Net cashflow models: Are they reliable?

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This paper discusses the development of a reliable net cashflow model to be used by contractors at the tendering stage. The model is based on cost commitment curves instead of the usual value curves. As the model includes many simplified assumptions, there was a need to test its reliability. The model was tested on five building projects and produced good results. The possibility of building an ideal cost curve was examined by building an average curve from the available projects. The average curve was used to forecast net cash flows for the five projects. The results demonstrated the validity of the model as a forecasting tool.

Keywords: Net cashflow models, tendering, contractors, cost commitment curves, reliability.

Introduction

Each year the construction industry usually experiences a proportionally greater number of bankruptcies than other industries. The final causes of bankruptcy are inadequate cash resources and failure to convince creditors and possible lenders that this inadequacy is only temporary. It is important to forecast cash requirements in order to make provisions for these difficult times. In times of high interest and inflation rates, the need for cashflow forecasting is even more important.

Contractors can undertake cashflow forecasts at two levels. One is at the estimating and tendering stage when the forecast is for a single project. This gives managers the opportunity to select the contracts which can be financed by the resources available. The other level is the prediction of cash flow for the whole company. This involves aggregating cash flows for all active projects and can be done regularly every quarter or every month.

The short period between receiving tender documents and submitting them limits the effort that could be invested in forecasting of individual cash flows. A quick and simple technique is therefore required by the construction industry to forecast accurately the financial requirements of a contract.

Previous models

Development of an ideal net cashflow 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 cashflow curves could be shown to conform to a predictable pattern, then this would be a most useful piece of information. However, cashflow curves tend to fluctuate so much that they appear to be a poor basis upon which to prepare any forecast.

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O'Keefe (1971) studied the cash flow of several contracts in order to measure their capital requirements and the main factors which influenced 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 cashflow profiles.

Development of value curves

In the absence of an ideal net cashflow curve, previous researchers have used ideal value curves to produce net cashflow 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 a considerable amount of research (Bromilow and Henderson, 1977; Singh and Woon, 1984; Drak, 1978; 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 25 projects considered, even when 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 flow over the life of a project. The model also calculates the cost of borrowing and the present value of a given cash flow. Trimble (1972) was of the opinion that the net cashflow is not sensitive to the shape of the standard curve chosen and therefore a model which is based on these curves will yield accurate forecasts. Mackay (1971) developed a computer program that estimated the shape of the value curve defined by a series of up to 20 break points connected by a series of straight lines. From this value model, various cost categories with their associated time delays, contract value, profit, retentions, etc., were input to compute the resultant cash flow throughout the project. Through test simulations of the program, he determined that the shape made little difference in the cashflow pattern. This approach has been adopted in commercial software packages for use by quantity surveyors and contractors (Ariadne, Cashflow, Cashflow Manager*). However, a library of typical S-curves is installed to allow the user to select an S-curve that closely represents his project. In addition, the user may input his own estimated curve if a suitable one cannot be found in the library.

Other researchers thought that value curves were unique to single contracts, and therefore should be estimated for each project. Peterman (1972) developed a net cashflow model using value curves based on bar charts of bill items. Allsop (1980) linked a cashflow model to an

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estimating program which already existed at Loughborough University of Technology. 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, and therefore the use of such models should be strongly justified. The justification lies in the importance of cashflow forecasts at the tendering stage and the level of inaccuracy of simplified S-curve models.

Accuracy of models

Studies on the accuracy of models based on ideal value curves are in conflict. The feasibility of building ideal value curves for different project types is questionable. There is evidence that single curves cannot be fitted accurately through even one type of project. Mackay's sensitivity analysis of net cashflow profiles to different value curves implies that either net cashflow curves conform to predictable patterns or they are sensitive to the selection of systematic delays.

Kenley (1986) studied the variability of net cashflow profiles by collecting the cash-out and cash-in data from 26 commercial and industrial projects. The goodness of fit was reasonably accurate and 26 net cashflow profiles were produced. Comparisons between the results indicated that there was a wide degree of variation between the profiles of individual projects.

The sensitivity of the net cashflow 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 controlled by contractual regulations and their variability tends to be fairly limited. If the accuracy of cashflow forecast is solely dependent on the selection of the delays, cashflow forecasting could be conducted simply and confidently.

Summary

Previous work indicates that there is a need for a simple and reliable net cashflow model at the tender stage. An ideal net cashflow curve is the simplest model but it is not reliable because actual net cashflow profiles tend to vary significantly. Models which are based on ideal value curves are also suspect, because ideal curves cannot be accurately fitted through a series of projects. However, there is some argument that these models were not sensitive to the choice of the value curve and therefore could be considered reliable. The mechanism of such models implies that variability of net cashflow curves could be the result of variability in systematic delays of cash-out and cash-in. The industry confirmed that the variation in times is relatively small. Therefore, 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 cashflow model

The main aim of this model is to forecast the net cash flow of a single contract, taking into account all the effective variables. The basic concept of the model is that an ideal cost commitment curve could be developed more accurately than a value curve. The cost commitment curve is used to generate the value and cash-out curves. Cash-in is developed from the value curve, and the net cashflow is the result of subtracting cash-out from cash-in curves. Within these processes there are many other variables that are not included in previous models. These variables add to the flexibility of the model and different shapes of net cash flows can be produced.

The model utilizes the 'Lotus 123' spreadsheet and is installed on an IBM system 2, model 50 microcomputer. The basic structure of the model is explained below and illustrated in Fig. 1.

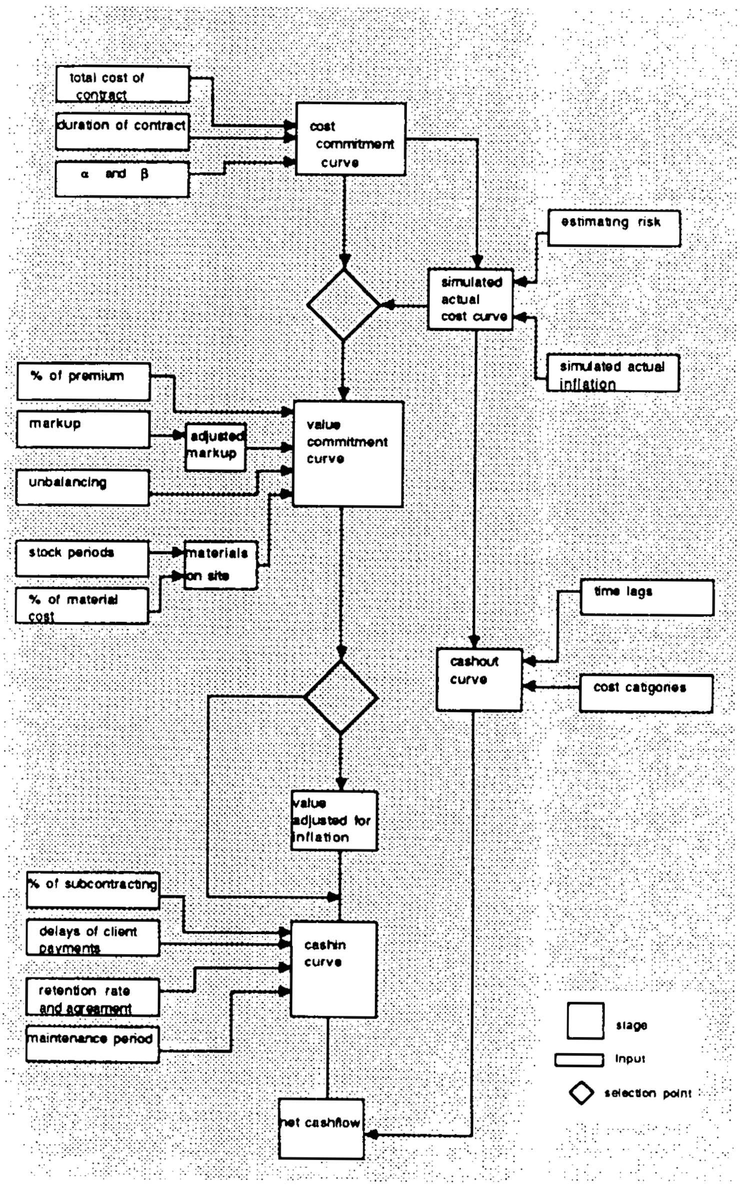

Fig. 1. Flowchart of the net cashflow model.

Cost commitment curve

The model uses cost commitment curves to predict cash flows for individual projects. The philosophy behind this is that an ideal curve could be developed more accurately for cost commitment than value or any other curves.

The value curve for a particular contract may differ due to different estimates and loadings. The contractor rarely loads the cost of items in a contract with the same rate. There are many factors which cause the contractor to unbalance a contract, one of the major ones being front-end loading to improve the net cash flow of the contract. A contractor may also detect an error in measurement or an item which is likely to have a major variation and hence load it accordingly. Any estimating errors are also reflected in the actual value curve. All these facts affect the value curve of a contract to some extent, such that in one contract it is easy to detect large variations between the submitted tenders (Stark, 1974). Cash-out curves are also variable within the same contract due to the effects of different proportions of subcontracting by different contractors.

Extensive investigation was conducted on how to build the cost model. Kenley and Wilson (1986) showed that an ideographic model yields more accurate results than a nomothetic approach. However, an ideographic approach could not be used in forecasting because the user has to define the curve prior to the forecast. It was decided to use the ideographic methodology to investigate the variability in the cost commitment curves and then develop an ideal curve for all projects which could be tested against the separate curves for the differences in the net cash flow.

The technique used for fitting the separate curves is the logit transformation as used by Kenley and Wilson. The basic procedure of this approach is to transform the data in percentage forms of each project by the following equation:

$$\text{logit} = \ln \frac{Z}{1-Z}$$

where Z is the variable to be transformed and the logit is the transformation.

When both the cost data (c) and time data (t) are transformed, they should approximate to a line described by:

$$Y = \alpha + \beta X$$

where

$$Y = \ln \frac{c}{100-c} \qquad X = \ln \frac{t}{100-t}$$

α and β are derived by linear regression of the transformed data and then installed in the following function to produce the fitted curve:

$$V = \frac{F}{1+F}$$

where

$$F = e^{\alpha}\left(\frac{t}{1-t}\right)^{\beta}$$

For more information, refer to Kenley and Wilson (1986) or Ashton (1972). The total cost and duration of the contract are entered into the model to produce the cumulative monthly cost commitment of the contract.

Simulated actual cost curve

The cost commitment model was based on past cost data from projects after adjusting for inflation using a cost index. When using these curves in the net cashflow calculation, they have to be readjusted to include inflation. The model simulates two kinds of inflation rates – the expected one and the simulated actual one. The expected inflation rate is entered by the user and affects the value curve. The simulated actual rate is generated randomly to simulate the effect of actual rates on the cash flow. The user enters a range of uniformly distributed factors to be multiplied by the expected rate in order to obtain the actual one.

The model also simulates the risk incorporated in estimating. This is represented by a range of random number generators applied to the cost schedule. Both of the above ranges may have positive or negative values.

Cash-out

The simulated actual cost commitment curve is converted to cash-out by selected time delays. Time delays differ between the different cost categories. Materials are purchased some time before using them – this is called the 'stock period'. The time period between the purchase and payment is subtracted from the stock period to find the time lag. The time lag for each cost category is entered in the model as a probability or percentage of the cost in that month, as shown in Table 1.

Table 1. Time lags for each cost category (%)

	No. of months delay				Percentage of total
Cost type	0	1	2	3	cost
Labour	100	0	0	0	15
Plant	0	20	60	20	5
Subcontractor	0	50	50	0	45
Materials	20	70	10	0	25
Site overheads	100	0	0	0	10
Total cost delay	30	41	28	1	

The material lag in Table 1 represents the result of subtracting the stock period from the credit period. The result is entered directly in the model as shown. When a delay is, say, 5 weeks, it is registered as the following month (i.e. 2 months). The total cost lags at the bottom of Table 2 are used for delaying the cost curve. Table 2 shows how a cost curve is delayed through the selected time lags in Table 1.

Table 2. Converting cost curve to cash-out (£) curve using total time lags[a]

Cost curve (£)	No. of months delay 0	1	2	3	Total cash-out curve
0	0				0
50	15	0			15
100	30	20	0		50
160	48	41	14	0	103
230	69	65	28	1	163
1		94	45	1	—
1			64	2	—
				2	

[a] These figures were rounded to no decimal places.

Value curve

The value curve is calculated from the cost commitment curve or the simulated actual cost curve, depending on the form of contract. Three forms of contracts were identified to have an effect on this:

- fixed contracts;
- fixed-adjusted for inflation; and
- cost-plus contracts.

In the case of fixed contracts, the cost curve is adjusted for the expected inflation rate and hence converted to the value curve. This represents the estimate of the contract for these forms of contracts. In fixed-adjusted forms where the valuations are adjusted for inflation by a formula, the cost curve is adjusted by the simulated actual rate. Cost-plus contracts are the forms which value the work done according to the actual cost. Thus, value curves are calculated from the simulated actual cost curve.

The process of converting the cost curve to the value curve depends on the premium cost, the mark-up and front-end loading. The value curve starts some time after the progress of the contract, because contractors usually incur transportation and site preparation at the start of the contract. The value of this cost is entered as a percentage of the total cost. The duration of it is calculated by the model from the cost curve profile. Some contracts cover such payments at the start of the contract, and therefore the user is expected to input zero cost.

The remaining cost schedule is multiplied by an adjusted mark-up rate. The adjusted rate is:

$$\text{adj } M = \frac{M \times C}{(C - Pr)}$$

where M is the entered mark-up site, C is the total cost of contract and Pr is the premium cost.

Front-end loading

Unbalancing of a bid occurs when a contractor raises the price on certain bid items and reduces the prices of others so that the bid for the total job remains unaffected. The most effective type of unbalancing is front-end loading. The main reason for front-end loading is to shift the project financing from the contractor to the owner by increasing the unit prices on early items and decreasing the unit prices on later ones. This influences the value curve significantly.

Ashley and Teicholz (1977) simulated this technique in their cashflow analysis through the development of an 'unbalance factor'. The model developed in this paper uses a similar approach but is modified to eliminate the binary search technique used in that model. It was thought that such a technique would increase the program execution time.

Figure 2 illustrates the basis of the adjustment used. The ordinate value of the sloping line at each time period is a scaling factor to multiply the valuations by. Different levels of front-end loading are produced by varying the value of d, the 'unbalance factor'. A straight line is drawn for each d value which intersects the point $(T/2, 0)$, where T is the total duration of the contract. The absolute difference of the resultant first half of the value curve and the original one are subtracted from the second half. A difference achieved at the third month of a contract which lasts 16 months will be subtracted from the 13-month value. The value of d depends on how much the contractor is able to get away with, taking into account the risk of errors in measurements and variations.

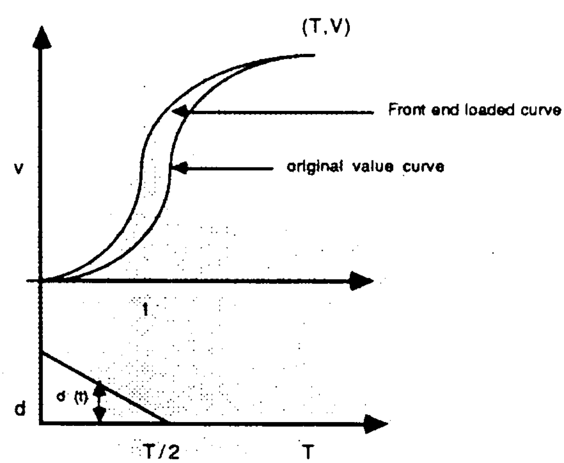

Fig. 2. The basic concept of the unbalancing technique.

Materials on-site

In some forms of contracts, clients pay the contractor for materials delivered to site in order to improve his cash flow. These payments are deducted when valuing any work these materials are installed in. In practice, when a stock of materials has been installed in the project, there will be others bought and stocked. Therefore, the difference in the stock value is evaluated monthly. If the stock has increased, then there will be payment to the contractor equal to that increase and vice versa.

The model estimates the overall cumulative value of materials delivered to site by entering the percentage or probabilities of stock periods. The stock period varies from 0 to 2 months. This is believed to cover a substantial probability of material stock. Table 3 shows an example of the entry to the model. Any period that falls between 4-weekly increments is carried over to the following month (i.e. 2 weeks of stock is entered as 0 months). The cumulative value of materials delivered to site is compared with that installed to find the value of stock at any month. The difference between the monthly stock values are added to or subtracted from the interim valuations.

Table 3. Example of stock periods

	Stock period (months)		
	0	−1	−2
Percentage of total material	50	40	10

Cash-in

The resultant value curve is converted to the cash-in curve by deducting retention and delaying for the time taken for the client to pay the monthly valuation. The model assumes that the contractor holds retention off subcontractors at the same rate it is held on him. Hence, the effective retention rate is calculated as follows:

$$\text{eff. ret.} = \text{ret.}\left(1 - \frac{SC}{V}\right)$$

where ret. = is the contractual retention rate, S = the percentage of subcontract cost to total cost, C = is total cost and V = is total value of contract.

The repayment of retention held is simulated in two steps: first, at the completion of the contract and, secondly, at the end of the maintenance period. The retention is usually deducted up to a certain level (e.g. 50% of the contract value). This is simulated in the model by entering the percentage of total value while the retention is applied.

Delays of payments are entered in the same manner as the cash-out curve. Although the delay is fixed in the contractual agreement, if may well vary due to disputes, claims, etc. The model assumes the delay period lies between 0 and 3 months.

Net cash flow

The cumulative cash-out is deducted from the cash-in to determine the net cash flow of the contract. Interest and present value can then be calculated for financial appraisal if required.

Testing the model

Two levels of tests were conducted on the model. First, the accuracy of the calculated net cash flow was tested. This was done by analysing past projects where all the required input data were provided by the managers involved in these projects. The output results were then compared with the actual net cash flow. The second test examined the possibility of building an ideal cost curve to be used for cashflow forecasting. An average cost curve was built from all projects analysed. This curve was then used in the model to determine the net cash flow for each project. The results were then compared with the actual data.

Collecting the data

The following data were required by the tests:

- cost commitments;
- net cash flows;
- percentages of cost categories; and
- indications of the rest of input data including mark-up, time lags, front-end loading, retention, etc.

Seventeen construction companies were requested to provide data. Ten companies showed a strong interest in the research but stated that such data was confidential. Five companies participated in the research and provided data on cost commitment curves, but didn't have separate listings of contracts' cash flows and therefore couldn't provide them. The remaining two provided the required data for five major projects (three commercial buildings from company A, and one commercial and one industrial from company B).

Table 4 presents the required input for the five projects. All these data were estimates provided by the companies' financial accountants, apart from the cost contributions which were calculated from the contract accounts. The unbalance factor had to be explained by several plots of value curves with different d values. The time lag for different cost categories is shown in Table 5, which shows little variation between different contracts and different contractors. Tables 6 and 7 show the client payment delay and the stock period respectively.

All of the contracts tested involved payments for materials on site. The values entered in Table 4 for the cost of materials refer to materials supplied by the contractor and not by subcontractors. Although contractors claimed that valuations were also made on material supplied by subcontractors, contractors pass on these payments to subcontractors and therefore the value of these payments is omitted from both sides of the equation.

Concerning the provision of site preparation cost, only one contract provided early payment as shown by the premium cost category in Table 4. The retention agreements were similar for all the projects. The agreed retention rate is deducted from valuations of the contract up to the level where the contract reached its half value.

Table 4. Input data for the five projects

Input	Project number 1	2	3	4	5
Duration (months)	15.00	17.00	17.00	12.00	16.00
Mark-up (%)	6.00	8.00	11.00	15.00	9.00
Premium (%)	2.00	2.00	0.00	4.00	5.00
Retention (%)	5.00	5.00	2.50	5.00	5.00
Unbalance	1.15	1.30	1.05	1.20	1.50
Labour cost (%)	5.15	4.40	2.92	22.26	21.21
Material (%)	12.15	23.00	12.86	30.95	41.21
Subcontract (%)	68.20	61.10	69.93	20.00	23.64
Plant (%)	4.50	3.50	5.29	16.79	8.94
Site overhead (%)	10.00	8.00	9.00	10.00	5.00

Table 5. Time lag between incurring of cost by contractor and payment of cost as % of cost by category, for all projects

Project number	Cost category	Time lag (months) 0	1	2	3
1	Labour	100	0	0	0
	Materials	10	50	30	10
	Subcontract	0	50	50	0
	Plant	0	0	70	30
	Overhead	100	0	0	0
2, 3	Labour	100	0	0	0
	Materials	10	50	30	10
	Subcontract	0	70	30	0
	Plant	0	0	70	30
	Overhead	100	0	0	0
4, 5	Labour	100	0	0	0
	Materials	10	40	40	10
	Subcontract	0	60	40	0
	Plant	0	0	70	30
	Overhead	100	0	0	0

Measurement of goodness of fit

To examine the performance of the model, it was necessary to use a measure of the goodness of fit. The measure chosen was that used by Kenley and Wilson. It is unfortunate that there aren't any published figures on the goodness of fit of the final net cashflow models produced by Kenley and Wilson; however, a comparison could be made between the cost model as opposed to their cash-out model. The measure chosen was the standard deviation about the estimate of Y (SDY), which is shown below:

Table 6. Delay in payments by client as % of total payments due

Project number	Delay (months)		
	1	2	3
1	70	30	0
2	100	0	0
3	100	0	0
4	80	20	0
5	80	20	0

Table 7. Age of stock by % of total used at any one month (current month = 0)

Project number	% stock bought in month		
	0	−1	−2
1, 2, 3	50	40	10
4, 5	40	40	20

$$\mathrm{SDY} = \sqrt{\{\Sigma(Y - YE)^2/N\}}$$

The model with the lowest SDY value demonstrates the best fit and is therefore the most desirable.

Results

The cost commitment model was first fitted for each of the five projects. The data for each project was transformed into the logit. The nature of the logit transformation is such that when the data approaches either 0 or 100%, then the logit will approach $-\infty$ or $+\infty$ respectively. Kenley and Wilson simulated many alternative exclusion ranges and found that by excluding data within the ranges 0–10% and 90–100%, a reasonable fit can be obtained. This was used in fitting the cost commitment model. Table 8 shows the α and β of each project with the associated SDY. An example of the fitted model is shown in Fig. 3. The

Table 8. α and β for five projects, with associated SDY

Project number	α	β	SDY
1	0.22	1.42	2.36
2	−0.13	1.20	3.08
3	0.30	1.53	2.89
4	−0.14	1.22	3.33
5	0.31	1.21	2.22

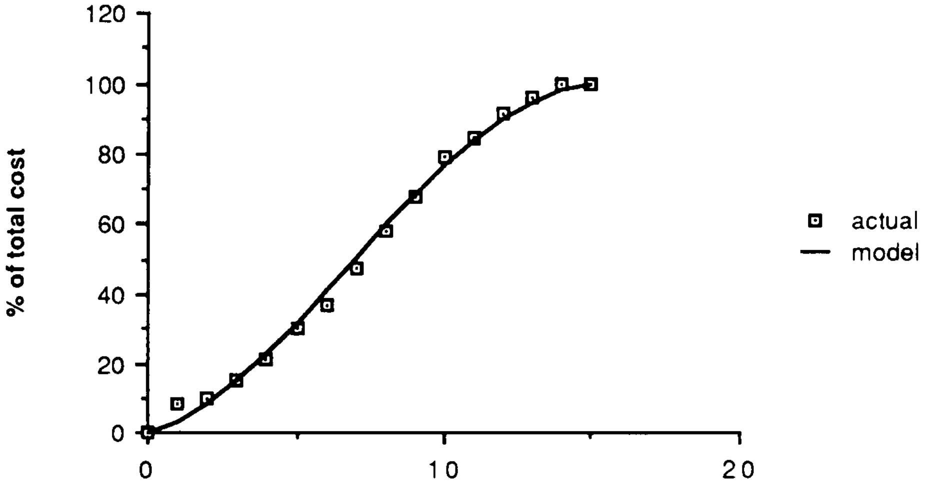

Fig. 3. Cost commitment model for project 1.

SDY values indicate that the model fits the different projects accurately and the values of the SDY are well below the outliers found by Kenley and Wilson (SDY 6%). The estimated net cashflow profiles obtained from these curves were compared with the actual ones. SDY values were measured to evaluate the accuracy of the model (Table 9). Unfortunately these values cannot be compared with previous models as this is the first attempt to test a net cashflow model with actual data.

Table 9. Comparison of SDY for individual and average net cashflow models

Project number	SDY Individual	SDY Average
1	0.96	0.67
2	0.90	1.20
3	0.97	0.86
4	1.58	2.10
5	1.30	2.08

The accuracy of the test was further demonstrated by two alternative methods. First, the estimated profiles were plotted against the actual data (Fig. 4a). The second method involves calculating the monthly difference between the actual and the estimated values (Table 10). These values are shown in percentage form and could be evaluated in monetary terms by multiplying them with the total cost of the relevant contract. The error is shown to vary $\pm 3\%$ at the extremes. In construction contracting, this range is considered well within acceptable limits and demonstrates the reliability of the model.

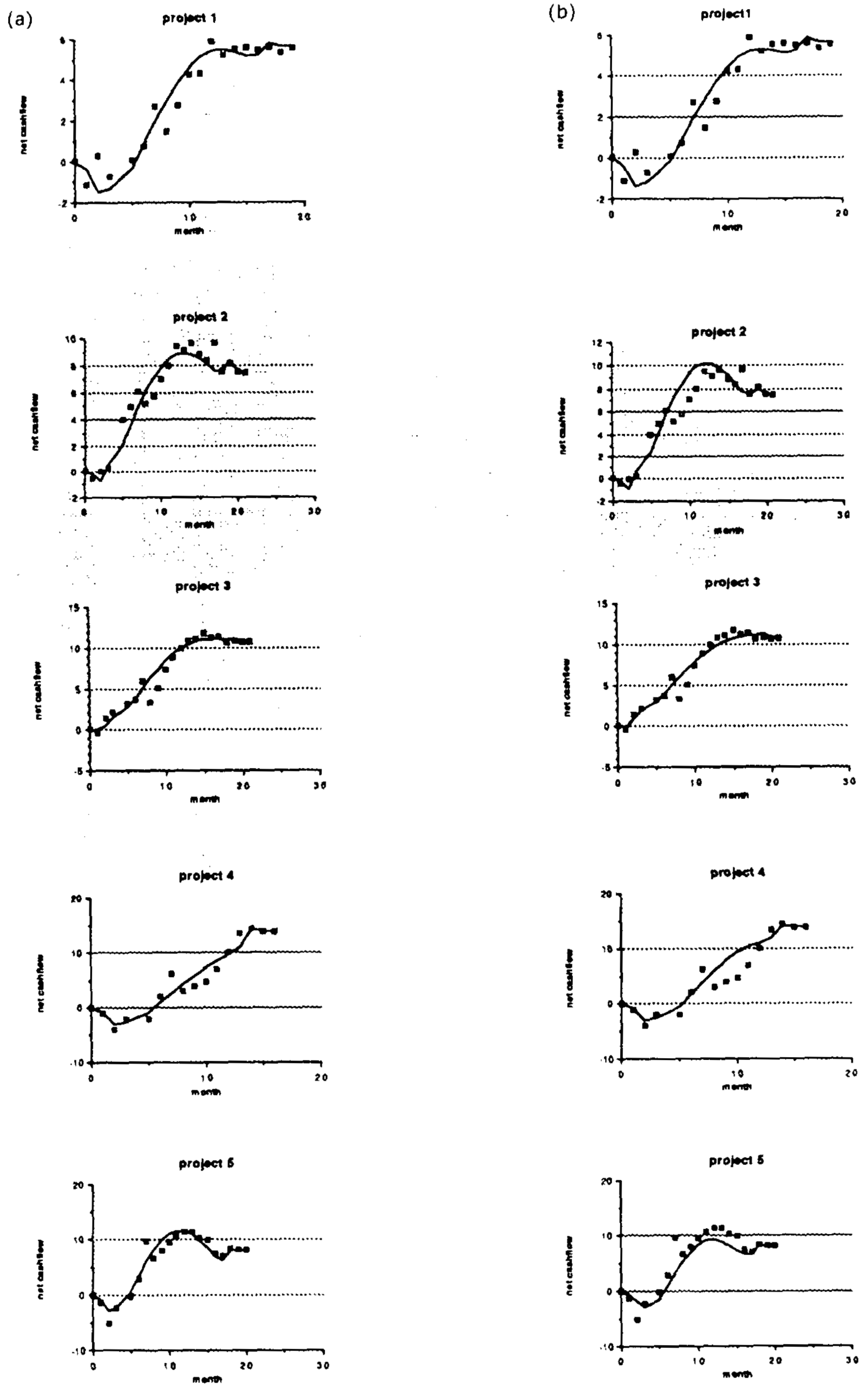

Fig. 4. Net cashflow model for the five projects: (a) fitted by the individual cost curve, (b) fitted by an average cost curve. ■, actual; ——, model.

Table 10. Measuring the monthly difference between estimated and actual net cashflows, using the individual cost curves

	Error				
Month	Project 1	Project 2	Project 3	Project 4	Project 5
0	0.046	0.018	0.000	−0.030	0.000
1	−0.901	−0.323	−0.300	−0.065	−0.601
2	1.381	0.753	0.846	−0.930	−2.334
3	0.099	−0.286	0.629	0.540	−0.118
5	−0.237	1.845	0.482	−1.209	−0.757
6	−0.773	1.330	−0.147	1.051	−0.734
7	−0.033	1.125	0.866	3.518	3.597
8	−2.286	−0.966	−3.002	−1.223	−1.452
9	−1.934	−1.366	−2.303	−1.867	−1.787
10	−1.120	−0.802	−1.075	−2.580	−1.502
11	−1.501	−0.478	−0.488	−1.536	−0.985
12	−0.127	0.681	−0.091	0.502	−0.283
13	−0.761	0.191	0.287	2.618	0.310
14	−0.275	0.814	0.228	0.066	0.482
15	0.067	0.324	0.699	−0.152	1.448
16	0.015	0.278	0.155	0.025	0.635
17	−0.256	2.004	0.354		0.745
18	−0.340	−0.107	−0.405		0.325
19	−0.130	−0.285	−0.224		0.110
20		−0.076	−0.037		0.089
21		−0.020	−0.014		

The average cost commitment model was based on all the five projects with the fitted line as shown in Fig. 5. The contrast between the average curve and the individual curve is demonstrated by the results shown in Table 11.

The SDY values for the individual curve is lower than the average curve. As the cost curve is one of the affecting variables of the net cashflow model, the effect of errors in the average curve should decrease in the residual model. This is shown in Fig. 4b. The net cashflow model is still a good fit to the actual data. A comparison of the standard deviations for the individual and average models upon which the net cashflow based is shown in Table 9. Finally, the monthly difference between the actual and the estimated net cashflows were calculated for each project (Table 12). A slight increase in error can be noticed; however, the model is considered a reliable tool for forecasting.

Conclusions

A simple net cashflow model was developed to help contractors forecast cash flows at the tender stage. The model was based on the cost schedule rather than the value schedule. The reason behind this was that a typical cost S-curve can be derived more accurately than a value curve. The model also included other variables which weren't taken into account in previous work.

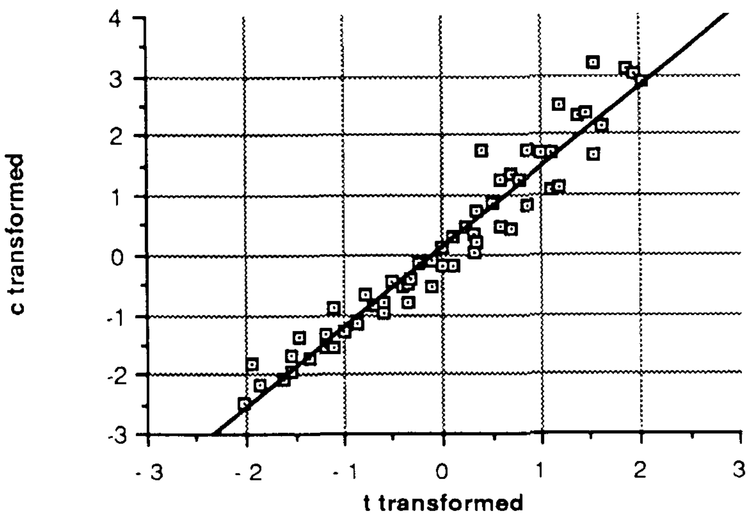

Fig. 5. Linear regression of all transformed data.

Table 11. Comparison of SDY for individual and average cost models

Project number	SDY Individual	SDY Average
1	2.49	2.36
2	6.86	3.08
3	3.69	2.89
4	6.26	3.33
5	3.14	2.22

The validity of the model was tested by comparing the output of the model with five actual net cash flows. Cost schedules were collected for five building projects and were separately modelled using the logit transformation technique. Contractors seemed to have a good knowledge of the remaining input data required, as they did in entering the testing requirements. The model produced good results as the difference between the estimated and the actual net cash flows was relatively small (as indicated in Tables 9 and 10).

The possibility of building an ideal cost curve was tested by fitting an average one through the five projects analysed. The average curve was used to calculate the net cash flow for each project and the results were compared with actual net cash flows, as presented in Tables 9 and 12. The SDY values in Table 9 and the errors calculated in Table 12 are relatively small, which indicates the reliability of the model as a forecasting tool.

The actual net cash flows analysed tended to vary, and when the previous research findings are also considered, the indication is that an ideal net cash flow is not possible. However, the model was proven to be highly flexible and adaptive to the profiles of individual projects.

Table 12. Measuring the monthly difference between estimated and actual cost cash flows, using the average cost curve

	Error				
Month	Project 1	Project 2	Project 3	Project 4	Project 5
0	0.044	0.028	0.000	−0.028	0.000
1	−0.695	−0.339	−0.247	−0.129	−0.826
2	1.692	0.906	0.556	−0.827	−3.101
3	0.495	−0.284	0.279	0.503	0.513
5	0.270	1.576	0.218	−1.599	1.331
6	−0.129	0.761	−0.249	0.229	1.893
7	0.740	0.270	0.969	2.288	6.390
8	−1.410	−2.059	2.689	−3.036	1.354
9	−0.998	−2.632	−1.809	−3.986	0.940
10	−0.173	−2.285	−0.444	−4.680	1.110
11	−0.595	−1.991	0.209	−3.392	1.508
12	0.688	−0.747	0.595	−0.959	2.067
13	−0.075	−1.052	0.891	−1.525	2.449
14	0.266	−0.157	0.694	0.091	2.224
15	0.464	−0.320	0.995	−0.159	2.662
16	0.259	−0.030	0.274	−0.069	0.858
17	−0.271	1.982	0.314		0.359
18	−0.335	0.000	−0.569		0.143
19	−0.120	0.107	−0.524		−0.054
20		−0.026	−0.076		−0.080
21		−0.033	−0.024		

Finally, the model proved to be a simple, fast and accurate forecasting tool to be used by contractors who appreciate the importance of cashflow forecasting at the tender stage. Typical S-curves could be derived by the contractor using the mentioned technique for any type of project they undertake. A detailed study is now in progress which should produce a series of S-cost commitment curves for different types of construction projects.

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