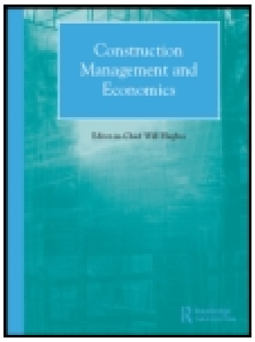

Routledge
Taylor & Francis Group

Construction Management and Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: www.tandfonline.com/journals/rcme20

Towards more flexible and accurate cash flow forecasting

Ammar P. Kaka

To cite this article: Ammar P. Kaka (1996) Towards more flexible and accurate cash flow forecasting, Construction Management and Economics, 14:1, 35-44, DOI: 10.1080/01446199600000005

To link to this article: https://doi.org/10.1080/01446199600000005

Published online: 28 Jul 2006.

Construction Management and Economics (1996) 14, 35–44

Towards more flexible and accurate cash flow forecasting

AMMAR P. KAKA

School of Architecture and Building Engineering, Liverpool University, PO Box 147, Liverpool L69 3BX, UK

Received 11 November 1994; revised 18 March 1995

Previous research has demonstrated significant variation in actual cash flow profiles. However, the results from traditional cash flow forecasting models do not exhibit these variations. This suggests that further variables are needed to enhance to flexibility of the cash flow profiles produced. This paper presents a model designed to use more than fifty variables to calculate the cash flow of individual contracts. In addition, some of the risk associated with construction contracting was incorporated into the cash flow mechanism. This has been achieved by introducing stochastic simulation and extra variables that contribute towards that risk. The testing of the model demonstrated that by merging further variables, the flexibility and reliability of cash flow forecasting are enhanced. The tests also demonstrated that contractors' cash flow is highly sensitive to risk (variations, cost variances, duration overrun and undermeasurement), which further justifies the methodology adopted.

Keywords: Cash flow, tendering strategies, S-curves, financial planning, risk.

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 overdraft; and the evaluation of different tendering strategies. Ideally, cash flow forecasts should be based on the construction programme and a bill of quantities (Peterman, 1972; Allsop, 1980). Cash flow forecasting at the tendering stage needs to be simple and fast however, considering the short time available and the associated cost. Contractors seldomly prepare a comprehensive construction plan at the tendering stage, but usually wait until winning the contract. Previous research has acknowledged the need for simple and fast techniques, and as a result cash flow forecasting models have been developed (Mackay, 1971; Ashley and Teicholz, 1977; Kaka and Price, 1991). These models are now incorporated in most standard construction management text books (Harris and McCaffer, 1989; Pilcher, 1992). These models tend to follow the same concept and mechanism. Standard S-curves which represent the running cumulative value of contracts (for example, those developed by Bromilow and Henderson, 1977; Singh and Woon, 1984; Drak, 1978; Hudson, 1978) are used to produce a running cumulative cost commitment curve by deducting the overall mark-up applied. These two curves are then converted (using time delays and retention) into cash in and cash out. The net of these curves gives the predicted cash flows for the contracts.

Studies on the accuracy of cash flow models based on ideal value curves have produced conflicting results. The feasibility of building ideal value curves for different project types is questionable. Kenley (1986) studied the variability of net cash flow profiles by collecting the cash in and cash out data from 26 commercial and industrial projects. Comparisons of the results indicated that there was a wide degree of variation between the individual project profiles. 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 (which is known not to be the case: see Nazem, 1968) or they are sensitive to the selection of systematic delays. The sensitivity of the net cash flow profile to the selection of systematic delays was studied by the author through a series of visits to 15 British construction companies. Contractors were asked to give their opinion on the extent of variation of time delays of payments from clients and to subcontractors. These visits confirmed that time delays are usually controlled by contractual regulations and their variability tends to be fairly limited (Kaka, 1990). It was thus concluded that such models are not reliable and hence there is a strong justification for building a more flexible model which can be adjusted to represent a wide range of variable profiles.

The effectiveness of traditional models as tools of financial planning is also questioned. Contracting usually does not require significant amounts of cash. This can be demonstrated when using traditional models. However when a particular contract goes wrong (excessive time delays, cost variances, undermeasurement, and so on), the cash deficit starts to be considerable. Therefore a new approach is needed to evaluate the effect of risk on the cash flow. This paper presents a model which incorporates risk into cash flow forecasting. This has been achieved by introducing stochastic simulation and incorporating additional variables not included in traditional models. This enabled the evaluation of the effect of certain factors such as variances between actual and budgeted costs and quantities variations on cash flows.

The proposed cash flow model

The previous section has indicated 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 these cash flow profiles, further variables must be incorporated. In addition, construction contracting is a risky business and so a reasonable amount of the data entry (e.g. the shape of the S-curve, actual profit to be achieved each month, under/overmeasurement, and so on) required to forecast cash flow cannot be determined precisely. Consequently, contractors need to evaluate the effect of this imprecise information on their cash flow. This would assist them in planning their cash flow requirements accordingly. By examining contracts' conditions (JCT80 was used as a standard) and the items involved in interim valuations, it was found that the following five factors were lacking in traditional models:

1. 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.
2. Tendering strategies (e.g. unbalancing, preliminaries pricing, and so on) are often adopted to manipulate cash flows, and should be incorporated when forecasting cash flow.
3. Different types of cost (e.g. labour, plant, materials, labour only subcontractors, and so on) have different time lags (time 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.
4. 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.
5. Errors in assessing cost, productivity and variations create irregularities that affect the overall performance of the project and the relationship between the cost commitment curve and the value curve. These elements of risk have to be incorporated when forecasting cash flow.

In order to accommodate the effects of the above on cash flow, further variables must be incorporated into the model. Consequently, the number of incorporated variables increased to over 50 as summarized in Appendix 1. The model is still considered to be simple as it does not relate to the detailed construction programme and bill of quantities. The model utilizes the 'LOTUS 123' spreadsheet and is installed on an IBM compatible microcomputer. The mechanism incorporated within the model is explained below and illustrated in Figures 1 and 2.

Cost commitment curve

The model calculates the monthly estimated costs of own labour, materials, plant, labour only subcontractors, labour and materials subcontractors, nominated subcontractors/suppliers and site overheads separately. For each cost category, the model user specifies the shape of the estimated cost build-up by entering two constants (a and b). A mathematical expression (logit transformation – used by Ashton, 1972; Kenley and Wilson, 1986; Kaka and Price, 1993) is used to generate the shape of the estimated cost build-up. Past research has 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

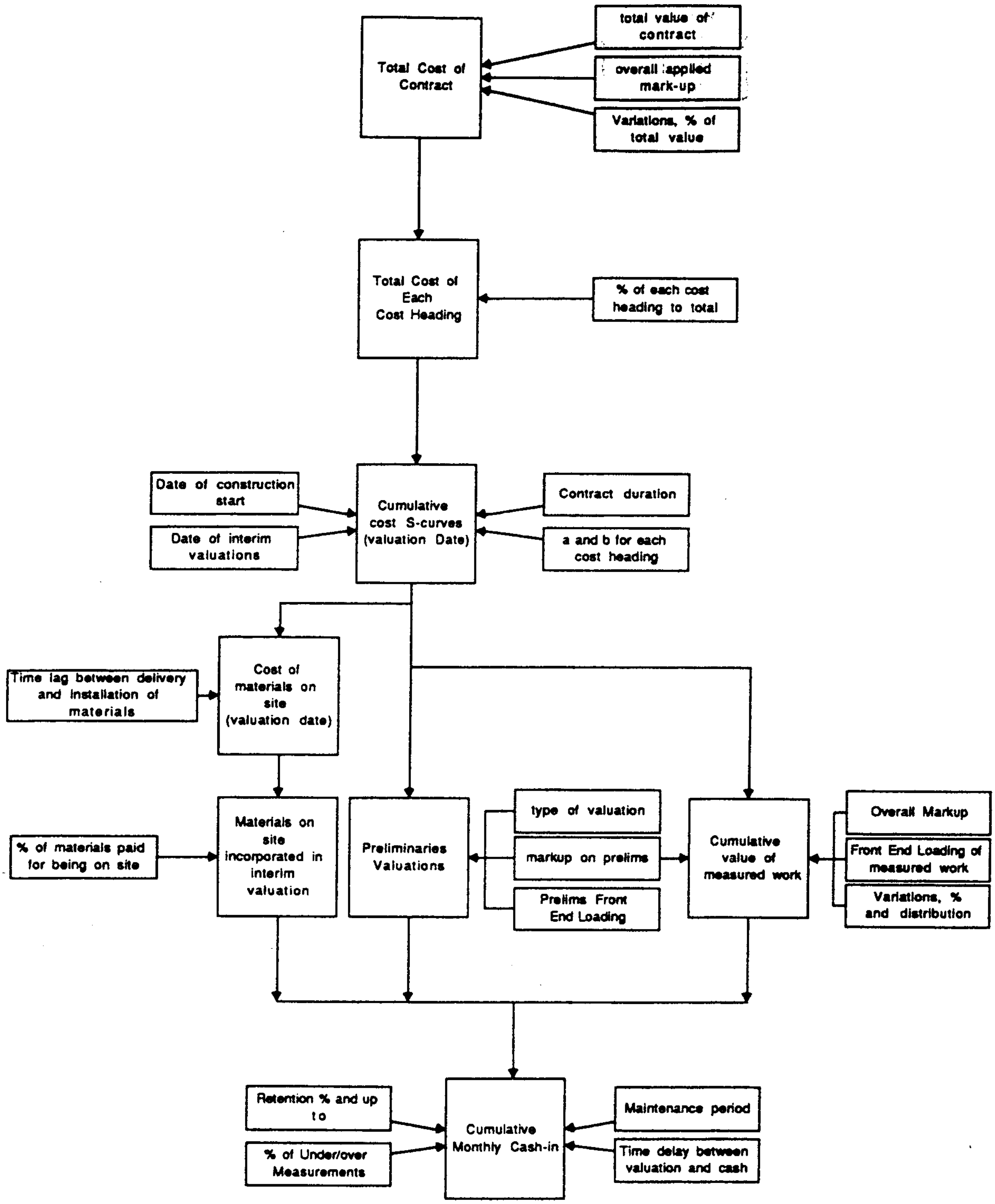

Figure 1 The mechanism of producing cumulative monthly cash in

individual categories of cost. To the author's knowledge, no one has attempted to develop standard cumulative cost commitment curves for cost categories. In the absence of standard curves, contractors may either relate to the contract's plan and detailed cost estimate, or use judgement to specify envelopes for the curves within which the actual values will fall.

The aim of the model is to forecast the cash flow values

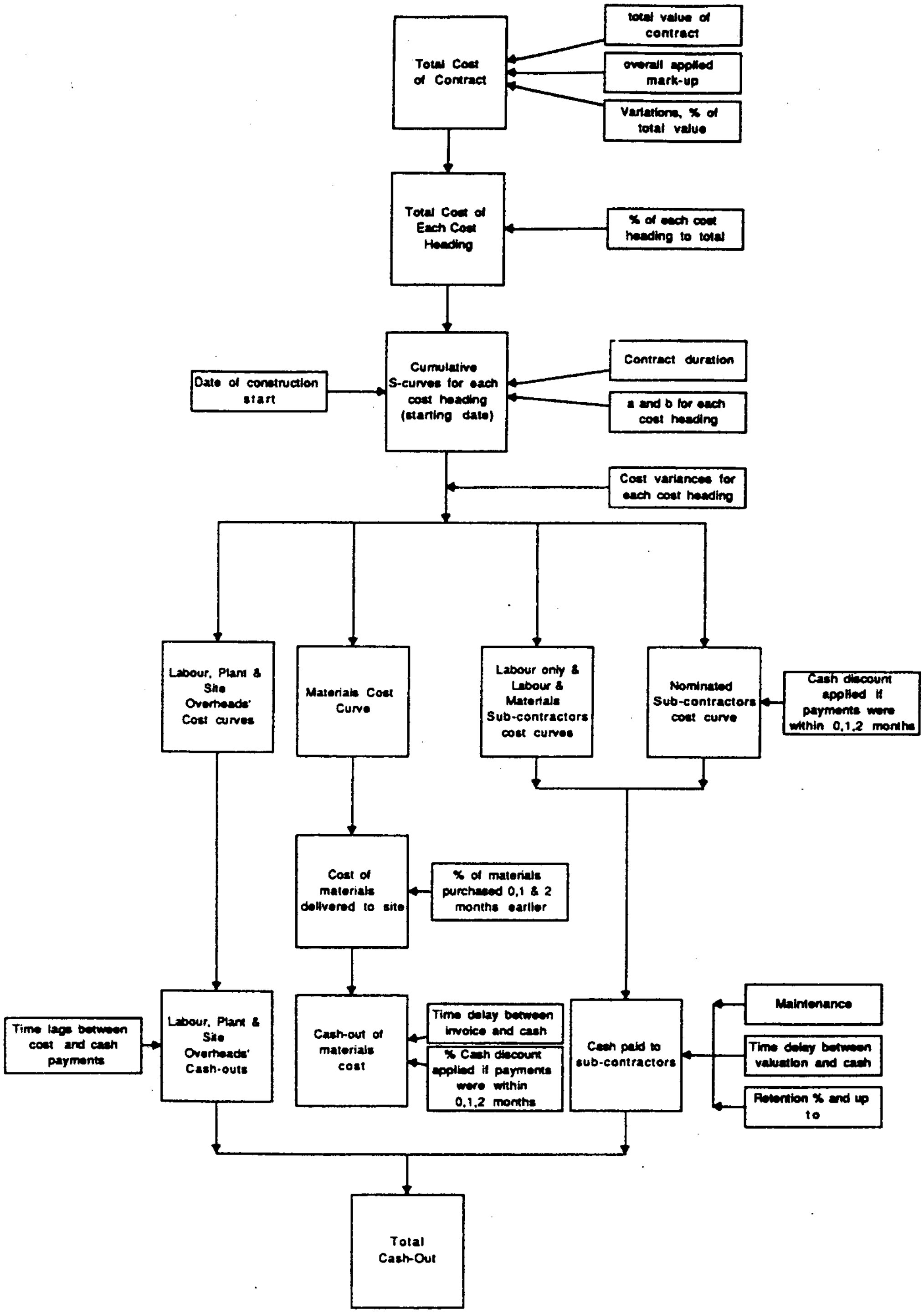

Figure 2 The mechanism of producing cumulative monthly cash out

at the closing down of each month (usually the last day of the month). Thus, the starting date of the contract needs to be taken into account. This is achieved by modifying the time intervals used to produce the S-curve. For example, a contract which starts on the 10th of February and ends on the 30th of May would have a duration of 3.67 months and time intervals of 0.67, 1.67, 2.67, 3.67 instead of 1, 2, 3, 4 respectively. This results in a more accurate assessment of the running costs than those produced using traditional models (in this case, the costs at the end of February would be overestimated using traditional methods).

Cumulative cash-out curve

The S-curves for the different categories of cost are converted into their corresponding cash out curves separately. Labour, plant and site overheads payments are delayed by the times specified by the user as percentages of each category to be paid in the month of commitment and/or in the two subsequent months. 'Labour only' and 'labour and materials' subcontractors are processed similarly except for the incorporation of retentions. These are calculated using the specified retention rates, the maximum percentage of cost on which retention is applied, and the specified defects liability period. In practice, the repayment of the retained money to the individual subcontractors usually occurs in two instalments: first at practical completion of the subcontractor's job, and second at the end of the defects liability period. The model does not calculate the completion date for each subcontractor on the job. Instead, it assumes two extreme cases where either all subcontractors are paid the first instalment at the practical completion of the contract (i.e. all subcontractors will complete their work on that date), or no money is retained for payment of first instalments (i.e. there are a vast number of subcontractors working for very short periods). The two resultant extreme cash out curves produce an envelope within which the actual is bound to lie.

The nominated subcontractors' cost curve is first modified by applying cash discounts. This is calculated using a discount rate to be applied if the contractor pays within a specified period. This is defined by the user, but is usually one month after certification. The rest of the conversion process is identical to that used for other types of subcontractors.

In the case of materials, the cost commitment curve is initially converted into the actual cost incurred to allow for the fact that materials are ordered and stocked before installation. This is done by defining the percentages of materials purchased in the month of their use and/or in the two months prior to this as shown in Table 1. The actual cost incurred of materials is then used to derive materials' cash out by applying cash discounts and payment delays as described in the case of nominated subcontractors.

The individually produced cash out curves are then added to form the overall cash out curve.

Cumulative value curve

The cumulative value curve is derived from the individual cost commitment curves. The time intervals used to produce the cost curves are now modified to incorporate the effect of the date of valuation. The cost curves produced earlier depict cumulative values expected at the end of each month. In cases where valuations are measured at other dates (say 21st of each month) the measured cost at these dates would be less than those calculated by the cost curves. Considering the example used earlier, the time intervals which need to be applied to calculate the new cost curves are: 0.37, 1.37, 2.37, 3.37 and 3.67 instead of 0.67, 1.67, 2.67 and 3.67. The differences between the above sets of time intervals results in the contractor having a value of work in progress at the end of each month (traditional models assume no work in progress).

The newly developed cost curves are then used to derive three elements of each month's valuations: measured work, preliminaries and materials on site. The cumulative monthly values of measured work are calculated using all the newly developed cost S-curves (labour, materials, and so on) except for preliminaries. The overall applied mark-up on measured work is calculated using the following equation:

$$P_m = \frac{(1 + P)\,C - C_{pr}(1 + P_{pr})}{M_c} - 1 \qquad (1)$$

where P_m is the overall mark-up applied to the cost of measured work, P is the overall mark-up applied to total cost, C is the total cost of the contract, C_{pr} is the total cost of preliminaries, P_{pr} is the overall mark-up applied to preliminaries and M_c is the total cost of measured work.

The calculated measured work's mark-up is then modified to incorporate 'unbalancing'. The user specifies a percentage of mark-up to be added to the calculated P_m, and the percentage of front to total cost over which to apply this extra mark-up. The model consequently calculates the mark-up to be applied onto the remaining proportion of the contract, so that the overall rate of mark-up on measured work remains unaltered. The two calculated rates are then applied onto the measured work cost curve to produce the measured work value curve as shown in Table 2.

Preliminaries valuations are derived from the preliminaries cost curve by applying preliminaries' mark-up. Three types of valuation are common (Upson, 1987) and hence incorporated into the model: time basis, percentage of measured work and actual valu-

Table 1 Converting the material cost commitment curve to actual cost incurred

Month	Materials cost curve (£)	% of materials purchased 0, 1, 2 months before installation: 0 (60%)	−1 (40%)	−2 (0%)	Converted cost
Nov				0	0
Dec			0	0	0
Jan	0	0	20	0	20
Feb	50	30	40	0	70
Mar	100	60	40	0	100

Table 2 Example of unbalancing of a contract's measured valuation

Month	Measured work's cost curve	Measured work's cumulative	Unbalancing	Adjusted cumulative value curve	Value curve with no unbalancing
1	10	10	10% × 10	11	10.5
2	20	30	10% × 20	33	31.5
3	40	70	10% × 30	76	73.5
4	30	100	0	106	105
5	10	110	0	116	115.5
6	10	120	0	126	126

Specified unbalancing factor is 5% for the first 50% of contract. Specified P_m is 5%.

ations. The user specifies the method of valuation according to the particular contract to be executed. Actual valuation of preliminaries entails the contractor submitting prices for the various units involved. In this case, the model applies unbalancing as in the measured work, but with the appropriate data entry.

Materials on site are calculated by subtracting the cumulative cost of materials installed on the building from the cumulative cost of materials delivered to site. The difference in materials on site between any consecutive periods is then used to assess the value to be certified by the client. The above three elements of valuation are then added to form the estimated cumulative monthly value curve.

Cumulative cash in curve

The cumulative cash in curve is derived by applying retention and time lag onto the cumulative valuation curve. The monthly values to be retained by the client are based on a specified retention rate of the cumulative value curve. The user has the option to apply this to any specified percentage of the total contract value after which retention ceases to apply. The model calculates the retention pay-back in two stages: the first half at practical completion and the second half at the end of the defects liability period (assigned by the user).

The payment delays needed to produce the cash in curve are entered by the user in probability terms. The user assigns probabilities to the client delaying payment by 0, 1, 2 and 3 months. This is a different approach to that used when delaying cost since monthly valuations are paid in lump sums. The assigned probabilities enable the model to delay any month's valuation by either 0, 1, 2 or 3 months.

Risk

All of the model's data entry can be represented in terms of ranges and distributions. This is useful in cases where the user is not quite certain about one or more of the values to be entered (e.g. those relating to the shapes of S-curves). The model is therefore incorporating uncertainty into cash flow. One of the major causes of contractors' failure is unexpected deficits in cash flow. In addition to its ability to simulate cash flow stochastically, the model identifies four ultimate factors that contribute to the risk faced by contractors. The factors are: cost variances, duration overrun, variations and under-measurement.

Cost variances are characterized by a range and random distribution which depict likely differences between actual and estimated monthly costs. These are used to generate monthly cost variances for labour, materials, plant subcontractors and preliminaries. Duration overrun is the difference between the contracted project duration and the actual. The model user enters a range and probability distribution for actual overall duration. The model, using these, randomly generates actual durations and compares them with the contracted duration. When the actual exceeds the contracted duration, the model calculates the liquidated damages to be paid by the contractor and the extra site overheads which will be incurred by the contractor. The model assumes that delays are the fault of the contractor. The model user may also simulate the effect of early completions when defining the range of the actual duration. Although this will not usually result in direct reward (as opposed to liquidated damages) from the client, the contractor's cash flow is expected to be improved (Kaka, 1995).

Delays (or early completions) caused by variations initiated by the client are also calculated. No liquidated damages are charged for delays caused by these variations, since clients (or their consultants) are expected to bear responsibility for any changes they make to original designs. Such variations, if accurately measured and fairly evaluated, should not affect the overall profitability of the contract unless the project is unbalanced. Variations are represented by a percentage of total value and a distribution over the running value of the contract. Using these, the model calculates the new unbalancing split point (the point that separates the two mark-up rates to be applied) since variations are often valued according to the original tender prices. The same (original) mark-up rates are applied to the newly developed value curve to come up with the adjusted valuations.

Undermeasurement is assessed using a percentage (or a range of percentages). This percentage is applied and deducted from the monthly valuations of the contract. The cumulative undermeasured value is then paid back to the contractor at the end of the maintenance period. A negative percentage may also be entered to simulate overmeasurements.

Cash flow

The cumulative cash out curve is deducted from the cumulative cash in curve to produce the cumulative cash flow curve.

Testing and validating the cash flow model

The next stage was to evaluate the feasibility of the proposed model as a reliable and useful tool for contractors' cash flow forecasting. A programme which incorporated a series of tests was devised to achieve this goal. One construction contractor participated in testing the programme, and offered to provide detailed project data. The following steps were taken within the evaluation programme.

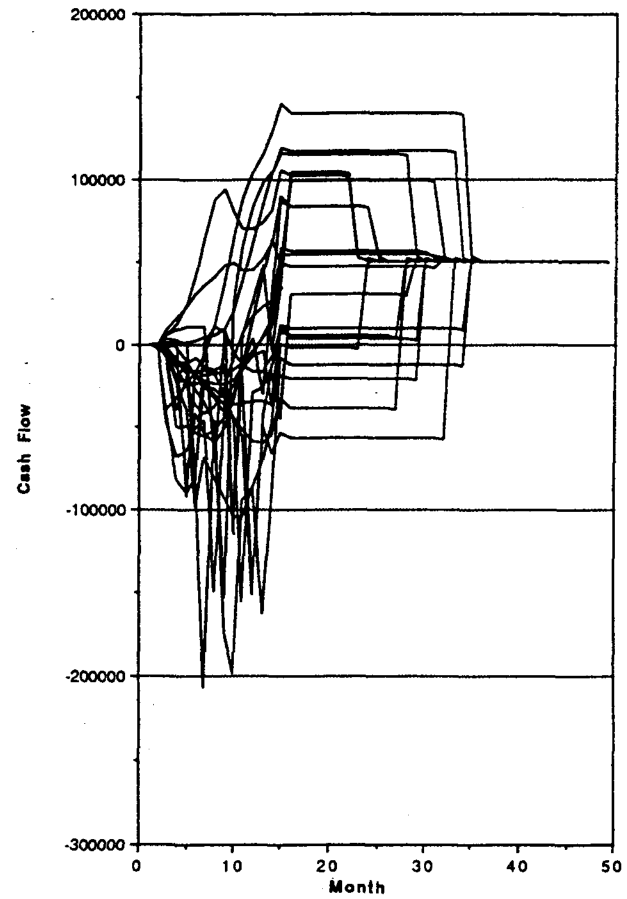

Figure 3 The cash flows of 20 projects

Testing the model for its capability to produce a wide range of cash flow profiles

The first task was to ensure that the model can produce the wide variety of cash flow profiles that has been shown to exist in the industry. A total contract value of £1M with a duration of 12 months was used to test the model stochastically, using 40 simulations. Apart from the total contract value, duration and time lags (time lags are already known to have significant influence on cash flow), 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. Figure 3 shows the resulting cash flow profiles of 20 runs. The extent of variation of these profiles is relatively high. The variations are also apparent when considering the maximum negative cash flow of each run. 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.

Testing the model for its accuracy as a simulation tool

Models are usually developed to simulate real life as accurately as possible. The cash flow forecasting model is a combination of mathematical expressions and equations installed on a computer. Many of the equations used were designed so that systematic data entry can be applied. Therefore before the model can actually be used, it has to be tested. The following points list the model parts that may be possible causes of inaccuracy:

1. The cost commitment S-curve assumes a mathematical formula (logit transformation). In real life cumulative monthly cost values conform to this formula but not precisely. Previous work has demonstrated this (Kenley and Wilson, 1986; Kaka and Price, 1993).
2. Unbalancing is simulated by splitting the contract cost curve into two parts where different mark-ups are applied. If contractors wish to adopt a more complex unbalancing strategy, the model may prove to be inaccurate.
3. Variations are simulated using an S-curve that is distributed over the running value of the contract. Although the user has the flexibility of modifying

the distribution significantly, some real life situations may not be accommodated accurately.

4. The time delays applied to individual cost headings are represented by percentages over 0 to 2 months. In real life these percentages may alter during the life of the project, in which case the model may become inaccurate.

The extent to which these causes apply are not known and need to be found out through tests on past actual contracts. One past project was studied (client's monthly valuations, internal valuations, detailed cost invoices, cost value reconciliation reports and cash flow) and some of the data entry required to run the model (many of the model's variables are simple and straightforward to identify) was estimated using the actual project data. This proved to be a cumbersome and time consuming task, which limited the testing to one project only. All the data entry, apart from the cost variances, were assigned fixed deterministic values. The model nonetheless had to be run stochastically to allow for the pre-assessed risk. To examine the performance of the model, it was necessary to use a measure of the goodness of fit. The measure chosen was the standard deviation about the estimate of Y (SDY) (Kenley and Wilson, 1986; Kaka and Price, 1991). The total estimated cost of the project was assumed to be £100, and hence all monthly cash flow values were converted accordingly. This enabled comparison between the proposed model and that developed by Kaka and Price (1991).

Results (shown in Figure 4) demonstrate the limited differences between the model's output and the actual cash flow. The average cash flow output is very close to the actual (SDY = 0.117). The envelope (maximum and minimum possible cash flow in any month) is shown to have a limited range. This is due to the limited cost variances associated in that particular contract. The difference (presented in SDY) between the average output and the actual is significantly lower than that experienced in previous cash flow models' validation (Kaka and Price, 1991). This is mainly due to the identification and incorporation of further variables.

Testing the model for its reliability as a forecasting tool

One objective of this test was to evaluate the extent to which contractors are able to forecast the data entry required to operate the model. The same project was used in this test, but instead of calculating the aforementioned variables, the contractor was asked to predict the data entry using only the information available at the tendering stage. The test highlighted the difficulties associated with predicting these variables accurately. Several of the variables were assigned ranges rather than fixed values, so that the model had to be run stochastically. An assessment of the associated risk was also made using educated judgment. The predicted data entry was then compared with the calculated one to ascertain the level of difference between the two. This indicated that there were no significant misjudgments in the forecasts, but the model was still needed to evaluate the effects these differences may have on cash flow.

The model was run 60 times. Figure 5 compares the forecast output with the actual. The difference between the average forecast cash flow and the actual is higher (but not significantly) than that achieved in the previous test (SDY = 0.780). This is still below the average error achieved using traditional cash flow forecasting models (Kaka and Price, 1991).

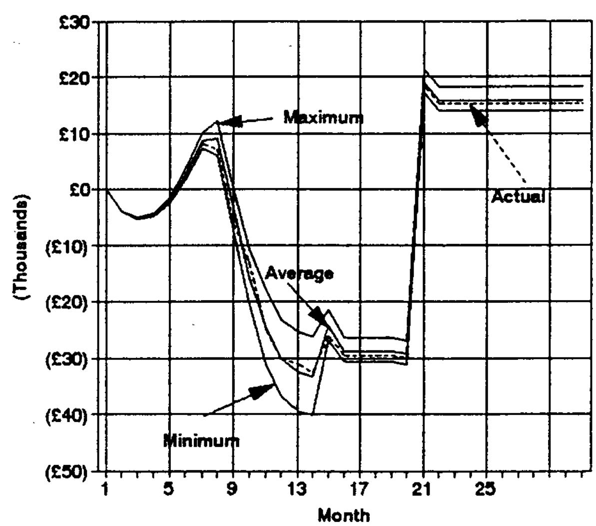

Figure 4 Average, maximum, minimum and actual cash flows obtained in the second test

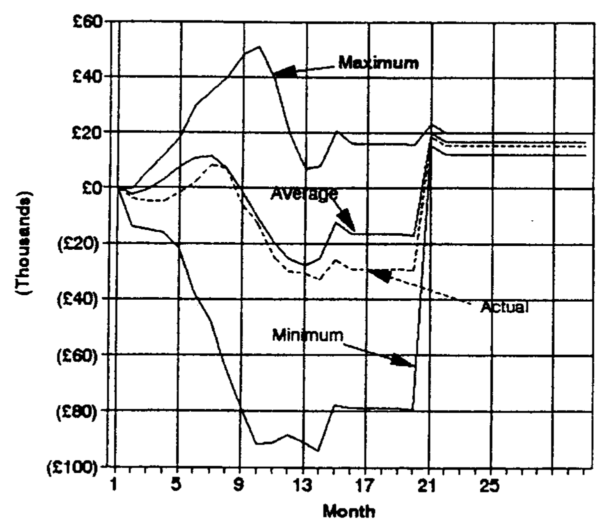

Figure 5 Average, maximum, minimum and actual cash flows obtained in the third test

Figure 5 also shows maximum and minimum possible cash flow values at any month. The wide envelope presented by these two curves demonstrates the high variability and volatility of cash flows. The overall profitability of the contract is shown to vary between £12 265 and £19 998. This is a limited variation when compared to the extreme values of cash flow (an ultimate variation between −£94 303 and £50 915). This provides strong support for the need to incorporate risk into cash flow forecasting.

Conclusions

The accuracy of current cash flow forecasting models is in question since they fail to explain the wide variability in cash flow profiles. One of the reasons for this is the limited amount of variables they incorporate. This paper identifies five factors lacking in current models. The consideration of these factors increased the number of variables to be incorporated into the cash flow mechanism to over fifty. Consequently, a computer-based cash flow forecasting model has been developed and validated.

Construction projects often possess a high level of risk, since the amount of unknowns is significant. Contractors are known to have a high rate of business failure. This vulnerability is not strictly limited to non-profitable contractors. A lack of finance to support a relatively short period of cash flow deficit may well cause insolvency and ultimately bankruptcy.

Therefore, if cash flow forecasting is to be useful it needs to incorporate the risk associated with contracting. The proposed model has been designed to incorporate risk and consequently stochastic simulation has been introduced. In addition, factors such as liquidated damages associated with duration overrun, discrepancies in client payment delays, variations, and so on have been incorporated into the model.

The model was validated in three stages: testing its capability to produce the wide variability of cash flow profiles known to exist in practice; testing the accuracy of the model as a simulation tool; and testing the validity of the model as a forecasting tool. All the tests yielded satisfactory results. Cash flow was demonstrated to be highly sensitive to the new variables incorporated. The extent to which the model's variables are predictable is shown to be reasonable. The last test demonstrated the high sensitivity of the cash flow profile to the risk factors incorporated. This explains contractors' vulnerability to insolvency, and supports the need to incorporate risk into cash flow forecasting and planning. The testing of the model is by no means complete (only one project was used to test accuracy). However, the results indicate that the proposed model is more accurate than traditional models.

References

Allsop, P. (1980) Cash Flow and Resource Aggregation from Estimator's Data. (Computer program CAFLARR). MSc in Construction Management Project Report, Loughborough University of Technology, UK.

Ashley, D.B. and Teicholz, P.M. (1977) Pre-estimate cash flow analysis. *Journal of the Construction Division*, ASCE, **103**, 369–79.

Ashton, W.D. (1972) *The Logit Transformation, Griffins Statistical Monographs and Courses.* No. 32, Griffin, London.

Bromilow, F.J. and Henderson, J.A. (1977) *Procedures for Reckoning and Valuing the Performance of Building Contracts (Second Edition).* CSIRO Division of Building Research Special Report, Highett, Australia.

Drak, B.E. (1978) A mathematical model for expenditure forecasting past contract, in *Proceedings of the CIB W65 Second International Symposium on Organisation and Management of Construction*, Haifa, Israel, November, **2**, pp. 163–83.

Harris and McCaffer (1989) *Modern Construction Management.* Collins.

Hudson, K.W. (1978) DHSS expenditure forecasting method. *Chartered Surveyor – Building and Quantity Surveying Quarterly*, 5, 42–5.

Kaka, A.P. (1990) Corporate financial model for construction contractors. PhD thesis, Civil Engineering Department, Loughborough University of Technology, UK.

Kaka, A.P. (1995) Evaluating the influence of cash flow management on contractors' performance, in *Proceedings of the 1st CSCE Construction Specialty Conference*, Ottawa, June, pp. 175–84.

Kaka, A.P. and Price, A.D.F. (1991) Net cash flow models: are they reliable? *Construction Management and Economics*, **9**, 291–308.

Kaka, A.P. and Price, A.D.F. (1993) Modelling standard cost commitment curves for contractors' cash flow forecasting. *Construction Management and Economics*, **11**, 271–83.

Kenley, R. (1986) Construction project cash flow modelling. PhD thesis, Department of Architecture and Building, University of Melbourne.

Kenley, R. and Wilson, O. (1986) A construction project cash flow model – an ideographic approach. *Construction Management and Economics*, **4**, 213–32.

Mackay, I. (1971) *To Examine the Feasibility of a Computer Program for Cash Flow Forecasting by Contractors.* MSc Project in Construction Management at Loughborough University of Technology, UK.

Nazem, S.M. (1968) Planning contractors' capital. *Building Technology and Management*, **6**(10), 256–60.

Oliver, J.C. (1984) *Modelling Cash Flow Projections Using a Standard Micro Computer Spread Sheet Program.* MSc Construction Management Report, Loughborough University of Technology, UK.

Peterman, G.G. (1972) *Construction Company Financial*

Forecasting. Internal report, Division of Construction, Arizona State University, USA.
Pilcher R. (1992) *Principles of Construction Management*. McGraw-Hill Book Company, Berkshire.
Singh, S. and Woon, P.W. (1984) Cash flow trends for high rise buildings, in *Proceedings of the International Symposium on Organisation and Management of Construction*, University of Waterloo, Canada, pp. 841–54.
Stark, R.M. (1974) Unbalanced highway contract tendering. *Operational Research Quarterly*, 25(3), 373–88.
Upson, A. (1987) *Financial Management for Contractors*. BSP Professional Books, Oxford.

Appendix 1: The variables incorporated into the cash flow forecasting model

A1 Total estimated value of project
A2 Total estimated 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/overmeasure as a percentage of total value of contract
A10 Defects liability 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)
A12 Percentage of own labour, materials, plant, labour only subcontractors, labour and materials subcontractors, nominated subcontractors and preliminaries to total cost (A12.OL, A12.M, A12.P, A12.LS, A12.LMS, A12.NS and A12.PR respectively)
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 mineral suppliers and nominated subcontractors
  A18.1 Percentage of running cost
  A18.2 Applied when paid within
A19 Retention held against: labour only, labour and 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)
A21 Cost variances for each of the cost headings (A21.OL, A21.M, A21.P, A21.LS, A21.LMS, A21.NS and A21.PR)
A22 Variations:
  A22.1 Percentage of total value
  A22.2 Distribution over the running value of the contract
A23 Duration variance:
  A23.1 Duration variances
  A23.2 Penalty per week.