scale but it’s not recognise it as innovation to the industry at large.

The other thing that we’ve done but I think is innovative, the environment we trading terms of risk transfer to us has changed dramatically in the last 5 to 10 years. So we are now… Years ago we would not take any risk for the design of the products that we are building, which would be someone else’s responsibility, we were just bolted together. We are now responsible for that design. So lasts few years there’s been a team of people that have been developing processes that enable us to measure that risk [involved design] more accurately and tangibly. Because what we found when we are just assessing the risk as a result of management judgement will getting it wrong. So we developed a robust set of procedures which takes very forms of checklists and technical tests that will measure the exposure to risk that we have. It’s a big business change to take all this risk.

What you think is the purpose innovation? Why does the firm try to innovate? What is the purpose of the task forces? What outcome are you trying to create?

Simplistically everything that we do is driven by a desire to generate shareholder value. If we can do business more effectively and efficiently and sell ourselves to a broader spectrum of customers
to make it more profitable that serves the primary purpose as a business which is to provide a
return to shareholders. I think when you boil down we were obliged to innovate because we are obliged to
provide a return to shareholders. In a competitive market if you do things that we did yesterday
you will be out of business in five weeks flat.

Do you think all these alternative performance measures such as customer satisfaction and
other quality driven processes they feed into profitability and shareholder return? that all
these different measures feed into higher financial metric?

I think we are driven by a higher purpose, profit being one. We have a different line when talking
to customers. When we ask all of our customers how they view us in certain things innovation
being one of them stop it would appear when you analyse the responses that our customers only
see innovation in new products or new techniques. They would not necessarily see us doing
something new more clever impute human of a particular piece of keep kit that got the sooner they
would not see that as innovation. Whilst we do a lot more of that clever stuff, through design and
procurement process, making construction more efficient they [customers] don’t see that as
innovation. They [customers] will only perceive innovation as things they can tangibly see such as
a product.

We talked about shareholder value how does that tie into how the firm measures impact of a
given innovation?

I don’t think it does. I don’t think we have any metrics that reliably tell me the impact of anyone
innovation. The safety metrics for example, and we analyse them overtime the most sophisticated
we get is we introduced X new procedure into our safety manual at such date and what factors that
had on our statistics. I don’t think we do anything doing anything more sophisticated that outside
core business KPIs. If someone had a little pet project there would almost certainly use standard
business KPIs to measure if it’s successful or not.

What inputs do you need to get innovation out’s at the firm level? Do you think thinking
resources culture government regulations which are the most important to your firm?

The most important are business level commitments to supporting something. it’s about freeing up
gross sources at one level and at another level creating culture where people are encouraged to
think differently. So I think it’s effectively a leadership function to enable innovation whatever
form it takes. it’s about culture and its relationships that we breed.

Touched on this slightly do you feel that resources are important to innovation not
necessarily just tangible ones in terms of cash also intangible ones such as experience and
leadership of things important to innovation as well?

Business is very simple, our assets of is purely people we don’t have big factories with big
equipment in it or anything like that. We don’t have big R&D budgets. So it’s very much the same
answer to the previous question about space training coaching people putting people in the right environment to naturally bring about innovation.

What is your understanding of organisational slack? Have you ever seen this phrases used before

I would describe that as… Two things… One in terms of capacity in our ability to take on more business which is fundamentally people, the other is our ability to deal with unforeseen problems which is our relates to more cash reserves. I can’t think of any provisions that we make, there’s not a lot more to us than that. So we fight a constant battle between avoiding having people sat on the bench doing nothing, and taking on business we can’t resource. Is a contra constant managerial challenge, what we tend to do when people are generally sitting there we utilise them in doing something different. Which essentially add some value; this could be anything from holiday cover to get involved with projects relating to business improvement. We try and manage that that’s slack intelligently. In terms of cash for unforeseen problems we make provisions in a whole host of ways: keeping cash reserves, continuing to funds at project level and a business level. There is a very clear commercial process for covering potential liabilities in terms of finance.

Assume that due to some sudden development, 10% of the time of all people has to be spent on work unconnected with normally activities. How seriously will your output be affected over the next year?

This makes me jump to effect on productivity; my mind thinks the it would make a slightest bit of difference. Because, I think most individuals have a natural amount of additional capacity. I don’t think we sweat any one individual that they are hundred percent usually. so… For a short period, let’s say a month I could lose 10% of people’s time/10% of people without having a massive impact because people would rise to that challenge. In the short term is not an issue. In the long term I think people would use to get would get used to the new working regime I wouldn’t say that my output would reduce by 10%

Just to put a number on it would be less than 5%?

Yes I think so.

Assume that due to an unforeseen development, your departments or firms’ annual operating budget is reduced by 10%. How significantly will your work be affected over the next year?

We have the business model where we try to reduce overheads every year. I have a significant amount of pressure on budgets every year. I wouldn’t say so much as 10% but there’s always a drive to make a reduction and it kind of links into your innovation ideas. In the past it’s forced us to rethink some of our processes, so we’ve streamlined the amount of work and individual has to do, so that they’re wasting less time, so we need less people in overall terms as we develop. I think that reducing operating budget is a useful tool to test efficiency. If a is a 10% reduction it’s quite a
lot, we run quite a tight ship, so I say there will be less output… This feels like losing more people than time [based on overheads] and that would have more of an impact.

so above 5% closer to 10% for this question?

Around five it would be 10% say… 5%

If your firm had a sudden increase in profits or profitability on projects due think it’s ability to invented, the would improve to think about her siphon more resources into innovation? Or would it stay roughly the same as it is now?

If it was a single win for you it would say the same. If we were able to increase our margin on an ongoing basis that would start recycling that back into innovative activities to again improve margin. However, this would be to a point, as the environment we working is a very low margin industry anyway. Good return on investment but poor margin.

Do you think slack plays a large role in construction firms all within your role specifically not just in relation to innovation but in relation to its normal operating procedures as well?

I particularly think so, I think it’s its number one challenge to business managers in terms of balancing the resources available with the demand…the ebbs and flows. Position part of the market cycle of the moon where demand is outstripping supply and availability of resources where for about three years was a doctor it’s certainly an ongoing business challenge.

Thinking outside your firm and for a moment and towards the construction industry as a whole due think there’s a general lack of slack within construction firms, and that there would functioning a bit too tightly…?

At this moment I’m definitely yes. During the recent economic downturn the industry lost a huge amount of talent when people left the industry, resulting in a lack of slack.

I’ve always thought that that due to low margins that everyone faces within construction there is not an ability to actually cultivate enough slack…

I think that is absolutely spot on. You can’t afford to have dead resources in most cases.

How does your firm measure firm level performance?

We use whole raft of KPIs that were measured on none of them will surprise you stop things like: profit being the main one I guess, turnover for the volume of business. Then at the project level we measure our ability to deliver to time to costs (what we said we would charge the client to what we did charge the client), client satisfaction, safety quality, performance based on defects. There are lots of others but they are the main ones.

What is more important to your firm long-term profit maximisation or short-term return?
We are a family owned business and we are now concerned with one thing only… And that’s giving it to the next generation… So it’s very different to that of the normal plc

So whilst we are looking at profits and turnover there is an over arcing drive towards survival of?

Yes, we have survived the most, we are one of the oldest construction firms.

What role do you think innovation plays towards performance?

I think it plays a massive role, and we perhaps to realise it...I think is massive I don’t think we continually innovate in relation to business… It’s huge.

Due think the presence of slack within your firm ties into your overall performance as well as in relation to innovation?

… It does… But that question does make me think that you need to be careful because too much slack can make you fat lazy and inefficient so. One of my project managers has always said me had rather be a man down the man up or too many because you can keep everyone focused. when a team gets too fat or this too much like this too much waste and can be properly managed.