Contractor's Financial Estimation based on Owner Payment Histories

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Research paper

A CONTRACTOR'S FINANCIAL VIABILITY IS AFFECTED BY LATE AND INCOMPLETE PAYMENTS FROM THE OWNER. Late and incomplete payments lead to cash flow uncertainty, additional bank interest, and delays in paying creditors such as suppliers and subcontractors, and may lead to decreased project performance, and possible additional time and cost due to disputes. The paper presents a method for cash flow and present value analysis under uncertainty based on an owner's payment history or estimated payment characteristics. The paper generalises existing modelling of uncertainty associated with late and incomplete owner payments to a range of claim types by the contractor, and different owner types. Aging contractor claims are analysed for claims submitted on a regular basis for amounts which may vary depending on project phasing. For each of the pre-identified typical owner payment practices, the estimated paid proportions of claims and the steady state distribution of payments in different age categories are established. A present value analysis assesses project viability from the contractor's viewpoint. Actual project data are used to confirm the validity of the method. The intent of the paper is to assist contractors establish suitable allowances in their tender pricing, to choose a suitable claim/payment schedule and/or to adopt suitable administration practices to optimise cash flow. The paper gives a summary approach for contractors, providing them with a practical tool in cash flow planning, control and risk management.

Keywords

Cash flow, Markov chains, contractor payment, owner classification

INTRODUCTION

Cash flow forecasting and cash flow management are essential but difficult aspects of a contractor's practices; they are central to the wellbeing of a contractor. Forecasting is also important as a means to obtain loans, because banks prefer to lend money to companies that can present periodic cash flow forecasts (Navon, 1995). However a contractor's cash flow is subject to many uncertainties, some of which result from owner payment practices. An owner which fully complies with payment terms outlined in the conditions of contract makes cash flow management much easier, while an owner which responds irregularly and incompletely to a contractor's claims may drive the contractor's cash flow to deviate far from what had been planned. An understanding of an owner's payment practices is, therefore, very useful for a contractor's cash flow planning purposes.

The paper presents a method for cash flow and present value (equivalently present worth) analysis under uncertainty based on an owner's payment history or estimated payment characteristics. Extending from the original work of Carmichael and Balatbat (2010), the method gives the change in claim payments in weeks/months following claim lodgement. Payments of individual claims are accumulated and superimposed on the planned cash outflows throughout the project, so that a detailed cash flow diagram can be obtained. A present value analysis is performed to assess project viability from the contractor's viewpoint.

Payment time lag to creditors such as subcontractors, owner type (represented by different payment profiles) and claim mark-up are analysis variables. Claims are allowed to change in line with project phasing and typical project S curve behaviour. Aging contractor claims are assumed to be submitted on a regular basis; claim amounts may vary depending on project phasing. For each of the pre-identified typical owner payment practices (Tran and Carmichael, 2013), the estimated paid proportions of claims and the steady state distribution of payments in different age categories are established. Real project data are used to confirm the validity of the method.

The aim of the paper is to assist contractors in establishing a detail cash flow forecast which takes into account cash inflow uncertainties due to late and incomplete owner payment behaviour, and cash outflow. As a follow-on, contractors are able to establish suitable allowances in their tender pricing or to choose a suitable claim/payment schedule to optimise cash flow. The paper's method can be used to address risks associated with negative cash flow, additional bank interest, and disputes, leading to more effective cash management by the contractor.

Although in some countries there exists legislation to protect contractors from late and incomplete payments and insolvency of the payer, payment arrears are still very common (Wu et al., 2011; Brand and Uher, 2010). Owner-caused delays and incompleteness in payments have been shown to have a large influence on a contractor's cash flow and financial viability (Carmichael, 2000, 2002; Carmichael and Balatbat, 2010). Cost and time associated with disputes may also place a large burden on contractors. An example given by El-Adaway and Kandil (2009) emphasises the severe losses to a contractor when it had to wait for a 3-year arbitration to run its course before recovering the majority of its claim.

The method presented in this paper can be combined with the Carmichael-Balatbat Markov chain formulation of owner payments and the classification of owner payment behaviour (Tran et al., 2011; Tran and Carmichael, 2012a,b, 2013) to form a complete cash flow analysis tool. While primarily intended for contractors, the method can also be used by subcontractors, suppliers and consultants when they deal with others higher in the contractual chain. It may also serve as a reference tool for project owners to enhance their relationship with contractors. The paper provides a practical tool for cash flow planning and management; it is a contribution to contractor financial planning and risk management.

The paper starts by reviewing related studies about claim-payment modelling and cash flow estimation and then summarises some key results from the literature. The existing literature is modified to incorporate claims that change with project phasing. Case study data are used to demonstrate the cash flow and present value calculations, taking into account alternatives in payment time lags to subcontractors and mark-up in claims.

Background Literature

Uncertainties in payments leading to cash flow difficulties have been highlighted as a cause of business failures and escalating disputes (Carmichael, 2002; Carmichael and Balatbat, 2010). Some research has attempted to assist in mitigating construction uncertainties associated with claims and disputes. Examples include predicting contractor failure (Russell and Zhai, 1996), evaluating and investing in construction projects under uncertainty (Ho and Liu, 2003), and developing an integrated method for project risk management from the owner's point of view (del Cano and de la Cruz, 2002).

Cash flow forecasting is about the distribution of income and expenditure as a function of time (Navon, 1995). It is noted that the majority of existing publications about cash flow forecasting focus on expenditure, which is taken from the project schedule. For example, Navon (1995) introduces a resource-based cash flow estimation, Kenley and Wilson (1986, 1989) model project net cash flow as a logit-transformation of percentages of project time and cost, Chen and Chen (2000) integrate a cost database and billing activity payments of subcontractors into the cash flow estimate, and Kaka and Price (1993) simplify the standard cost-commitment curve to enable contractors to perform cash flow estimates at the pre-tendering stage more readily. Blyth and Kaka (2006), Hwee and Tiong (2002), and Mavrostas et al. (2005), among others, use a project's S curve as a guide for estimating cash outflow; an underlying assumption in these cash flow forecast models is that payments occur as anticipated pre-project.

Some studies that discuss changes in cash inflow are Park et al. (2005), Chen et al. (2005), Kaka and Price (1991) and Kaka (1996). The model by Park et al. (2005) allows contractors to incorporate the time lag between expenditure and payment of a related cost item. Chen et al. (2005) recommend the inclusion of more detailed payment conditions, and differential payment lags and frequency in order to increase the accuracy of cost-schedule integrated cash flow forecasting techniques. Kaka (1996) mentions payment delays and retention in cash flow calculations, assuming that delay is minimal and the work in progress and the value of progress claims are equal.

Doubtful accounts in retail businesses are modelled as Markov chains by Cyert et al. (1962) to estimate collectibles and the probable time to collection. The estimates of collectibles are then calculated for the case where monthly inputs of claims vary cyclically as occurs in retail businesses. There are several modifications to and comments on the original contribution of Cyert et al. (1962), including Corcoran (1978), van Kuelen et al. (1981), Barkman (1977), Wort and Zumwalt (1985), Kallberg and Saunders (1983) and Frydman et al. (1985).

Carmichael and Balatbat (2010) use Markov chains to model late and incomplete owner payments. States are defined as the period of time by which payment is overdue. Transition probabilities are estimated based on summaries of total project outstanding amounts over time. The analysis gives probabilities of payment by a certain date and the average time to payment. The present analysis follows this line of thinking but allowing for different claim submission schedules that reflect project phasing.

Background Theory

Carmichael and Balatbat (2010) model contractor payments by owners using Markov chains in the following summary way.

Let period i = 0 be the time that the claim is made by the contractor; then periods i = 1, 2, 3, ... represent months/weeks beyond that time. Let the (transient) states be the amount outstanding to the contractor beyond period i. The states reflect the aging amount believed by the contractor to be owed on the project. Two additional (absorbing) states n' and n are also introduced. n' is the 'Paid' state and n is the 'To be resolved' state. As noted, states 0, 1, 2, ..., n-1 are referred to as transient states, while states n and n' are referred to as absorbing states.

Transition probabilities between periods i and i+1 are calculated from,

$$p_{jk} = \frac{\alpha_{jk}}{\sum_{k=0}^{n'} \alpha_{jk}}$$

$$j, k = 0, 1, 2, \ldots, n, n' \quad (1)$$

Here α is the amount in state k that is transferred from state j between periods i and i+1.

p_{jk}, for j, k = 0, 1, 2, ..., n, n', comprise the elements of an transition matrix P which is partitioned to give Q (n x n) and R (n x 2) matrices. R applies to transitions from transient states to absorbing states, while Q applies to transitions between transient states. A fundamental matrix $N = (1-Q)^{-1}$, and a matrix NR are then computed. The first column of NR gives the probabilities of amounts being paid. The second column of NR gives the probabilities of amounts needing resolution.

Extension of the Carmichael-Balatbat Formulation for Calculating Changes in Payments

The Carmichael-Balatbat formulation can be used to estimate the change in amounts in the transient states following a claim submission. Consider a claim of value c_1. A claim is equivalent to an amount (here c_1) entering state 0, with zero amounts in the other states 1, 2, ..., n. These other states only take values when transitions between states occur. Accordingly define 1 × n row vector $C_1 = [c_1, 0, 0, \ldots, 0]$ as the vector of new state additions. Over one time period, the amounts in the transient states change to C_1Q, over two time periods to C_1Q^2 and so on.

In the following time periods i = 2, 3, ..., (here a month, week, ...), allow claims respectively of c_2, c_3, ... And so, using equivalent notation as above, the amount in each transient state contributed by the latest claim (after 0 time periods) is C_i, contributed by the previous claim (after 1 time period) is $C_{i-1}Q$, contributed by the claim before that (after 2 time periods) is $C_{i-2}Q^2$, and so on. The cumulative amount in each transient state contributed by all claims is $C_i + C_{i-1}Q + C_{i-2}Q^2 + \ldots$

For claims of constant amounts $C_1 = C_2 = \ldots = C_i = C$, the steady state amount in each transient state is

$$C + CQ + CQ^2 + CQ^3 + \ldots =$$
$$C(1 + Q + Q^2 + Q^3 + \ldots) = CN \quad (2)$$

CN is a 1 x n vector.

A similar argument can be used for the absorbing states. Of any new claim, CR will be absorbed, of the preceding time period claim CQR will be absorbed, of the time period CQ^2R claim before that will be absorbed, and so on. That is, the steady state amount absorbed is

$$CR + CQR + CQ^2R + CQ^3R + \ldots =$$
$$C(1 + Q + Q^2 + Q^3 + \ldots)R = CNR \quad (3)$$

CNR is a 1 x 2 vector.

Thus, the claim submission schedule of the contractor can be converted to an estimate of future cash inflow, which can be combined with planned cash outflow. Actual claim submission schedules can be used. Alternatively, constant claims within project phases may be assumed. Below, a case study project is used to demonstrate the method.

Case Example A

Consider the claims and payment data for the construction of noise-reduction walls along a metropolitan railway line. The project contains 12 progress claims totalling approximately $1.2M. The project duration was approximately 12 months. Two progress claims were not paid and the reasons given were that the work had not been completed, or insufficient detail was submitted in the progress claim. Table 1 shows the summary of the outstanding project money against the number of months after claims lodgement.

Based on the payment profile in Table 1, the matrices Q and R can be assembled according to Carmichael and Balatbat (2010),

$$Q = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 0.331 & 0 \\ 0 & 0 & 0 & 0.616 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

and

$$R = \begin{bmatrix} 0 & 0 \\ 0.669 & 0 \\ 0.384 & 0 \\ 0 & 1 \end{bmatrix}$$

Changes in payment

For each unit new claim of $1, the first entries of CR, CQR, CQ^2R, and CQ^3R are 0, 0.669, 0.127 and 0, and these enter the 'Paid' state in subsequent time periods. Thus the first claim of $95.0K (in the first month) gives rise to payments of $0, $63.6K, $12.1K and $0 in subsequent months. Similarly, the second claim of $143.9K in the second month gives rise to payments of $0, $96.3K, $18.3K and $0 in subsequent months. And continuing, strings of payments of claims in the third, fourth, etc. months can be calculated. Summing the payment contributions of each claim leads to the total payments in months 1, 2, 3, ... of $0, $63.6K, $108.4K and so on.

Figure 1 plots shows the claim-payment relationship for the project, in which the payments are calculated using the above extension of the Carmichael-Balatbat formulation.

The total claimed value was approximately $1,134.2K, while the to-

Total claimed amount ($K)	Outstanding amount ($K) at			
	1 month	2 months	3 months	4 months
1,134	1,134	375	231	231

Table 1 **Outstanding claimed amounts at months following claim lodgement – case example A; n = 4**

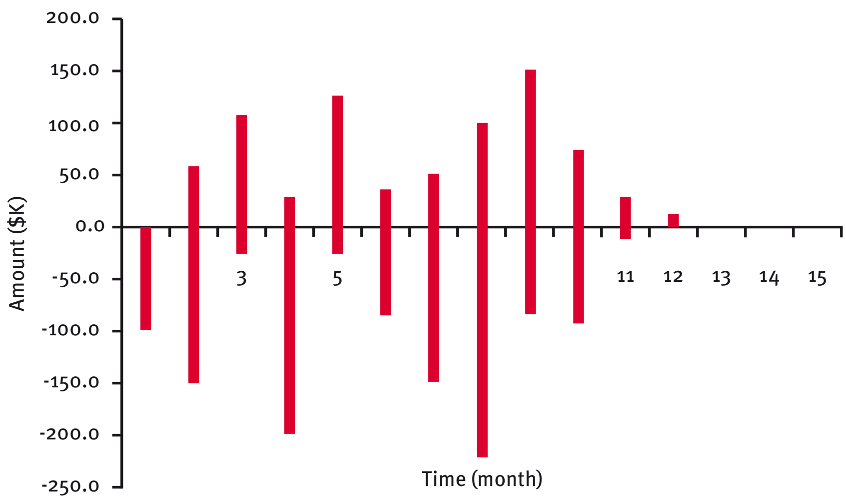

Figure 1: **Claim-payment relationship - case example A**

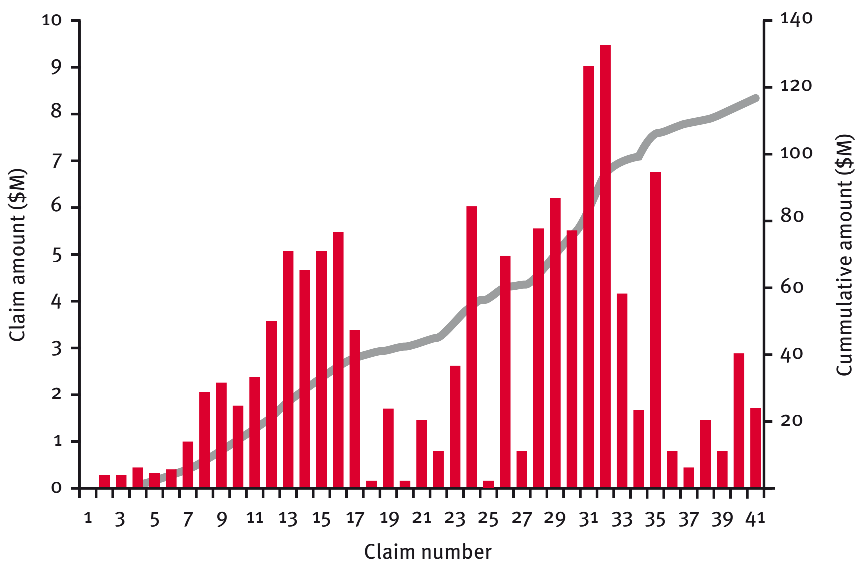

Figure 2: **Claims data – case example B**

tal payment was less at approximately $903.1K. If this payment scenario had been anticipated, the contractor could have increased claim mark-up in order to improve its net cash flow. Such payment information, if available from past projects, can be used to estimate payments on future projects.

Below, a project S curve is approximated by piecewise linear portions equivalent to claims constant in time but of differing magnitudes, in order that cash inflow estimation can be readily obtained.

Claims According to Project Cumulative Expenditure

A piecewise linear approximation to a project cumulative expenditure or project S curve will cover most situations. Each straight-line portion represents a period of claims of constant but differing amounts. One, two or more straight-line segments may be appropriate, depending on the fluctuation of claims over the project duration. The textbook project S curve might be approximated by three straight lines - an initial phase where expenditure and claims are low and constant as project activities are being initiated and the project resources mobilised, a middle phase where expenditure is high and constant and contractors could expect to submit claims of similar amounts regularly, and a final phase where expenditure and claims are low and constant as the project winds up (Blyth and Kaka, 2006).

The data from three projects are shown here to demonstrate typical claims practices, and how the cumulative claims plots may be approximated by multiple straight-line segments, where the number of segments may vary from project to project.

Case example B: the construction of a 7 km two-lane grade separated road. 41 progress claims were made over a total duration of 32 months (Figure 2). Because of the peak claims either side of small claims, the cumulative claim schedule of this project may require approximating by several segments.

Case example C: the construction of a rural highway including earthworks, drainage, pavements, road furniture and traffic management. The 22 progress claims are shown in Figure 3. This cumulative plot might be approximated by several segments, or more severely by one segment.

Case example D: the refurbishment of a city building with total cost of approximately $60M and duration of approximately 20 months. The cumulative claims given in Figure 4 might be approximated by two straight segments either side of the middle of the project.

The number of straight-line segments assumed to represent cumulative expenditure is at the discretion of the contractor. Stylised assumptions, in order to simplify the calculations, however might be in terms of:

- One straight-line (constant slope) segment over the entire project.
- Two straight-line segments where the change occurs near project midpoint.
- Three straight-line segments with the larger claims in the middle part of the project.

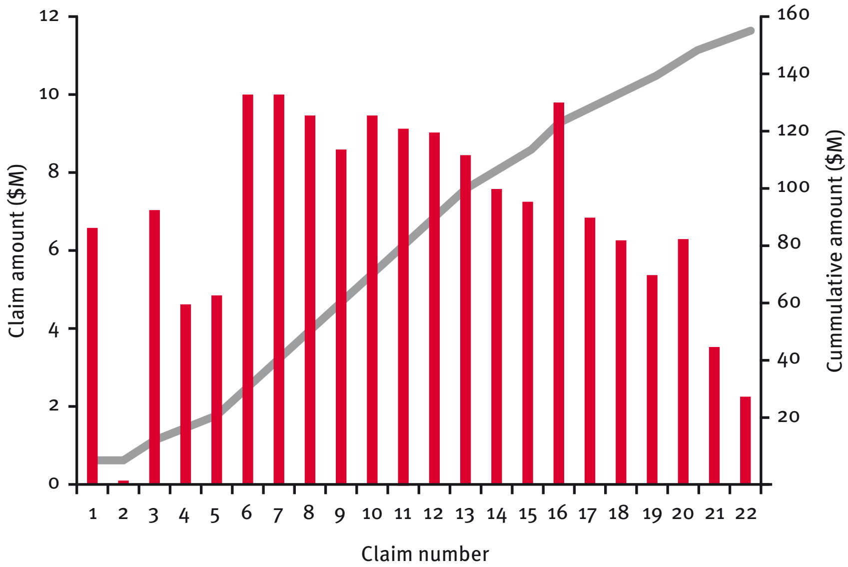

Figure 3: Claims data – case example C

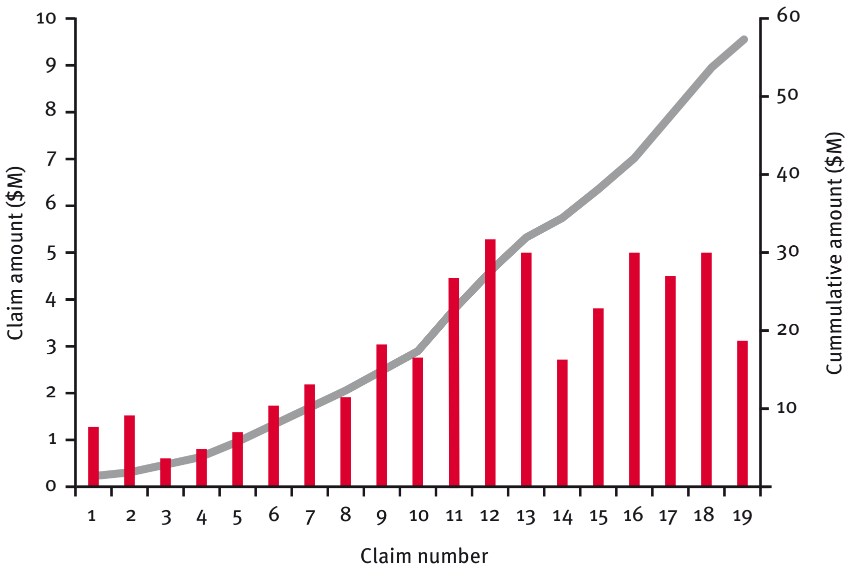

Figure 4: Claims data – case example D

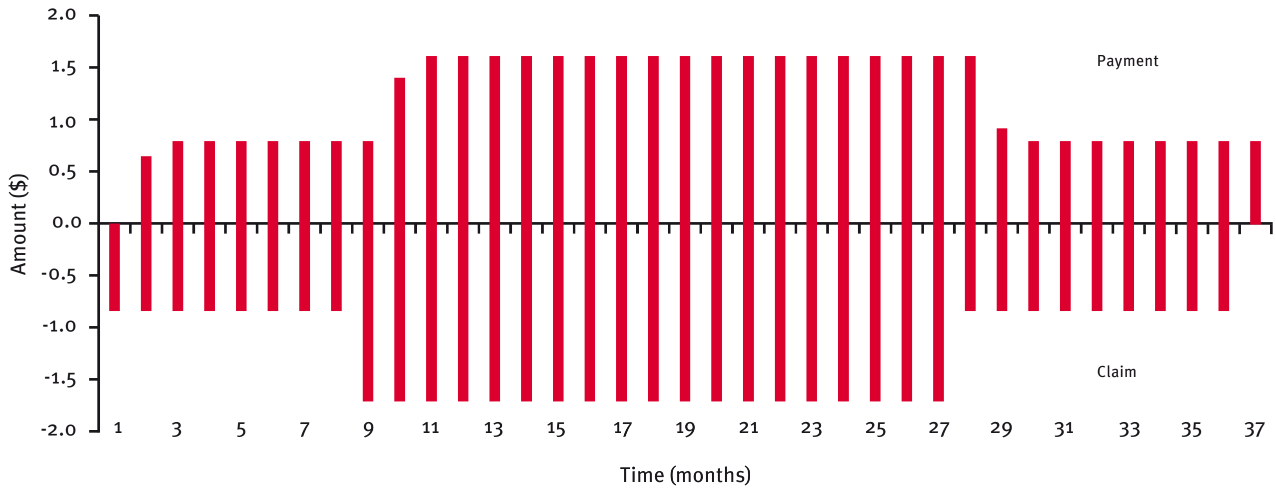

Figure 5: Case example A extension; payment-claim relationship based on unit claims for the first 9 and last 9 months, and twice this for the middle 18 months

Nonlinear segments can also be assumed in place of linear segments, for example by using quadratic or exponential functions. Numerical experiments conducted by the authors show that the difference in the results between linear and nonlinear assumptions is negligible. In the steady state there is almost no difference in the values of the matrix NR or the vector CNR between the assumptions of linear or nonlinear segments. Accordingly the extra accuracy that might be thought possible through the use of nonlinear approximations is not there; as well, it comes with increased burdens of mathematical understanding and computational load.

Estimation for a Future Project – Case Example A Extension

Assume that the owner payment practices of case example A apply, but now add the following new (future) project specifics. There are 36 monthly progress claims, where the first 9 claims, the next 18 claims and the last 9 claims have ratios of 1:2:1. The claims submitted include a mark-up (17.6%) to account for overheads; the actual spending of the contractor is 85% of what it is being claimed. The contractor pays for the work as it is done irrespective of getting any payment from the owner.

For each unit or $1 claim, the change in payments in subsequent months 1, 2, 3 and 4 are $0, $0.669, $0.127 and $0, respectively. The payment-claim relationship is plotted in Figure 5.

Present Value

Let the net cash flow, the difference between the payments and the expenditure at each time period, i = 0, 1, 2, ... be x_i. The present value (PV) is the sum of the discounted x_i,

$$PV = \sum_{i=0}^{m} \left[\frac{x_i}{(1+r)^i} \right]$$

where r is the monthly discount rate and m extends until the last payment is received.

Consider the values as in Figure 5. The steady state payment to the ‘Paid’ state is $0.796. Since the actual cash outflow each month is 85% of each claim, the contractor’s net cash flow in each of the first 36 months is negative. The non-discounted total payment is $42.98 while the non-discounted total expenditure is $45.90. Based on a monthly discount rate of 1%, the present value of the net cash flow is -$2.90.

Effect of mark-up on present value

The above analysis shows that the contractor has a negative net cash flow throughout the project. The mark-up of 17.6% is not high enough to give a positive present value as the contractor would like. The minimum mark-up that needs to be applied in order to have a non-negative present value is of interest to the contractor.

Figure 6 shows a range of mark-ups and the associated present value amounts. It is seen that the contractor needs to adopt at least a 27% mark-up (value at the intersection of the present value plot and the horizontal axis) in order to have a non-negative present value.

Effect of delaying payments to creditors on contractor’s cash flow

In order to improve present value, the contractor may consider the option of delaying payments to creditors such as subcontractors and suppliers. This delays cash outflows. Different time lags in payments to creditors can be examined by shifting the cash outflows to the right.

Consider the situation (in the same case example) in which the contractor delays its cash outflow by one month, then the present value for a 17.6% mark-up becomes -$2.50. To make the present value non-negative, a 26% mark-up is required. Delaying cash outflow by a further month, a 25% mark-up is required to bring the present value to a positive amount ($0.13). This may assist the contractor’s bid to be more competitive.

Figure 7 shows how the present value changes for different time lags in paying creditors, assuming a 25% mark-up.

The effect on present value of delaying the cash outflow is more apparent when the discount rate is higher. With a discount rate of 1.5% per month, the minimum mark-up required to have a non-negative present value for delays of 0, 1, and 2 months is approximately 26%, 25% and 24%, respectively.

The above example shows the contractor the impact of mark-up choices and creditor payment policies on its finances. This may assist, for example in being more competitive at tendering time, or in administering funds during a project.

Typical owner payment behaviour

A study of the classification of owner payment behaviour by Tran and Carmichael (2013) established that there are six main types of owners when characterised in terms of their late and incomplete payment histories. Owners are classified according to three parameters representing uncertainties in payments, namely, the proportion of total amount paid within a certain time frame, the time following the submission of the claim to the initial payment made, and the consistency in the promptness in responding to each individual claim.

Owner Type	Average payment in 2 months (standard deviation)
1	0.54 (0.24)
2	0.27 (0.1)
3	0.70 (0.15)
4	0.34 (0.13)
5	0.76 (0.11)
6	0.80 (0.11)

Table 2 **Average payment in 2-month period following claim submission, as a proportion of total claimed amount, of the six representative owner types of Tran and Carmichael (2013)**

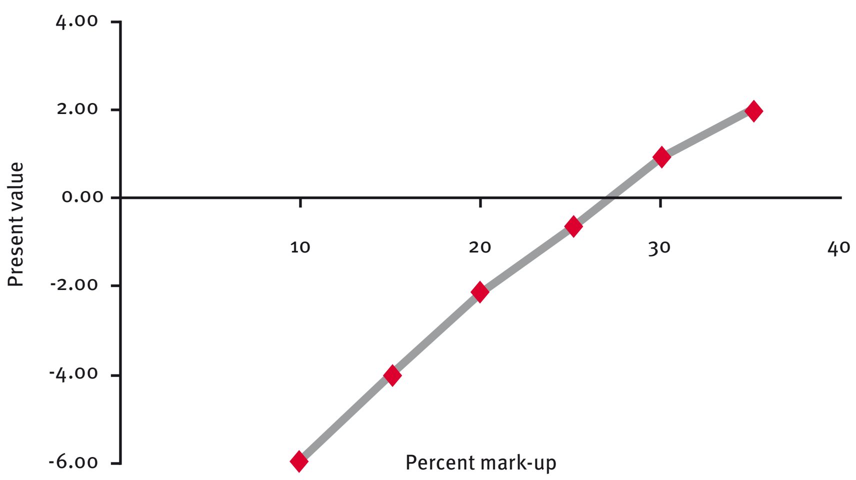

Figure 6: **Effect of mark-up on PV - case example A extension**

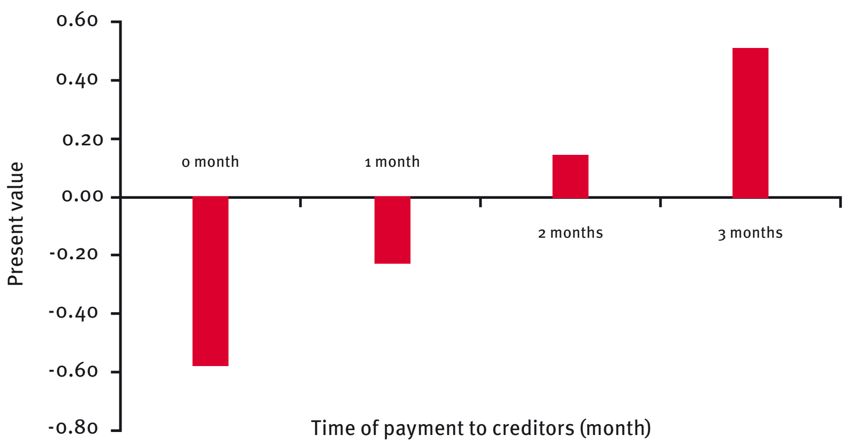

Figure 7: **Present value based on different payment time lags to creditors; 25% mark-up, 1% monthly discount rate - case example A extension**

Accordingly, it is shown that owners with incomplete payment histories fall within one of six levels of practice: from poor – Type 1 to excellent – Type 6 (Tran and Carmichael, 2013). The anticipated payment in terms of proportion of total claimed amount, for example in 2 months following claim submission, for each typical owner type is shown in Table 2.

For owners Type 1, Type 2 and Type 4, given that the steady state paid amount in the 2-month allowance is no more than 60% of the claim, the contractor's real expenditure should be lower than 60% of its claimed amount in order to have a positive monthly net cash flow. This implies a mark-up of more than 100%. Therefore, such owners are not desirable to work for. Owners Type 5 and Type 6 have steady state payments equal to 76% and 80% of the claimed amount, respectively. Hence mark-ups of at least 31.5% and 25%, respectively, are required in order to have a positive present value when working with these owner types. Owner Type 3 may also be suitable to work for, but a contractor might also simultaneously consider other practices such as front-end loading or up-front payments.

The classification of owner payment behaviour allows contractors to perform an analysis based on the identified type of the owner, derived from the contractor's own experiences or others' experiences. The requirement of having specific historical owner payment data can be eased, yet the result of the analysis remains practical. For example, consider a contractor working with an owner Type 6. Based on the anticipated payment practices of this owner (as given in Table 2) and the assumed future project scenario as in Figure 5, the contractor is advised to adopt at least a 25.5% mark-up, assuming payments to creditors are not delayed. The mark-up can be reduced to 23.9%, 22.7% and 21.5% respectively for 1-, 2- and 3-month payment time lags to creditors. The contractor, based on this analysis, can also modify its cash flow diagram by unbalancing its claims schedule to give a further reduction in the mark-up, thereby improving its competitiveness.

Summary of the Approach for a Contractor

The above development is summarised for the purpose of being implemented by contractors (as well as subcontractors, suppliers and consultants when dealing with others higher in the contractual chain). The method requires no more than a summary or estimate of outstanding project money against time after claim lodgement from a past project. All cash flow and present value calculations can be readily done using a spreadsheet.

1. Decide on a relevant time period and how many time periods must pass before a claim is conceded as needing resolution. Based on past projects or estimates, summarise the outstanding amounts against time since claim lodgement. Estimate the entries of the matrix P in the Markov chain formulation (Carmichael and Balatbat, 2010).
2. Calculate the submatrices Q and R.
3. Generate a cash outflow diagram based on the project schedule. Simplify the cash outflow diagram by allowing constant claims over project phases, if detailed estimation is not available.
4. For each claim, calculate the values of CR, CQR, CQ^2R, ..., $CQ^{n-1}R$, where C = [c, 0, ..., 0] is a 1×n vector and c is the amount of the claim. These are payments in the weeks or months following claim lodgement.
5. Add claim payments to the cash outflow diagram to produce a complete cash flow diagram.
6. Perform a present value analysis. Examine changes in assumptions on mark-up, discount rate and payment time lag to creditors in order to assist decision making on tendering policy and/or project administration practices.

Conclusion

The paper provides a practical way for a contractor to perform financial calculations based on past payment experience with an owner, or estimates of an owner's payment practices. The contractor is able to forecast future cash flows and hence potential project profitability. The method is best applied pre-tender when simple and quick cash flow estimates are required. It can also be used during a project to understand the cash position of the contractor, or to adjust claims practices.

For each owner type, the method allows contractors to:

- Calculate the payment expectancy for individual claims, including increments in payments in weeks/months following claim lodgement.
- Generate a cash flow diagram by looking at a series of claims.
- Perform a present value analysis of payments and expenditure, considering various possible time lags in cash outflow to creditors, discount rates and mark-ups, and hence decide on the most suitable bidding and claim practices.

The method permits a number of discretionary parameters including choice in time periods, and choice in time lags in payment to creditors. The cash outflow calculations may be simplified by allowing constant claims over different project phases as demonstrated in case examples B, C and D. The contractor may also examine different options in claim submission schedules, taking into account any possible front-end loading. The methodology remains the same.

The analysis is not only applicable to owners with incomplete payment histories, but also applicable to complete payment situations as identified in Tran and Carmichael (2013). Based on knowledge of the timing of payments from the owner, the contractor can perform the same analysis to estimate the increments in payments following claim lodgement and feed this into the cash flow diagram. Because claims are paid completely, the timing of payments may not largely affect the present value, but it still gives very useful information about the monthly/weekly cash flow of the contractor.

Future research. The analysis presented in this paper could be extended by considering different claim schedules made by the contractor in an upcoming project. Instead of assuming the cash outflow being constant over certain project phases, cash outflow estimated from actual project schedules could be used to estimate payment portions and timing. Another extension of the research could be incorporating probabilistic cash flow forecasts into the analysis, taking into account uncertainty associated with discount rate, project schedules and investment life spans. The whole analysis could be integrated into a spreadsheet tool requiring only user inputs of a summary of owner historical payment data, and a future cash outflow schedule. The spreadsheet tool would allow the contractor to examine the effect of tardy payments from the owner, possible changes in discount rates and payment policies to creditors on its net cash flow and net present value. The classification of typical owner payment behaviour could be incorporated in the analysis tool for quick and simple estimation.

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