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DOES THE INCORPORATION OF MORE VARIABLES IMPROVE THE ACCURACY AND FLEXIBILITY OF CASH FLOW FORECASTING?

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Abstract
Previous research has demonstrated significant variation in actual cash flow profiles. However, evaluation of traditional cash flow forecasting models indicates that the extent of variation in cash flows is not considerable. This suggests that further variables are needed to enhance the flexibility of the cash flow profiles produced. This paper presents a model designed to incorporate as many variables as possible, without becoming too complex. The model uses fifty variables to calculate the cash flow of individual contracts. Initial testing of the model proved that by incorporating further variables, the flexibility of the model is enhanced. Previous construction projects are currently being used to evaluate the accuracy of the model.

Key words: Cash flow, Tendering strategies, S-curves, Financial planning.

Introduction
Accurate cash flow forecasting is essential at the tendering stage to all contractors. It provides contractors with information regarding: the amount of capital required to perform a contract; the amount of interest that needs to be paid to support any overdrafts; and the evaluation of different tendering strategies. Ideally, cash flow forecasts should be based on the construction programme and a bill of quantities. Cash flow forecasting at the tendering stage also needs to be simple and fast because of the short time available and the associated cost. However, contractors seldomly prepare a comprehensive construction plan at the tendering stage, but usually wait until winning the contract. Previous research has acknowledged this need, and as a result simple cash flow forecasting models have been developed. These models are now incorporated in most standard construction management text books. They tend to follow the same concept and mechanism, that is: using standard S-curves to represent the running cumulative value of contracts, which is then converted to the running cumulative cost committed on the contracts by deducting the overall mark-up applied; these two curves are then converted (using time delays and retention) to represent cash in and cash out. The result is the predicted net cash flows for the contracts.

This paper investigates the reliability of this approach by evaluating previous research. It confirms that since the variability of the developed cash flow profiles is limited, the reliability of this approach is in question. Actual cash flow profiles have been shown to vary significantly, consequently, a new cash flow forecasting model has been developed. The model incorporates further variables to the ones already used by the traditional models. The hypothesis that: 'by incorporating further variables, the variability of cash flow profiles increases' was then tested stochastically. The results demonstrated that the variability of actual cash flow profiles can be explained by using improved mechanisms to better reflect the cash flow equation.

Previous attempts to develop an ideal net cash flow curve
In his early work, Nazem (1968) suggested that by analysing a company's financial records of single net cash flows, one reference curve may be derived to form the basis of forecasting. If
the shape of cash flow curve could be shown to conform to a predictable pattern, then this would be a useful piece of information since no further calculation would be needed. However, cash flow curves tend to fluctuate so much that they appear to be a poor basis upon which to prepare any forecast. O'Keefe (1971) studied the cash flow of several contracts, in order to measure their capital requirements and established the main factors which influence these requirements. However, apart from showing that profit margin was a contributing factor, the analysis failed to produce a convincing explanation of the full range of possible cash flow profiles.

Development of value curves
In the absence of an ideal net cash flow curve, previous researchers have used ideal value curves to produce net cash flow profiles. The method defines the cash-in curve as the value curve minus any retention held, with an allowance for time lag. Similarly, the cost curve is derived from the earnings curve using specified lags and percentages of earnings.

The possibility of building an ideal value curve based on historic data has been the subject of considerable research (Bromilow and Henderson 1977; Singh and Woon 1984; Drak 1978; and Hudson 1978). Although these approaches have gained general acceptance, they have not been without criticism. Hardy (1970) found that there was no close correlation between the figures given for twenty-five projects considered, even though the projects were similar. Oliver (1984) analysed projects collected from three construction companies. He concluded that, although the number of projects analysed was statistically small, construction projects are individually unique and follow such diverse routes that value curves based on historical data are not capable of providing the accuracy required for individual contract control.

Computer applications of value curves
These and other curves were used in computer packages to forecast the net cash flow for construction projects. Ashley and Teicholz (1977) developed a model based on the value curve to assist in the analysis of cash flows over the life of a project. The model also calculated the cost of borrowing and the present value of a given cash flow. Trimble (1972) was of the opinion that the net cash flow is not sensitive to the shape of the standard curve chosen, therefore, a model which based on these curves should yield accurate forecasts. Mackay (1971) developed a computer program that estimated the shape of the value curve as defined by a series of up to twenty break-points connected by a series of straight lines. From this value model, various cost categories with their associated time delays, contract value, profit, relations, etc. were input to compute the resultant cash flow throughout the project duration. Through test simulations of the program, he determined that the shape made little difference in the cash flow pattern. This approach has been adopted in commercial software packages (Cash flow; Cash flow manager) for quantity surveyors and contractors. However, a library of typical S-curves is installed to allow the user to select an S-curve that closely represents individual project. In addition, the user may input his or her own estimated curves if a suitable one cannot be found in the library. Other researchers considered that value curves were unique to single contracts, and therefore should be estimated for each project. Peterman (1972) developed a net cash flow model using value curves based on bar charts of bill items. Allsop (1980) linked a cash flow model to an estimating program. The program used the estimated cost and estimated value with the contract schedules to calculate the cash flow of the project. The preparation of work schedules involves complex and expensive analyses at a time when resources are least available, therefore the use of such models must be justified. The justification lies in the importance of cash flow forecasts at the tendering stage and the level of inaccuracy associated with simplified S-curve models.
Accuracy of models
Studies on the accuracy of models based on ideal value curves have produced conflicting results. The feasibility of building ideal value curves for different project types is questionable. There is evidence that single curves cannot be fitted accurately, even to one type of project. Mackay's (1971) sensitivity analysis of net cash flow profiles to different value curves implies that either net cash flow curves conform to predictable patterns or they are sensitive to the selection of systematic delays.

Kenley (1986) studied the variability of net cash flow profiles by collecting the cash-in and cash-out data from twenty-six commercial and industrial projects. The 'goodness of fit' was reasonably accurate and twenty-six net cash flow profiles were produced. Comparisons between the results indicated that there was a wide degree of variation between the individual project profiles.

The sensitivity of the net cash flow profile to the selection of systematic delays, was studied by the authors through a series of visits to construction companies. These visits confirmed that time delays are usually controlled by contractual regulations and their variability tends to be fairly limited. If the accuracy of cash flow forecasting is solely dependent on the specification of the delays, cash flow forecasting could be conducted simply and confidently.

Need to build a more logical model
Previous work indicates that there is a need for a simple and reliable net cash flow model at the tender stage. An ideal net cash flow curve is the simplest model, but it is not reliable since actual net cash flow profiles tend to vary significantly. Models based on ideal value curves are also suspect since ideal curves can not be accurately fitted through a series of projects because of the high variability associated. However, there is some argument that these models are not sensitive to the choice of the value curve and can thus be considered reliable. The mechanism of such models implies that variability of net cash flow curves could be the result of variability in systematic delays of cash-in and cash-out. Data supplied by the industry has confirmed that the variation in time lags is relatively small. It was concluded that such models are not logical and hence there is a strong need to build a more logical model which is capable of being adjusted to represent a wide range of variable profiles.

The net cash flow model
The Engineering and Physical Sciences Research Council has recently supported a research project aimed at developing a reliable cash flow forecasting model for both individual projects and contracting companies. The hypothesis of the research was that traditional cash flow forecasting models for individual projects were inaccurate and inflexible in terms of the extent of variability of the profiles produced. In order to improve the accuracy and variability of cash flow profiles that were produced, further variables needed to be incorporated. The following four factors were identified to be lacking in traditional models:

- The cash flow output needs to be presented monthly at the date of financial, cost and management accounts close down. The implication of this is that the starting date of construction, duration of the contract (in days) and the dates of interim valuations need to be taken into account when forecasting cash flow.
- Tendering strategies (e.g. unbalancing, preliminaries pricing, etc.) are often adopted to manipulate cash flows, and should be incorporated when forecasting cash flow.
- Different types of cost (e.g. labour, plant, materials, labour only subcontractors, etc.) have different time lags (i.e. time different between costs committed and cash paid out). This necessitates the use of individual S-curves for individual cost headings,
rather than one curve for the total cost.

Contractors usually retain a percentage of the money paid to subcontractors. This is bound to have an effect on contractors' cash flows. Traditional models have neglected this retention. Also, contractors are usually allowed a cash discount (from suppliers and nominated subcontractors) if payments are made within a specified period. This obviously affects cash flow and profit. Again traditional models do not take these factors into account.

The net cash flow model was developed taking into account the above points, consequently, the number of the incorporated variables increased to over 50 variables as summarized below:

- **A1** Total value of contract.
- **A2** Total duration of project.
- **A3** Overall mark-up.
- **A4** Preliminaries mark-up.
- **A5** Starting date of construction.
- **A6** Interim valuation date.
- **A7** Unbalancing on preliminaries pricing:
  - **A7.1** Mark-up added/subtracted on/from a front portion of total preliminaries.
  - **A7.2** Applied up to (percentage of front to total cost of preliminaries).
- **A8** Retention:
  - **A8.1** Percentage of retention.
  - **A8.2** Applied up to (percentage of total value).
- **A9** Under/over measure as a percentage of total value of contract.
- **A10** Maintenance period.
- **A11** Unbalancing of measured work:
  - **A11.1** Mark-up added/subtracted on/from a front portion of total measured work.
  - **A11.2** Applied up to (percentage of front to total cost of measured work).
- **A13** Probabilities of cash delay of 0, 1 and 2 months for OL, M, P, LS, LMS, NS and PR.
- **A14** Probability of client's payment cash delay of 0, 1 and 2 months.
- **A15** Percentage of materials purchased 1, 2 and 3 months earlier than installed.
- **A16** Percentage of materials on site incorporated in interim valuations.
- **A17** a and b constants required to develop the shape of S-curve for each of the cost headings.
- **A18** Cash discounts earned from material suppliers and nominated subcontractors.
  - **A18.1** Percentage of running cost.
  - **A18.2** Applied when paid within.
- **A19** Retention held against: labour only, labour & materials and nominated subcontractors.
  - **A19.1** Percentage of the cost heading's running cost.
  - **A19.2** Applied up to (percentage of the cost heading's total cost).
- **A20** Method of preliminaries valuation:
  - (time basis, percentage to measured valuation or actual valuation).

The model is still considered to be simple since it does not relate to the detailed construction programme and bill of quantities. The mechanism incorporated within the model is illustrated in Figures 1 and 2.
Figure 1 The mechanism of producing cumulative monthly cash-ins
Figure 2 The mechanism of producing cumulative monthly cash-outs
The cost commitment S-curve is derived from the individual cost headings' S-curves. These are developed using the logit transformation model. Two constants (a and b) are required to produce the shape of the S-curve for each individual cost heading. Past research has been concentrated on evaluating these constants for different types of projects (Kenley and Wilson 1986; Kaka and Price 1993). However, these were targeted towards overall cost commitment S-curves instead of the individual cost headings. Therefore, new research is needed to investigate the prospect of developing S-curves for individual cost headings. This is not an issue to be investigated by this paper. Here, the mechanism of calculating the cash flow of individual projects, given various shapes of the S-curves is considered.

**Testing and validating the net cash flow model:**
Contractors are currently being asked to provide data to enable the model to be tested on as many past projects as possible, in order to compare the model output with actual cash flows. In the mean time, the research has concentrated on establishing if the development of a flexible model can explain the wide variability in actual cash flow profiles. A sensitivity analysis (to evaluate how sensitive output data are to individual variables) was considered, but since the relationships between the variables incorporated are unknown, the extent of the variability of the cash flows produced may not be determined.

A total contract value of 1M pounds with a duration of 12 months was used to stochastically test the model using 40 simulations. Apart from the total contract value and duration of the contract, a range of possible values was determined for each variable using logic, experience and previous research results (Kaka and Price 1991). A uniform distribution was assigned to each range, and random numbers generated by LOTUS 123, were used to allocate data for each run. The applied range of each variable are listed in Table 1. Figure 3 shows the resulting cash flow profiles of twenty runs. The extent of variations of these profiles is relatively high. The variations are also apparent when considering the maximum negative cash flow of each run.

**Conclusions and recommendations for further work:**
The reliability of traditional cash flow forecasting models is questionable since they do not explain the high variability of actual cash flow profiles witnessed in past projects. A net cash flow model, incorporating more variables, has been developed to overcome this deficiency. The mechanism of the model was based on previous research plus an additional four factors that has not previously been considered. The model was tested stochastically for its ability to produce a wider range of cash flow profiles. The stochastic test confirmed that in order to develop a reliable cash flow forecasting model, more variables need to be incorporated into the cash flow mechanism.

The accuracy of the net cash flow model can only be determined by using a large number of past projects. Research is currently being performed to fulfill this objective. The research also intends to evaluate the sensitivity of the cash flow output to each of the modeled variables. This should determine which (if any) of the variables can be eliminated. A variable that has limited effect on the output will be excluded from the cash flow mechanism since its presence will not be justified, especially when considering the simplicity of the model. Further testing will hopefully determine, more accurately, the extent to which separate consideration of individual cost headings affect the accuracy and flexibility of cash flow models. This requires data to be collected from contractors and new S-curves models to be developed for the individual cost headings. The authors are currently performing tests to investigate the feasibility of pursuing the aforementioned tasks.
Figure 3  The cash flows of 20 projects
Table 1  The ranges of the data entry used to run the model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3</td>
<td>5%</td>
</tr>
<tr>
<td>A4</td>
<td>0% to 50%</td>
</tr>
<tr>
<td>A5</td>
<td>1st to 29th</td>
</tr>
<tr>
<td>A6</td>
<td>1st to 30th</td>
</tr>
<tr>
<td>A7.1</td>
<td>0% to 10%</td>
</tr>
<tr>
<td>A7.2</td>
<td>0% to 50%</td>
</tr>
<tr>
<td>A8.1</td>
<td>2.5% to 10%</td>
</tr>
<tr>
<td>A8.2</td>
<td>50% to 100%</td>
</tr>
<tr>
<td>A9</td>
<td>-10% to 10%</td>
</tr>
<tr>
<td>A10</td>
<td>6 months</td>
</tr>
<tr>
<td>A11.1</td>
<td>0% to 15%</td>
</tr>
<tr>
<td>A11.2</td>
<td>0% to 50%</td>
</tr>
<tr>
<td>A12OL</td>
<td>0% to 8%</td>
</tr>
<tr>
<td>A12M</td>
<td>calculated by deducting the generated sum of all minus 100%</td>
</tr>
<tr>
<td>A12P</td>
<td>4% to 8%</td>
</tr>
<tr>
<td>A12LS</td>
<td>13% to 19%</td>
</tr>
<tr>
<td>A12LMS&amp;NS</td>
<td>16% to 22%</td>
</tr>
<tr>
<td>A12PR</td>
<td>4% to 10%</td>
</tr>
<tr>
<td>A13:</td>
<td>0(0month) 1(month) 2(months)</td>
</tr>
<tr>
<td>OL</td>
<td>100%</td>
</tr>
<tr>
<td>M,P&amp;LMS</td>
<td>60% 40%</td>
</tr>
<tr>
<td>LS</td>
<td>30% 60% 10%</td>
</tr>
<tr>
<td>NS</td>
<td>90% 10%</td>
</tr>
<tr>
<td>PR</td>
<td>60% 40%</td>
</tr>
<tr>
<td>A14:</td>
<td>0%(0(month) 90%(1(month) 10%(2(months))</td>
</tr>
<tr>
<td>A15:</td>
<td>50%(0(month) 50%(-1(month) 0%(-2(months))</td>
</tr>
<tr>
<td>A16</td>
<td>80% 100%</td>
</tr>
<tr>
<td>A17.1</td>
<td>-2 to 2</td>
</tr>
<tr>
<td>A17.2</td>
<td>1 to 3</td>
</tr>
<tr>
<td>A18.1</td>
<td>0 to 0</td>
</tr>
<tr>
<td>A19.1</td>
<td>2.5% to 5%</td>
</tr>
<tr>
<td>A19.2</td>
<td>100%</td>
</tr>
<tr>
<td>A20:</td>
<td>60% 20% 20%</td>
</tr>
</tbody>
</table>

References


CASH FLOW. *ABS Oldacres Computer Ltd.*, 64-70 High Street, Croydon, England.


