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Model on cash flow forecasting and risk analysis for contracting firms

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Abstract

When a construction project is in progress, it would be beneficial to the contractor if prior knowledge on trend of cash flows in the project is available. The purpose of this paper is to present a computer based model that has a cash flow forecasting ability and to study the impact of five risk factors on a project's cash flows. The five factors are duration, over/under measurement risk (during work progress), variation risk and material cost variances. The model was developed into a program that can be used to predict future trend of cash flows in a project, as well as to analyse impact of risk factors on cash flows. The five risk factors were tested on the model and analysed with sensitivity analysis. In the research, the internal rate of return and capital requirement are used to indicate the performance of cash flow. With data from actual projects, the forecasting capability of the model and impact on cash flow caused by the five uncertainties were studied. The results show that the model gives a good prediction of internal rate of return and capital requirement of projects.

Keywords: Cash flows; Predictive model; Forecasting; Risk factors; Sensitivity analysis

1. Introduction

When a construction project is in progress, its cash flow is the most important factor that can affect the profitability. It would be beneficial to the contractor if prior knowledge on trend of cash flows in a project is available. The purpose of this paper is to present a computer model that has a cash flow forecasting ability and to study the impact of five major risk factors on a project's cash flows. The factors chosen are duration, over/under measurement risk, variation risk and cost variances for material. The list of factors is not exhaustive as there are factors such as labour and overhead costs that form the major cost components in a construction project. For many years, the construction industry has suffered a proportionally high bankruptcy rate than other industries. One of the major causes of bankruptcy is inadequate cash resources and failure to convince creditors that this inadequacy is only temporary. Moreover, profit margin in this fiercely competitive industry is usually very tight and is exposed to many uncertainties during the construction phase [1]. There is thus a need for contractors in the construction industry to forecast the likely cash-flow profile of each project and understand the risk factors affecting it. With a reliable pre-hand estimation of project's cash flow, contractors will be able to implement measures that improve the financial position of projects and make provisions for loans to match up with the projected temporal deficit. It was in this context that CAFFS, acronym for Cash Flow Forecasting System, was developed [2]. (Note: the currency unit used is the Singapore dollar, S$.)

2. Cash flow forecasting

Accurate cash flow forecasting is essential at the tendering and construction stages for all contractors. It provides contractors with information regarding the amount of capital required, the amount of interest that needs to be paid to support an overdraft and the evaluation of different tendering strategies. As the construction progresses, how cash flow will be affected, as the varying risk factors change, can also be made known earlier to the project manager. It serves as a cost control tool during the construction phase. The need for simple and fast techniques in cash flow forecasting has been acknowledged in previous research [3,4] and, as a

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result, cash flow forecasting models have been developed. These models tend to follow the same concept and mechanism. Ideally, cash flow forecasts should be based on the construction program and a bill of quantities.

Standard S-curve [5,6], which represents the running cumulative value of contracts 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. These models usually involve a complicated procedure and a large number of variables. For example, Kaka (1996) incorporated more than 50 variables in his model. Furthermore, most of these models are stochastic in nature and require extra effort to analyse the results. Thus, these models do not lend themselves readily for contractor's use where simplicity is an important consideration.

In this project, the authors have used Internal Rate of Return (IRR) and maximum capital requirement as indicators to the project's performance. These indicators are derived from the project's cash-flow profile that is sensitive to the risk factors present in a project. As the project's cash flow stretches over many years, it will be more meaningful to represent profit in terms of IRR.

Besides maximising IRR, contractors also pay special attention on keeping the cash deficit low. Throughout the project's duration, the cumulative cash-flow profile is in deficit most of the time. It is only in the later part of the project that a positive cash flow will be generated. In order to finance this deficit, funds must either be generated internally within the company or borrowed from financial institution. This means that there is a hidden cost in the project in terms of interest lost on unrealised deposits or interest payable for overdrafts from banks. Furthermore, having an account in the red does not help the contractor in appeasing creditors and in harnessing more loans when necessary. This explains why having a large working capital requirement would put a contractor in an unfavourable position [5,7].

3. Development of model

CAFFS gives prediction of cash flow profile of a construction project. It takes into account the contractual factors in a project as well as present working practices and trends that affect the project's cash flow. Impacts of other varying uncertainties (e.g. over measurement, variation of contracts, cost fluctuation) can be reflected on the cash-flow profile too.

The input data when integrated with the 'S-curve' theory gives a cash-flow profile that will re-adjust itself to suit the actual cash flow as more data on the project's progress are made available.

In the system, the primary output, i.e. the monthly cash flow, is transformed to give information in terms of internal rate of return and monthly maximum working capital graphs. These two final products are more useful for contractors as they present a clearer picture of the project's performance. The formalisation stage involved gathering of information and mapping the key concepts and relations into a formal representation. From available literature and interviews with the industry experts, an algorithm framework was formulated. During implementation, the formalised framework was reorganised and a prototype program using Microsoft Excel was developed.

4. System structure

The system structure of CAFFS is represented schematically in Fig. 1.

The **User Interface** is designed to process input information that is subsequently used by the **Program** to predict the cash-flow profile. It consists of two spreadsheets that distinguish the types of data to be fed into the system. Fig. 2 shows the details of input in the two spreadsheets. Input Data 1 consists of information available to the user before commencement of the project. These variables are fixed during the tendering or formulation of contract. Input Data 2 consists of information of the project's monthly progress in monetary terms. Once a month, it will be updated when new information of measurements, variations, costs and duration changes are available. (See Appendices 2 and 3.)

In the **Program**, information from the user is processed. It consists of two major modules, namely 'S-curve Generation' and 'Real-time Adjustment'. Fig. 3 illustrates the mechanism in the **Program** and **Output** stages.

As mentioned earlier, the 'S-curve' theory has been adopted as the basis for cash flow prediction. In the

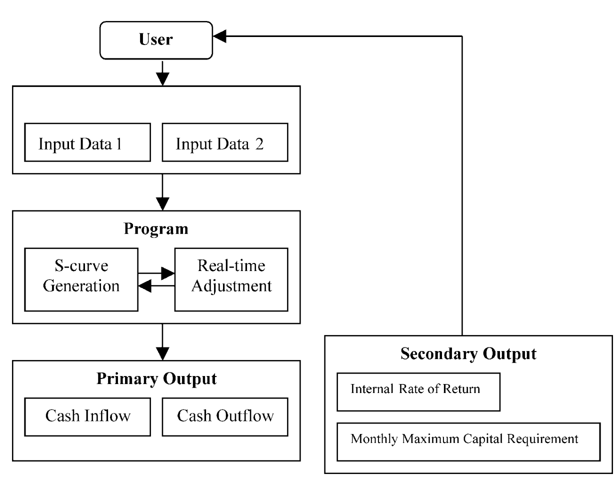


Fig. 1. System structure of CAFFS.

Input Data 1

1) Contract's sum stipulated in contract
2) Duration of project stipulated in contract
3) Defects liability period
4) Markup percentage applied by contractor
5) Payment delay period (developer, sub-contractors, suppliers)
6) Retention percentage and limit
7) Estimated proportion of different cost groups (% of labour, material, plant, sub-contractors and indirect costs)

Input Data 2

1) Expected changes to duration
2) Variation Orders by developer
3) Monthly work progress measurement (developer and sub-contractors)
4) Monthly incurred costs in different cost groupings

Fig. 2. Input data required for CAFFS.

'S-curve Generation' module, some of the data from the **User Interface** are used to generate the theoretical S-curve cash flow profile. From the information of contract's value and duration, the cumulative S-curve value is generated. If during the construction, there are expected changes in duration or contract's value (variation orders), the model will adjust itself to the new data to produce a new S-curve.

In the 'Real-time Adjustment' module, the progressive construction data like monthly measurement and incurred costs are taken and adopted by the program to reflect the progress and trends of the project. Also, these data indirectly give information that can help in the forecasting of future cash flow. For example, with an up-to-date monthly work progress measurement data, the remaining contract value yet to be measured on the contractor's work can be found (controlled by contract and variation orders). This remaining contract value will be calculated by the 'Adjustment' module to be fed back to the 'S-curve' module for future cash flow prediction. This process ensures that the system is capable of giving predictions that changes as the construction progresses and more information is known.

The **Output** from **Program** primarily consists of monthly cash inflow and monthly cash outflow. (See Appendix 4.) For the cash inflow module, two sources of cash inflow values are taken. On the months that work has been done and work progress measurement has been made, real time data will be taken. But in future months, they will take on the forecast value from **Program**. For example, a project with an estimated duration of 12 months is presently in its fourth month of work. Monthly progress measurement values for the first 3 months are available, but the remaining 9 months will take on the values generated by S-curve. Then, using hybrid progress measurement values, other variables like retention, payment delay and defects liability period are inserted to give the final product (cash inflow).

For the cash outflow module, the output takes two sources of data, as in the case of measurement value mentioned earlier, from the monthly real time incurred costs and **Program** prediction. However, among the different cost groupings, only the materials and sub-contractors have got the payment delay variables. For other cost groupings, the problem is simplified by assuming that payment is made on the month that invoices are issued.

IRR and maximum capital requirement (C_{max}) have been used as a measurement of profitability for projects. In the **Secondary Output**, these two indicators of project's performance are calculated.

5. Testing of model's forecasting capability

Data from six building projects that were completed were used for the testing. These projects are classified into small (<\$50 million), medium (\$50 million to \$100 million) and large (>\$100 million). (See Appendix 1.)

To test the predictive ability of the model, the author simulated the actual construction progression by feeding monthly measurement and costs data into worksheet ‘input data 2’ progressively in five stages.

Information of monthly measurement and costs are fed into the model up to the pre-determined point. The start of the project, a quarter point of contract duration, a half point of contract duration, three-quarter point of contract duration and at the end of construction are the five points chosen. With this arrangement, the model accuracy in predicting the cash flow as the project progresses and more data are available can be investigated.

Table 1 shows the results in terms of IRR and variances of the forecast of IRR from the actual IRR.

The table shows that the IRR forecast by the program gives fairly good results. As the project progresses to completion, the IRR forecast becomes more accurate.

Fig. 4. consists of graphs showing the comparison of capital requirement forecast with the actual capital requirement. These graphs only show the monthly cash flow condition before client payment, thus, they do not have the saw-tooth characteristics.

The graphs show that the model can forecast fairly accurate capital requirement trends, especially for smaller size and/or shorter duration projects. As more real-time information is made available to the model, it is able to predict the general trend of future cash flow, and gives advance warning to the contractors on the likely chances of a higher or lower capital requirement in the near future. Take for example Project S1; the model foresee, when the project is into its third month (1/4 point), that there will be another surge in capital requirement about 6 months later. In Project M2, at the early stage of project (1/2 point or 18th months), the model has predicted that there will be a large surge in capital requirement to about $14 500 000 in the near future. Although the forecast at the start of project shows a rather low requirement of $9 500 000.

It is fair to conclude from the results seen from the graphs that the model gives a fairly good prediction of

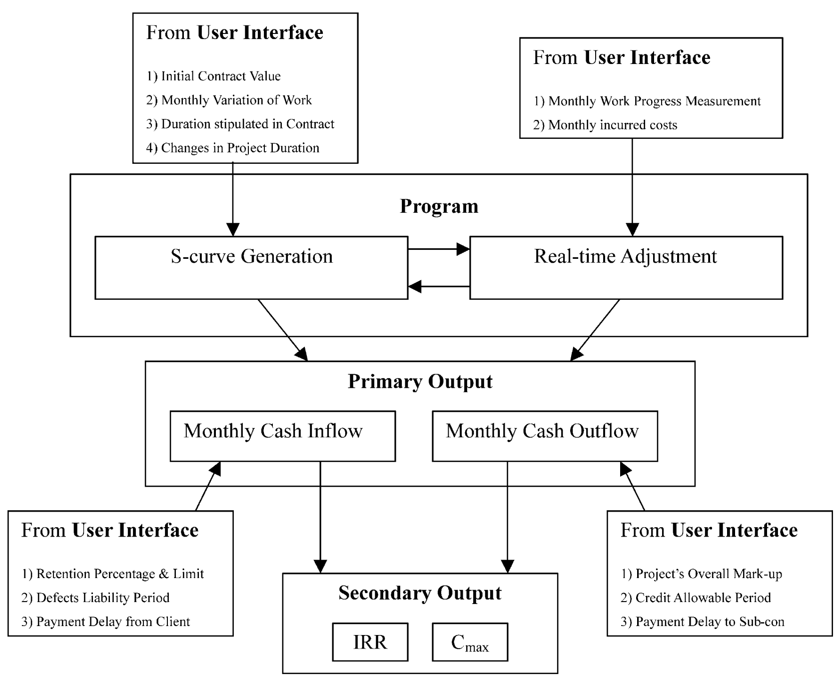


Fig. 3. Mechanism of **Program and Outputs**.

Table 1
Comparison of forecast IRR with actual IRR

Project	Start of project (%)	1/4 point of project (%)	1/2 point of project (%)	3/4 point of project (%)	Actual IRR (%)
S1	13.84	14.10	12.26	12.55	12.92
S2	13.13	12.87	12.57	12.76	12.84
M1	5.98	5.56	6.26	6.15	6.16
M2	4.62	4.47	4.68	5.82	5.35
L1	8.47	7.81	9.29	9.15	9.09
L2	11.18	11.37	11.06	11.17	11.04

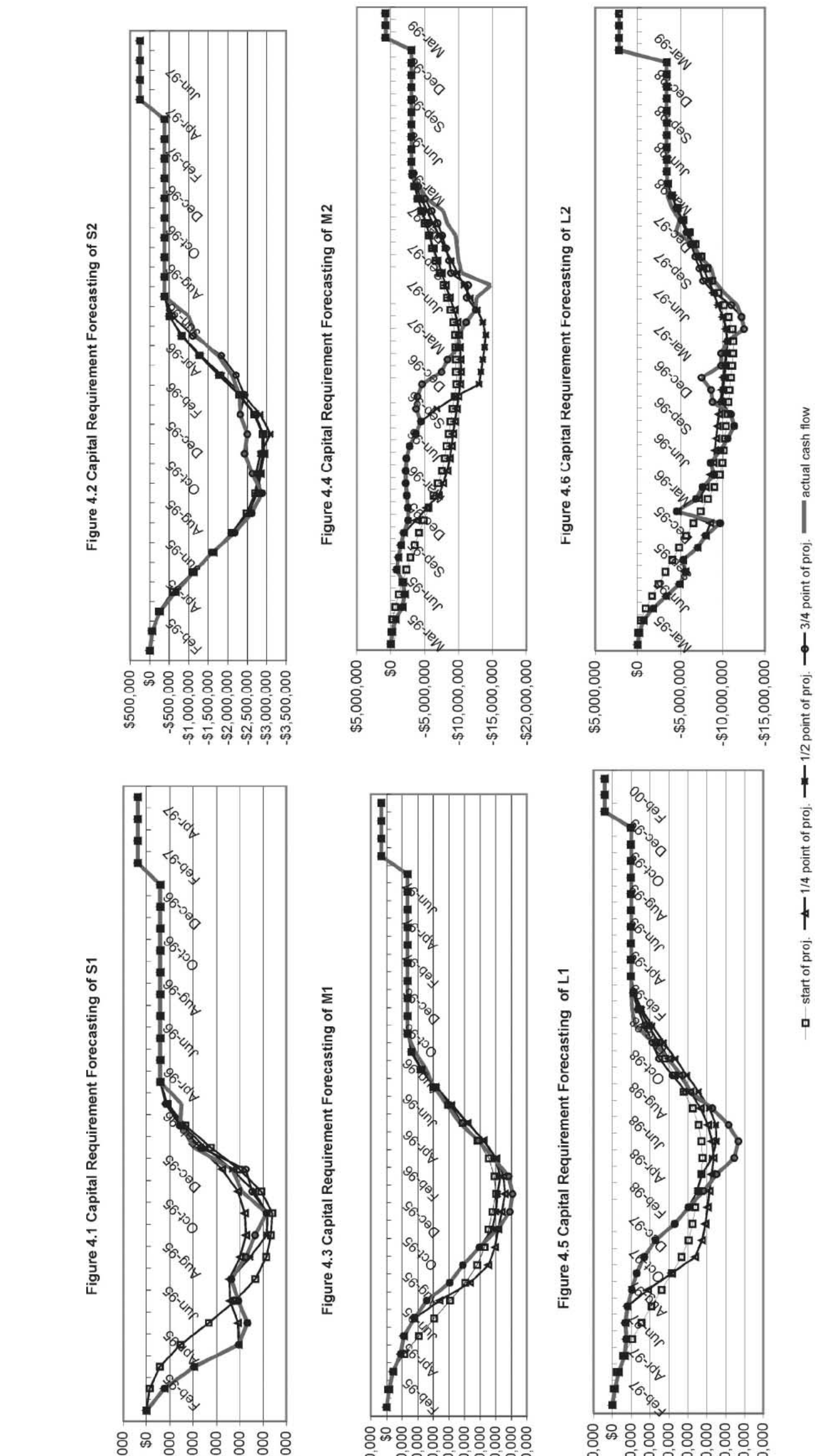


Fig. 4. Graphs of comparison of $C_{\max}$ of projects.

the general trend of capital requirement and advance advice on any sharp surge in the value.

The testing of the model's forecasting capability shows that the S-curve concept that has been used as the foundation of forecasting ability in the model does give a fairly good estimation of the cash flow. Moreover, as project progress and more information on measured work done and incurred costs are available, the model will re-adjust itself to give a better IRR and capital requirement forecast. This implies a better cash flow prediction too.

Even though previous literatures, for example, Kaka (1996) have suggested that cash-flow forecasts should be based on the construction schedule and bill of quantity, the model has shown that simplification of the problem does give a fairly good estimate as well, without the hassle of handling gigantic volume of data and complicated concepts. However, the authors do not discount the fact that having a more elaborate model can enhance the accuracy.

6. Risk analysis

With the help of the developed model, sensitivity analysis was done on the five risk factors: project duration, over/under measurement (developer), over/under measurement (sub-con), variation of work and material cost variances. These five factors were chosen for analysis because they are among the most important risk factors of a project's cash flow [3]. By making variation to the data entered into **User Interface**, conditions that simulate the risk effects can be achieved.

In sensitivity analysis, only one varying factor is changed with the others held constant. If the outcome does not change much to the variable, then that variable is said to be non-sensitive.

7. Duration changes

To simulate the changes in project duration, the data entered into worksheet 'input data 1' was varied. Usually, the duration cannot vary very much from the duration stipulated in contract. Thus the duration was varied by a range of $\pm 25\%$ of the contract duration for the simulation process.

Figs. 5 and 6 show the results of the analysis. We can see that medium and large projects are more sensitive to duration changes. This could be due to the fact that inherently, larger projects are longer in duration and have a higher average monthly cash transaction. As such, when a large project and small project duration is increased or decreased proportionally, the impact on IRR is amplified in the large project cash flow. Take for example, Projects S1 and M2 both have their duration reduced by 25% (3 months for S1 and 9 months for M2). M2 with a higher average monthly cash transaction and more reduction in months will be affected more than S1.

Fig. 6 shows that C_{max} increases substantially and this large surge in money requirement could offset the advantage of a slightly higher IRR brought about by a shorter project duration.

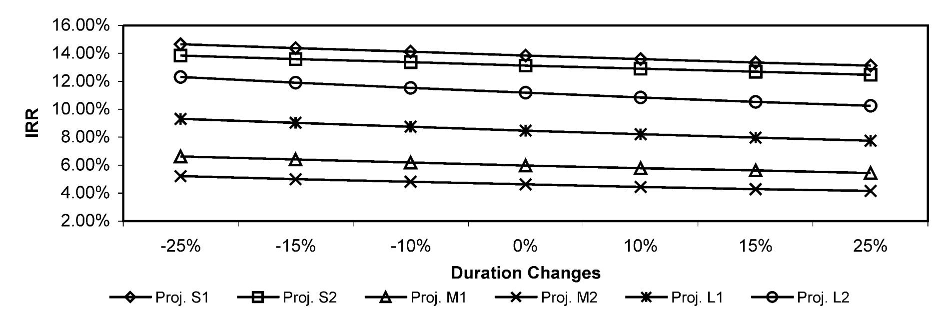


Fig. 5. IRR over duration changes.

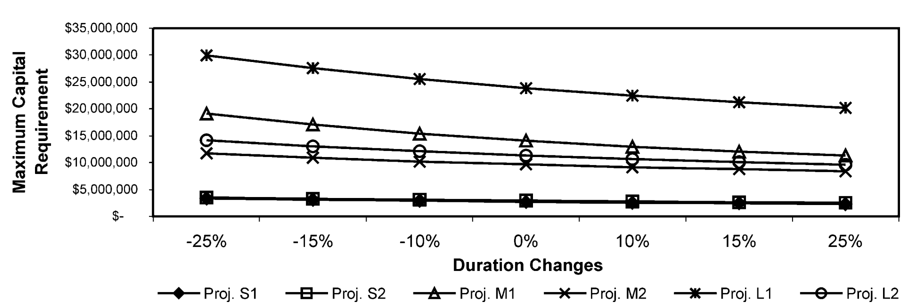


Fig. 6. Maximum capital requirement over duration changes.

8. Over/under work progress measurement between developer and main contractor

Even though over/under measurement can occur during the course of project construction, the total contract value never changes. Ultimately, the full sum of payment will be received, but it does change the cash flow of the project. If more payment is received earlier, it will be favourable for the main-contractor.

To simulate this process, the authors have simplified the test by assuming that for the first half of the project duration; the measurement data are increased/decreased by a certain percentage. Then in order to balanced up the total contract value, the second half is decreased/increased proportionally, to make up the difference.

Figs. 7 and 8. show the results of the analysis.

Fig. 7 shows that IRR is indeed very sensitive to over/under measurement risks. Good results can be achieved from the over measurement but under measurement can have a significant downside for contractor's cash flow too. Fig. 8 shows that C_{max} is very sensitive to over and under measurement. If severe under measurement occur, C_{max} can be expected to increase by a lot. This is because as more payment from the developer are being delayed through under measurement in the earlier part of project, the contractor will have to find other means of funds to bridge the widening difference between incurred costs and payment received. Over measurement on the other hand, can decrease C_{max}, but the effect is not as great.

9. Over/under work progress measurement between main contractor and sub-contractors

For the measurement with sub-contractors, the same concept applied earlier was used. However, this time, the adjustments were made on monthly sub-contractors costs. The sub-contractors costs were varied over a range of ±20% for the first half of the project, and the later half were adjusted to keep the total sub-contractors costs the same.

It is observed that the projects are quite insensitive to the measurement (sub-contractors). This is not surprising as sub-contracting costs only account for about 10% of the total costs in these six projects. However, if the proportion of sub-contracting costs increase, then the impact should be more significant.

10. Variation of work

During the construction phase, variation orders can reach the main-con at any month, but in this paper, the variation is assumed to be in the first month. The variation value was varied over a range of ±20% of the contract sum.

To balance up with the variation, total measurement must also increase as much as the variation; the monthly measurement was increased by the same percentage. In this paper, the authors also assume that the costs increase proportionally with variation as more work is done.

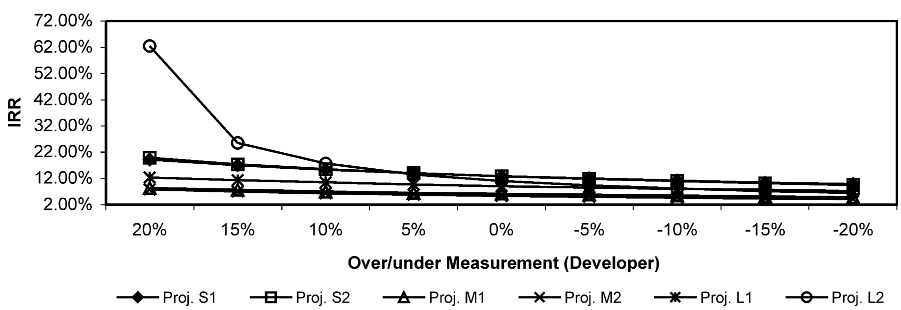


Fig. 7. IRR over/under measurement (Developer).

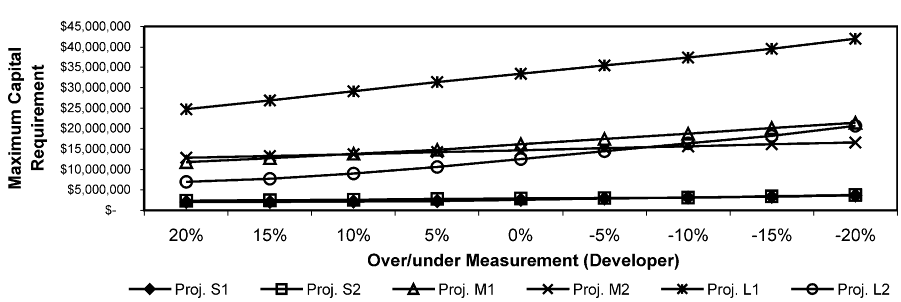


Fig. 8. Maximum capital requirement over over/under measurement (Developer).

Figs. 9 and 10. show the results of the analysis.

Fig. 9 shows that when there is increment, IRR increases and vice versa. However, only when the variation is large, then its impact on IRR will be significant. This is because when variation orders increase, both contract value as well as incurred costs will increase proportionally. This leaves very little net increment in cash flow especially when the variation order is small.

From Fig. 10, it can be seen that variation affects $C_{\max}$ significantly. Thus, when the variation value is large, the contractor must prepare itself to absorb the temporal deficit that will increase as well. This high surge in $C_{\max}$ is due to the increase in incurred costs which comes together with the variation increment.

In summary, if variation is high, one can expect IRR to be slightly higher. However, the sharp increase in capital requirement may serve as a warning to contractors that finances must be prepared to meet this demand. If a project with many expected changes is taken up, contractors should be aware of how $C_{\max}$ can fluctuate and be prepared for a much higher capital investment if variation orders become high in the latter part of the project.

11. Material cost variance

Among all the different costs in a construction project, material cost usually accounts for the majority of the costs. For building, about half of the money is spent on materials. With such a high proportion, it makes project cash flow very sensitive to material cost fluctuation. Thus, the authors have chosen material for the research. Material costs were varied over a range of ±20% of the original costs.

Figs. 11 and 12 show the results of the analysis.

Fig. 11 shows that IRR is very sensitive to material cost fluctuation. This is not alarming as material cost

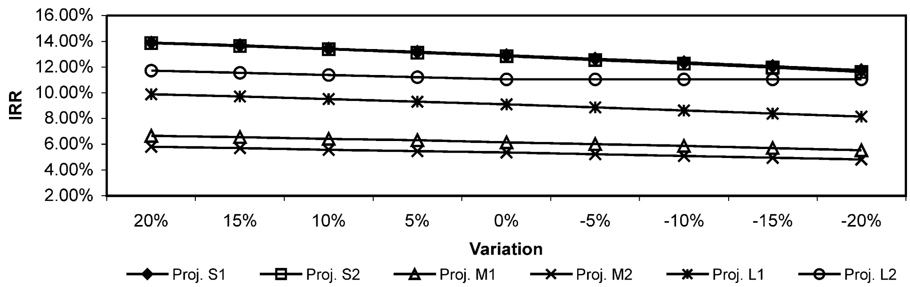


Fig. 9. IRR over variation.

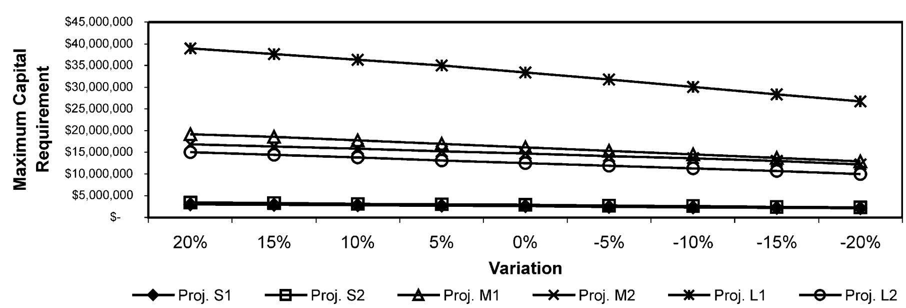


Fig. 10. Maximum capital requirement over variation.

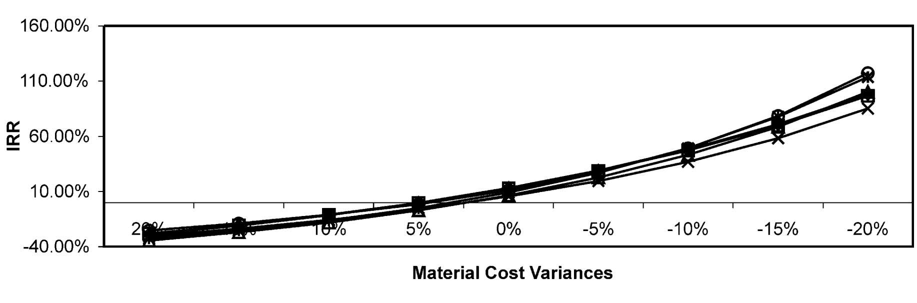


Fig. 11. IRR over material cost variances.

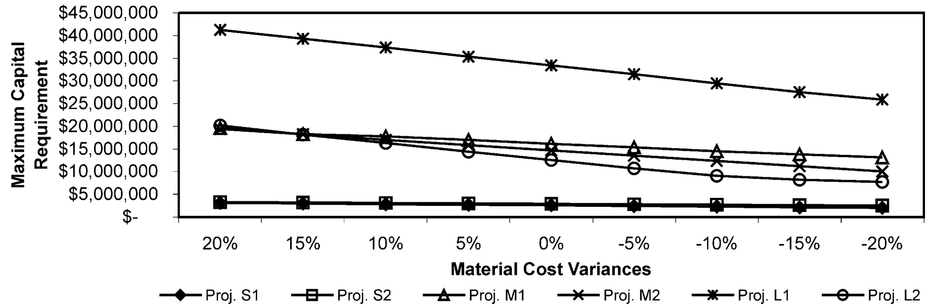


Fig. 12. Maximum capital requirement over material cost variance.

Table 2
Summary of sensitivity analysis

Factors	Sensitivity of i	Sensitivity of C_{max}	Remarks
Project duration	Low	High	More sensitive for larger projects especially the C_{max}
Measurement (developer)	High	High	i Sensitive to over measurement, C_{max} sensitive to under measurement
Measurement (sub-contractors)	Very low	Very low	Could increase with higher sub-contracting rate
Variation of work	Low	High	Could be more sensitive if front loading or claim loading is applied
Material cost variance	Very high	High	Dependent on the proportion of material cost to total cost

constitutes about half of the total cost in these six projects. In construction projects, materials are always responsible for a large proportion of the cost. It is observed that even with a small increment of 5%, IRR becomes negative (project running at a loss). This shows how sensitive IRR can be to material price changes, especially in projects that have a very tight mark up. However, on the upside, if material cost can be well controlled, then the benefits will be great. Results from Fig. 12 further reinforce the findings that project's cash flows are very sensitive to material cost.

From the analysis, it can be shown that projects are highly sensitive to material cost variance. The major reason for this is because material accounts for almost half of the costs in building projects. Table 2 gives a summary of the sensitivity analysis of the five factors.

12. Conclusion

In this paper, the authors have highlighted the importance of having prior knowledge of cash flows and understanding the impacts of risk factors. A computer model was developed to help forecast cash flows and analyzed the risk factors. Five risk factors that will continuously affect the project's outcome during the construction phase were chosen in this paper. The IRR and capital requirement were used to compare the performance of the project's cash flows.

Testing done on the forecasting capability of the program shows that good results can be achieved. Even though the data input required in this model was relatively simple and few, it gave a fairly accurate prediction on IRR and capital requirement trends of projects. From the sensitivity analysis done to test the risk factors, the authors were able to observe some trends and changes in outcome of cash flows.

When project duration was varied, it was observed that IRR was slightly improved with shorter time. However at the same time, C_{max} increased significantly, especially in large projects. Contractors with tight financial resources may like to take note of this during their decision making process. On the other hand, with a longer duration, C_{max} can be decreased at the expense of IRR. But with possible liquidity damages payable, it would not be wise for contractors to prolong construction.

From the analysis of measurement risk with developer, it was found that both IRR and C_{max} were very sensitive. With substantial over measurement, IRR was greatly improved and C_{max} decreased. However, findings also show that severe under measurement caused C_{max} to increase significantly.

As for the measurement risk with sub-contractors, both IRR and C_{max} were non-sensitive to the test. However, for projects or companies that prefer to have more sub-con involvement, it can have significant impact on cash flows.

Analyss on variation orders shows that both IRR and C_{max} increased with variation increment. However, the increase in IRR was very small and overwhelmed by the large increase on C_{max}. This result suggests that a project with a lot of uncertainty in design, details or value, must have its C_{max} monitored. The contractor must be able to find provisions to meet the higher C_{max} when the need arises.

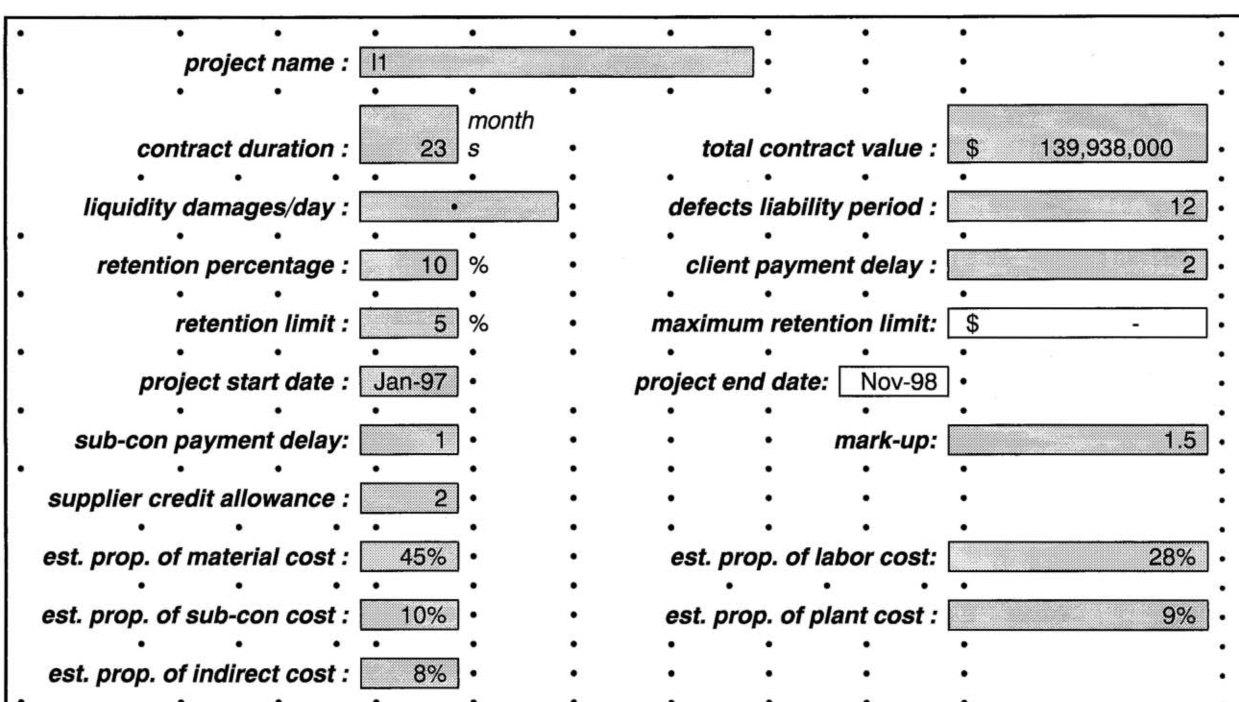
In the final test, material cost variance was analyzed. With material being a main component in the project's cost, it was found that the impact on cash flows was great. The analysis shows that if cost variance increases too steeply, profitability will be threatened. On the other hand, if savings can be derived from material cost, great benefits can be passed on to increase IRR and decrease C_{max}.

In conclusion, the developed cash flow program could be helpful in predicting the cash flow as the project progresses. Also, an understanding on the impact of the risk factors on the performance of a project's cash flows was established.

Appendix 1. Project Information

Project	S1	S2	M1	M2	L1	L2
Contract Value	$ 9,687,000	$ 12,494,000	$ 66,950,000	$ 75,660,000	$139,940,000	$111,777,000
Project Duration	12 months	15 months	18 months	36 months	23 months	36 months
Measurement & Certification Interval	1 month	1 month	1 month	1 month	1 month	1 month
Payment Delay Period	1 month	1 month	1 month	1 month	1 month	1 month
Credit Allowable Period	2 months	2 months	2 months	2 months	2 months	2 months
Sub-con Payment Delay	1 month	1 month	1 month	1 month	1 month	1 month
Retention Percentage	10%	10%	10%	10%	10%	5%
Retention Limit	5%	5%	5%	5%	5%	5%
Defects Liability Period	12 months	12 months	12 months	12 months	12 months	12 months
Mark-up Percentage	2.0%	2.0%	1.0%	1.0%	1.5%	2.0%

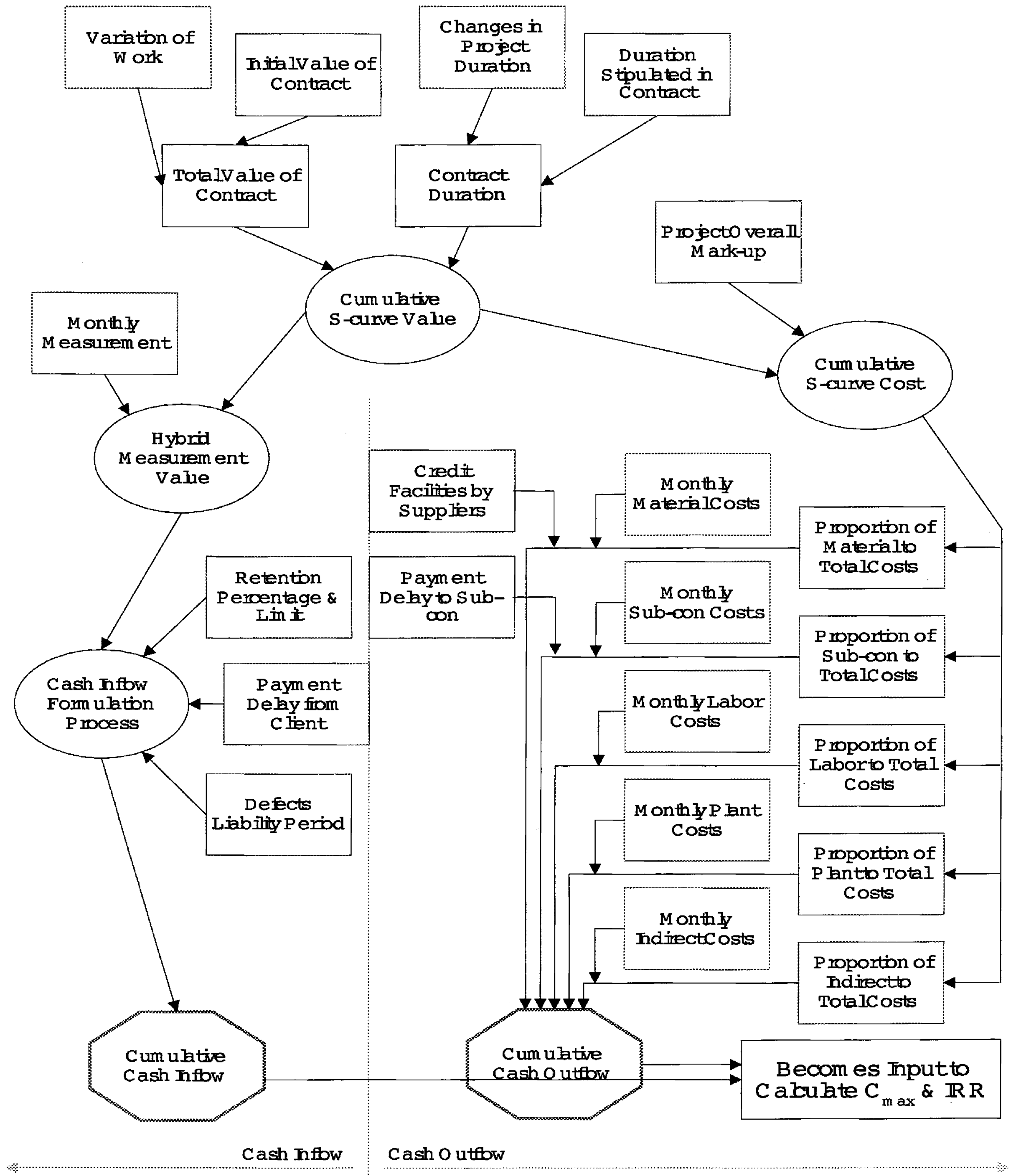
Appendix 2. Sample Input Data 1



Appendix 3. Sample Input Data 2 (measurement & variation)

planning		•	•
no of month	23	con.value	$139,938,000
start date	Jan-97		•
end date	Nov-98	•	•
real time		•	•
no of month	23	con.value	$139,938,000
start date	Jan-97	variation	$ -
end date	Nov-98	total value	$139,938,000
•	•	•	•
date	variation	measurement	value left
Jan-97	$ -	$ 1,451,000	$138,487,000
Feb-97	$ -	$ 2,182,000	$136,305,000
Mar-97	$ -	$ 1,624,000	$134,681,000
Apr-97	$ -	$ 1,421,000	$133,260,000
May-97	$ -	$ 1,878,000	$131,382,000
Jun-97	$ -	$ 2,761,000	$128,621,000
Jul-97	$ -	$ 3,187,000	$125,434,000
Aug-97	$ -	$ 3,218,000	$122,216,000
Sep-97	$ -	$ 6,384,000	$115,832,000
Oct-97	$ -	$ 8,668,000	$107,164,000
Nov-97	$ -	$ 10,008,000	$ 97,156,000
Dec-97	$ -	$ 10,668,000	$ 86,488,000
Jan-98	$ -	$ 14,251,000	$ 72,237,000
Feb-98	$ -	$ 14,636,000	$ 57,601,000
Mar-98	$ -	$ 14,728,000	$ 42,873,000
Apr-98	$ -	$ 13,388,000	$ 29,485,000
May-98	$ -	$ 8,719,000	$ 20,766,000
Jun-98	$ -	$ 7,633,000	$ 13,133,000
Jul-98	$ -	$ 6,638,000	$ 6,495,000
Aug-98	$ -	$ 5,187,000	$ 1,308,000
Sep-98	$ -	$ 1,066,000	$ 242,000
Oct-98	$ -	$ 223,000	$ 19,000
Nov-98	$ -	$ 20,000	$ (1,000)
Dec-98	$ -	$ -	$ (1,000)
Jan-99	$ -	$ -	$ (1,000)

Appendix 4. Generation of cumulative monthly cash in and cash out



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