A PROPOSED MODEL FOR PREDICTION OF CONTRACT CASH FLOW

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ABSTRACT

Cash flow planning and control is an important tool for proper management in the construction industry. A contractor has to produce accurate curves of income and expenditure of each contract. A number of models has been developed for forecasting construction contract cash flow, almost all of them give approximate results or do not fit various types of contract. The objective of this paper is to develop a model to establish an accurate forecast of both contract expense and income. Different types of cost entry are used in order to model the way in which costs are likely to be incurred. The concept of controlling activities is introduced in order to model the way in which revenues are likely to be paid in different types of contract. In addition, the model allows specified cost entries to be escalated according to a chosen set of inflation rates. Three economic indicators are calculated to be used to check feasibility of the contract. A computer program is developed in FORTRAN to implement the proposed model. Application to a real-life project is reported. The results are compared with those which can be obtained from the widely-used Primavera software where considerable differences are recorded.

Keywords: Construction management, Cash flow, Realistic modelling, Economic analysis, Construction Contracts.

1. INTRODUCTION

Cash flow planning and control is an important tool for proper management in the construction industry. Forecasting cash flow for a construction company, over a period of time, is simply the summation of individual contracts cash flow over that period. A contractor has then to produce accurate curves of contract cash flows. A number of models were developed [1,2] for forecasting contract cash flow. However, the most important software models are reviewed next.

Toma [3] demonstrated how to produce cash outflow using Primavera software. The total cost of a resource used by an activity is uniformly distributed along the activity duration. However, the user is allowed to specify two other resource usages; e.g., a 100% resource usage at activity start or finish time to satisfy start or finish costs respectively. Expenses can be obtained assuming a suitable delay for each resource usage. However, the program do not allow contract duration to be extended. The income curve can be extracted using Microsoft Excel where expense values are manipulated to satisfy contract markup, advance payment, repayment and retention. These procedures yield approximate results as will be seen later in this paper.

The Project Cost Model (PCM) software [4] allows the user to build up contract cost based on the operational estimating method. This requires that a complete activity and resource schedules to be provided. Cost elements are supplied related to activities and resources. A range of cost types is introduced to take account of the inter-relationships between cost and time. An established forecast of contract cost and expense can then be produced.

The model allows the user to supply revenue values assigned to activities and resources in a way similar to that used for the cost values. This is a time consuming task and yields approximate pattern of cash inflow.

On the other hand, Au and Hendrickson [5] reported that the effect of inflation on the gross profit of a fixed price contract (where the contractor bears all inflation risk) is often omitted. In the present economic climate, such omission may produce misleading results, particularly for large-scale construction projects extending over a number of years. As most Egyptian construction projects are let on a fixed price basis, it is very useful for the contractor to be able to predict escalated cash flows and to include in his tender price a contingency for cost inflation.

A contractor should check feasibility of a contract before submitting a tender. Two indicators are essential for him. The real value of his profit can be obtained by calculating the net present value (NPV) of the contract net cash flows using his minimum attractive rate of return (MARR). The second indicator is the maximum negative cash flow which should lie within a prescribed range. On the other hand, Hardy et al [6] advocated that the best way for the owner to select a contractor to execute a contract is by calculating present value of the payment program required by each contractor and selecting the contractor of the minimum present value. For the above reasons, it is necessary to provide a cash flow model with the ability to calculate the above economic indicators.

It is obvious from the above review that contractors are in need for a further established model to forecast contract cash flow. The required model should satisfy various types of cost and various types of contract, should have the facility for escalating cash outflow and should have the ability to carry out economic analysis of the contract cash flow. This paper will propose a model to achieve all the above requirements and this will be discussed in the following sections.

2. MODELLING CONTRACT CASH OUTFLOW

The cash outflow of a contract results from its direct and indirect costs. Direct costs; DC, are related to the contract activities and both key and secondary resources. Indirect costs are related to the whole contract and they are treated as general resources. The following preparations are taken into consideration to allow the model to produce an accurate cash outflow.

2.1 *Cost Headings*

A number of cost headings is specified in order that the contract cost entries will be effectively distributed under these headings. Typical examples of cost headings are: temporary labour, permanent labour (staff), hired plant, depreciated plant, imported plant, compensated materials, non-compensated materials, free-market materials, owner-supplied materials, subcontractors, nominated subcontractors, indirect costs, and so on. Cost entries are grouped under the same cost heading to satisfy one of the following conditions:

- Cost entries are incurred on the same timing; for example, staff paid at end of every month.
- Cost entries have the same payment delay; for example, material costs paid to the suppliers four weeks after delivery.
- Cost entries have the same escalation percentage at the same time.
- The desire to know total cost of a specified group of entries.

2.2 *Cost Types*

A number of cost types is specified in order that the model can take full account of the inter-relationships between cost and time to allow a realistic forecast of contract cost to be produced. The unit of time is assumed to be the week. The chosen range of cost types contains the following:

- Start cost "Sn" : incurred n weeks before start of activity or resource. If n is equal to zero, this means that the cost will be incurred at start of the activity or resource. Examples include cost of materials delivered by the start of an activity.
- Finish cost "F" : incurred at finish of activity or resource. An example is transportation cost of an item of plant upon leaving site of the works.
- Time-related cost "T" : cost per week applied uniformly over the duration of an activity or

resource. If this cost is related to a calendar date cost heading, it will be accumulated to be incurred at the specified date.

- Periodical cost "Pm" : incurred every m weeks over an activity or resource duration. If the last interval of the duration is less than m, a value will be incurred at finish time of the activity or resource. If m is equal to one, then Pm is an equalizer to T. An example for this cost type is head office charges to a contract.
- Usage-related cost "U" : cost per unit of resource used.
- Capacity-related cost "C" : cost per unit of resource provided.

The differences between the proposed cost types and those adopted by PCM software can be summarized as follows:

- Start cost can now accept cost entries incurred before start of activity or resource.
- Time-related cost can now be linked to a calendar date.
- The new periodical cost type is introduced.

2.3 *Cost and Expense Curves*

The user can use the proposed cost types to model direct and indirect cost elements of the contract. A complete activity and resource schedules should be provided in order to determine timings at which costs will be allocated. In this way the cost curve of the contract can be derived, and the value of the contract total cost; TC, is determined.

The timing of actual payment of the cost elements is represented by a delay specified to each cost heading. By taking these delays into consideration, the contract expense curve can then be derived.

2.4 *Escalated Cash Outflow*

To include effect of cost inflation on a contract cash outflow, the model should be supplied, for each cost heading, with the escalation rates(s) and the corresponding time(s) at which it(they) will start to effect. The percentage rates should be related to the basic cost values given at start of the contract. The working span of each rate ranges from its start date to the start date of the next rate.

During the process of allocation of a cost element to the appropriate timing in order to determine the expense curve of the contract, the model will determine the escalation rate which has a working span that covers the date of allocation. The cost element is then escalated by this rate.

3. MODELLING CONTRACT CASH INFLOW

The contract cash inflow is usually linked to a group of work items, which when executed the contractor will receive the corresponding prices. On the other hand, a work item may be broken down to several activities in the plan of the project. This situation suggests the introduction of the concept of controlling activities.

3.1 *Controlling Activities*

A controlling activity is the activity which when executed, the contractor will gain the price of the contained work. It may be necessary for the contractor, to gain the price, to execute a set of activities before or in the same time of execution of the controlling activity. This set of activities will be called caught activities. A set of caught activities may be empty (when a controlling activity represents a work item wholly) or may contain one or more activities.

As revenues will be obtained via execution of the controlling activities only, the cost of each resource should be distributed over the activities that share the use of the resource. The distribution factor is equal to the ratio of an activity resource usage to total resource usage.

Revenue is assumed to be uniformly distributed over the duration of a controlling activity. Therefore, for each controlling activity, the model will sum up the direct cost of all the caught activities (irrespective of type of the corresponding cost entries) and then distribute it uniformly over the duration of the controlling activity. Type of contract should be considered in order to calculate the contract revenue. This will be discussed next.

3.2 *Case of Admeasurement Contract*

In this case, the controlling activities represent the bid items. The model should be supplied with the following information : 1) period of payment request which is usually equal to four weeks, 2) the markup; M, given as percentage of contract TC and 3) whether the bid is balanced or unbalanced. For a balanced bid, the direct cost assigned to a controlling activity is multiplied by the factor R given by equation (1) to get the relevant revenue.

$$R = TC\,(1 + M) / DC \qquad (1)$$

For unbalanced bid, some controlling activities will be loaded by a higher percentage of markup and indirect cost. To keep the bid price unchanged, the rest of controlling activities must be multiplied by a lower percentage. The user should specify the loaded activities and the corresponding percentage increase in their price; L. The direct cost of each loaded activity is then multiplied by R (1 + L). This will give an increase in total tender sum equals V. If the tender sum of non-loaded activities (calculated using R values) is W, then the multiplier for direct cost of each non-loaded activity will be R (1 - V / W). Having determined the revenue associated with each controlling activity, the model will calculate revenues for each period of payment request. It will sum up, for each consecutive period of payment, the revenue of the part of each controlling activity that will be executed during the period.

3.3 *Case of Lump Sum Contract*

Payment to the contractor in this type of contract may be staged at intervals of time on the completion of milestones. Therefore, the model should be supplied by the following information : 1) dates of payment request (which are compatible with finish dates of milestone activities) and 2) the contract markup percentage.

The revenue associated with each controlling (milestone) activity will be calculated as in the case of balanced bid. The model will then sum up revenues for each period laying between two consecutive dates of payment.

3.4 *Case of Cost-Plus Contract*

In a cost-plus contract, the contractor is reimbursed for actual costs plus a specified fee for head office overheads and profit. He may prepare estimate of expenses for the coming month and receive the money in advance. Therefore, the contract cash flow will be in favour of the contractor.

To satisfy the above situation, the model will consider every construction activity as a controlling activity with an empty set of caught activities. Site mobilization costs should be assigned to an activity at the beginning of the contract. The contract indirect cost contains site monthly expenditures only. The model should be supplied with the fee; f, given as percentage of actual costs. Then, the fee replaces markup in equation (1), and R' becomes:

$$R' = TC\,(1 + f) / DC \qquad (2)$$

The direct cost assigned to a controlling activity is multiplied by the factor R' to get the corresponding revenue. Monthly revenue is then summed up.

3.5 *Revenue and Income Curves*

The model should be supplied by the relevant conditions of contract that are necessary for cash inflow calculations. These are : 1) advance payment percentage, 2) repayment percentage, 3) retention percentage and 4) delay in receiving revenues (for a cost-plus contract, a four-week lead time is alternatively assumed). The value of advance payment will be allocated as revenue at start of the contract. Each subsequent revenue will be reduced by:

- The repayment percentage until the advance payment is covered, and
- The retention percentage until the end of the contract.

The retained money will be paid at end of the contract. Income values can be obtained by adding the delay in receiving revenue (for relevant contracts) to the timing of each revenue. Obviously, the advance payment is not subjected to this delay.

4. ECONOMIC ANALYSIS OF CONTRACT CASH FLOW

The contract income and expense curves can be combined into one graph to represent the contract cash flow curves. The difference between these two curves can be drawn to represent the contract net cash flow. Three economic indicators are then calculated to check feasibility of the contract. These are : 1) maximum negative cash flow, 2) NPV of net cash flow and 3) cost of the contract to the owner.

For calculation of NPV, the model should be supplied with the chosen MARR (which should be compatible with the unit of time of the contract). The cost of the contract to the owner is the present value of the contract income and is calculated using a supplied discount rate.

5. IMPLEMENTATION ASPECTS

A computer program; named P4, is written in FORTRAN to transfer the proposed model into effect. The program should be provided by the necessary data. This section contains description of the data required and program output. Complete description of program P4 is given by Toma [3].

5.1 *Contract Time and Cost Data*

Program P4 depends on three FORTRAN programs developed previously by Eldosouky [7,8]. A complete activity schedule (linked to calendar dates) can be imported from the construction network analysis program; P1.

Program P2 can provide a complete resource schedule. It deals with three categories of resources : key resources which should be considered in the resource scheduling or resource smoothing process; secondary resources which have no constraints on their availability and general resources which are contract oriented rather than activity oriented resources.

The third program; named P3, can feed program P4 with required contract cost data. It can also provide contract DC and TC. This program is now modified to accept the range of cost types discussed earlier.

5.2 *Cash Flow Data*

Program P4 should read in the following data :

- An index representing timings of cash flow analysis; early, late or schedule start.
- An index representing whether cash outflow values will be escalated or no.
- An index representing type of contract : balanced or unbalanced measurement, lump sum or cost-plus contract.
- Calendar date cost heading numbers.
- Delay in receiving revenue (billing period)
- Period or dates for payment request.
- Controlling activities numbers and the corresponding caught activities numbers (no need for this data in case of a cost-plus contract).
- Loaded activities numbers and the associated percentage increase in their prices (in case of unbalanced bids only).
- Percentages of : advance payment, repayment, retention, markup or fee and discounting.
- For each cost heading; delay in payment and up to six escalation rates and the corresponding timings of start of effect.

5.3 *Output of the Program*

The following results can be obtained from program P4 :

- Weekly values of contract cost, expense, revenue, income and net cash flow. These values are given in tabular form. Any computer software for drawing graphs can then be used to draw the corresponding curves.
- Contract escalated expenses.
- Contract NPV and maximum negative cash flow.
- Cost of the contract to the owner.

6. APPLICATION

The proposed model is applied now to a real-life project. Project plan was given by Thompson [9]. The corresponding activity schedule obtained using program P1 is shown in Table (1). Contract duration is 98 weeks. Information about project resources is given in Table (2). Timings of these resources (which are compatible with resource usage defined by Thompson) are obtained using program P2. Note that total quantity of concrete used is 18671 m3.

Costs of both activities and resources are allocated to ten cost headings. These are defined in Table (3). Given also in this table are the payment delay and escalation data associated with each cost heading.

Table 1 Activity Schedule of the Studied Project

Activity No.	Duration (weeks)	Schedule Start	Schedule Finish	Activity No.	Duration (weeks)	Schedule Start	Schedule Finish
1	4	1	4	18	2	5	6
2	3	13	15	19	15	26	40
3	7	56	62	20	4	26	29
4	11	26	36	21	6	37	42
5	19	37	55	22	1	41	41
6	1	9	9	23	38	49	86
7	4	56	59	25	6	87	92
8	4	9	12	26	6	89	94
9	5	13	17	27	5	87	91
10	2	26	27	28	5	92	96
11	23	26	48	29	8	41	48
12	21	5	25	30	2	87	88
13	21	16	36	31	10	87	96
14	22	18	39	32	13	43	55
15	20	26	45	33	2	87	88
16	2	7	8	34	2	89	90
17	7	30	36	35	6	93	98

Table 2 Information about Project Resources

Code	Resources	Type	Duration (weeks)	Level provided
Air	Compressed air	Key	49	
Car	Carpentry	Key	89	480 m2/wk
Con	Concrete plant	Key	89	
Lab	Labour	Key	97	50 No.
Scr	Scrapers	Key	81	
Rod	Maintenance of haul roads	Secondary	81	
Ovr	Overheads	General	98	

Table 3 Information about Cost Headings for the Studied Project

Cost Heading Number	Description	Payment Delay (weeks)	Escalation data							
			%*	start week	%*	start week	%*	start week	%*	start week
1	Formwork	4	5	26	7	70	10	90		
2	Steel	4	5	26	8	50	10	80	15	90
3	Concrete	4	2	26	3	50	8	80	10	90
4	Other materials	2	5	26	10	50	15	70		
5[a]	Permanent labour	0	10	26	20	78				
6[b]	Temporary labour	0	10	26	20	78				
7	Subcontractors	4								
8	Overheads	0								
9	Owned plant	0								
10	Hired plant	1	5	26	9	60	15	80		

* Percentage increase in original cost value
a Costs are incurred at end of month
b Costs are incurred at mid and end of month

Table (4) contains different cost entries supplied to the program under the different cost headings and using the previously defined range of cost types. Total project cost obtained using program P3 is LE 51 809 187. The contract of the work was let on an admeasurement basis as reported by Thompson. It is assumed that markup is 5% of contract total cost and is uniformly distributed over bid items. Advance payment is 5% of tender price. Both repayment and retention are 5% each of monthly payment. Period for payment request and delay in receiving revenue are 4 weeks each. Contractor's MARR is 12% per annum while discount rate for calculating cost of the contract to the owner is 10% per year.

Costs of the first activity will be distributed over the contract duration because it does not represent a bid item as declared by Thompson [9]. Each of the remaining activities represent a bid item and will be considered as a controlling activity.

Cash flow curves are shown in Fig. 1.a and the corresponding net cash flows are shown in Fig. 1.b. From these figures, it can be seen that escalated cash outflow will reduce final contract profit by about 94%. The corresponding NPV of net cash flows will be reduced by about 101%. However, cost of the contract to the owner is LE 49.9 m.

6.1 *Other Types of Contract*

For the purpose of illustrating the capabilities of the proposed model, the contract of the works is assumed to have different types; i.e., unbalanced admeasurement, lump sum or cost-plus. Results of these cases are given next.

In case of unbalanced bid, assume that the contractor will load prices of the following activities: 2, 8, 12, 18 and 19. The corresponding percentages increase are 5%, 10%, 15%, 20% and 20% respectively. All other data are the same as given before. Figure 2 shows a comparison of net cash flow for the two cases of balanced and unbalanced bids. Obviously, net cash flows in case of unbalanced bid have less negative values than those of the balanced one.

In case of lump sum contract, it is assumed that payment to the contractor will be at the following weeks: 12, 24, 36, 48, 60, 72 84 and 98 with no payment delay. All other data are the same as given before. Figure 3 shows net cash flow for this case. As it is expected, the contractor will have to provide more cash to deal with this type of contract. Maximum cash lockup is LE 6.59 m.

In case of cost-plus contract, the user has to delete one of the cost entries; that is of head office charges. Assume that the fee percentage is 8%. There is no advance payment. All other data are the same as given before. Figure 4 shows net cash flow for this case. As it is expected, the contractor has nearly not to provide cash to deal with type of contract.

6.2 *Comparison with Primavera Results*

Information about project activities and resources are identically supplied to Primavera. However, cost entries are different. Three cost types are allowed within Primavera. These are start, finish and time-related costs. Cost entries supplied to Primavera are given in Table 4 in a form that is equivalent to that used by program P4.

The procedures outlined in this paper concerning development of contract cash flows using Primavera are then applied. Figures 5a and 5b show a comparison of cash outflow and cash inflow curves obtained from the proposed model and Primavera. The corresponding net cash flows are given in Fig. 5c. Maximum cash lock up obtained from Primavera is 1.79 times that obtained from the proposed model. The corresponding NPV of net cash flows is 80%.

The above differences are due to the following reasons:

- Within Primavera, lead times are not allowed for start cost type. Neither are Pm and C cost types allowed.
- Time-related costs within Primavera are not linked to calendar dates.
- Consequent approximation in developing contract cash inflow.

7. CONCLUSIONS

In this paper, a model for prediction of contract cash flow has been established. A computer program was developed to carry the proposed model into effect. Application to a real-life project was carried out. The proposed model has the following advantages: 1) it accommodates a wide range of cost types, 2) it satisfies various types of construction contract and 3) it has the facility to derive escalated cash flows and to carry out economical analysis of contract cash flows.

Table 4 Cost Entries Supplied to the Proposed Model and to Primavera Software

Act or Res	Cost Heading Number	Proposed Model		Primavera Software		Act or Res	Cost Heading Number	Proposed Model		Primavera Software	
		Cost type	Value (LE)	Cost type	Value (LE)			Cost type	Value (LE)	Cost type	Value (LE)
1	9	F	33600	F	33600	19	6	S0	20000	S0	20000
1	6	T	6000	T	6000	19	6	T	18000	T	18000
1	4	T	100000	T	100000	20	4	S0	100000	S0	100000
2	7	F	99600	F	99600	20	10	F	40000	F	40000
3	1	S2	40000	S0	40000	20	6	T	18000	T	18000
3	2	S3	180000	S0	180000	21	10	P4	14400	T	4800
3	4	T	1429	T	1429	21	6	T	3000	T	3000
3	6	S0	15000	S0	15000	21	6	S0	9000	S0	9000
3	6	T	6000	T	6000	21	1	S2	24200	S0	24200
4	7	P4	121733	T	33200	21	2	S3	36000	S0	36000
5	1	S2	220000	S0	220000	22	7	F	9600	F	9600
5	2	S3	720000	S0	720000	23	10	S0	30000	S0	30000
5	4	T	1579	T	1579	23	10	P4	95760	T	25200
5	6	T	6000	T	6000	23	10	F	20000	F	20000
5	6	S0	84000	S0	84000	23	6	T	21000	T	21000
6	7	F	33200	F	33200	25	4	T	33333	T	33333
7	1	S2	33000	S0	33000	25	10	P4	30000	T	10000
7	2	S3	151200	S0	151200	25	6	T	6000	T	6000
7	4	T	1500	T	1500	26	4	T	1666	T	1666
7	6	S0	12000	S0	12000	26	6	T	6000	T	6000
7	6	T	6000	T	6000	27	1	S2	3000	S0	3000
8	9	F	21600	F	21600	27	6	S0	3000	S0	3000
8	10	F	74400	F	74400	28	9	F	15000	F	15000
8	6	T	15000	T	15000	28	6	T	18000	T	18000
8	4	S4	240000	S0	240000	29	7	F	104000	F	104000
9	10	S0	30000	S0	30000	30	7	F	66000	F	66000
9	10	P4	26000	F	52000	31	4	T	8000	T	8000
9	6	T	6000	T	6000	31	9	P4	10000	T	3000
10	10	F	20800	F	20800	31	6	T	3000	T	3000
10	6	T	6000	T	6000	32	1	S2	110000	S0	110000
11	10	P4	39866	F	239196	32	2	S3	342000	S0	342000
11	6	T	6000	T	6000	32	6	T	6000	T	6000
12	7	P4	223332	T	63809	33	10	T	5000	T	5000
13	1	S2	28000	S0	28000	33	6	T	18000	T	18000
13	6	S0	12000	S0	12000	34	4	T	5000	T	5000
14	4	S6	176000	S0	176000	34	6	T	6000	T	6000
14	10	S0	20000	S0	20000	35	7	F	148800	F	148800
14	10	P4	58666	T	16000	Lab	5	C	2500	T	125000
14	10	F	20000	F	20000	Air	9	S0	6000	S0	6000
15	1	S2	25000	S0	25000	Air	9	P4	67846	T	18000
15	6	S0	9000	S0	9000	Air	9	F	4000	F	4000
16	9	F	6000	F	6000	Air	5	S0	10000	S0	10000
16	4	T	10000	T	10000	Air	5	T	45000	T	45000
16	1	S2	17000	S0	17000	Air	5	F	6000	F	6000
16	6	T	3000	T	3000	Air	4	S0	10000	S0	10000
16	6	S0	6000	S0	6000	Car	5	C	37.5	T	18000
17	4	S4	200000	S0	200000	Con	9	S0	20000	S0	20000
17	10	S0	30000	S0	30000	Con	9	P4	89774	T	23200
17	10	P4	70000	T	20000	Con	9	F	20000	F	20000
17	6	S0	20000	S0	20000	Con	5	T	14500	T	14500
17	6	T	18000	T	18000	Con	3	S2	20000	S0	20000
18	9	F	6000	F	6000	Con	3	U	300	T	62936
18	4	T	10000	T	10000	Ovr	8	P4	246960	T	63000
18	1	S2	13400	S0	13400	Ovr	8	P4	78400	T	20000
18	6	T	3000	T	3000	Rod	9	P4	38572	T	10000
18	6	S0	6000	S0	6000	Rod	5	T	8000	T	8000
19	4	S4	493400	S0	493400	Scr	9	P4	192857	T	50000
19	10	S0	30000	S0	30000	Scr	5	T	18000	T	18000
19	10	P4	75000	T	20000						

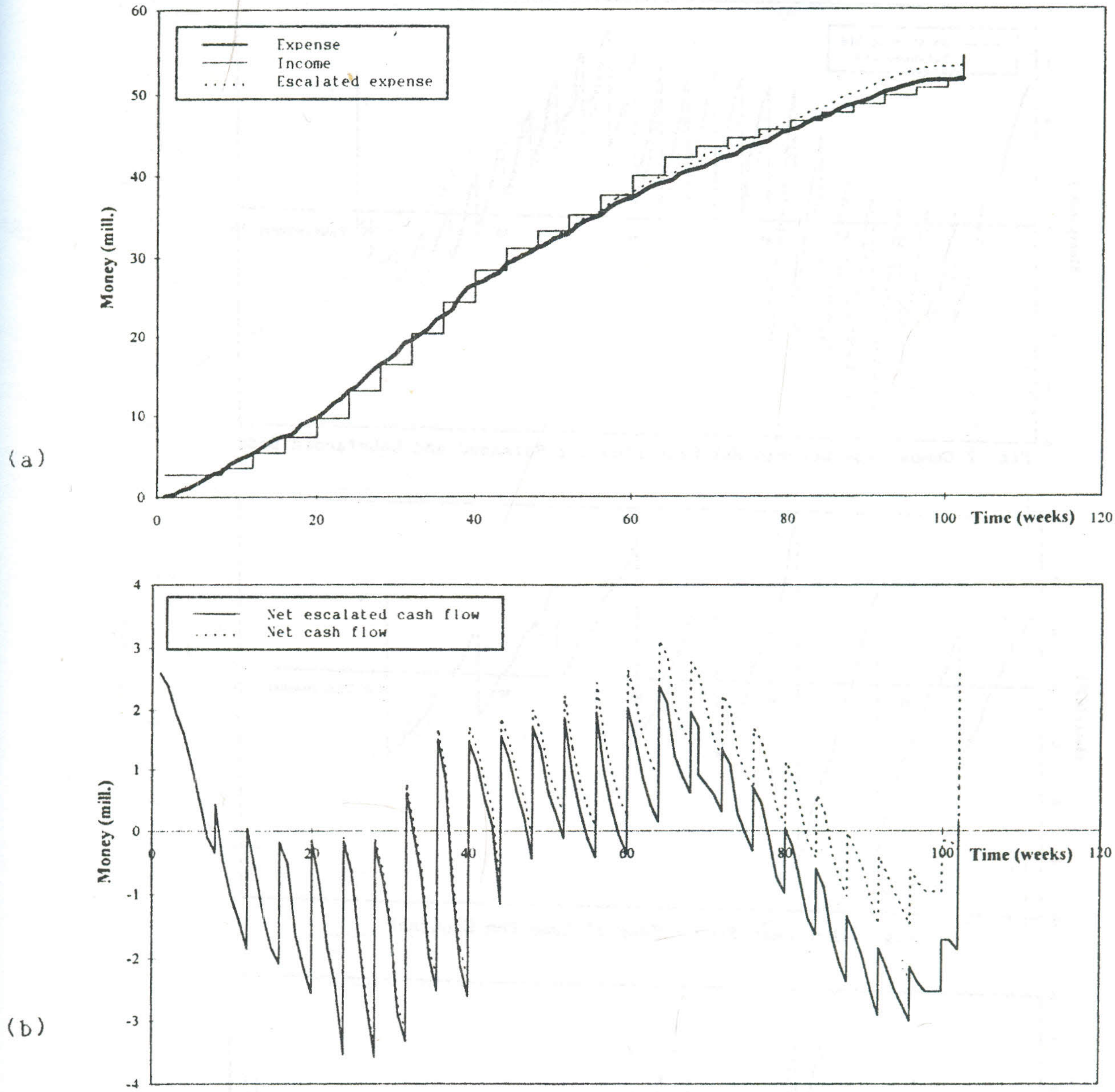

Fig. 1 Results of the Proposed Model
(a) Expense, Income and Escalated Expense Curves
(b) Net Cash Flow and Net Escalated Cash Flow Curves

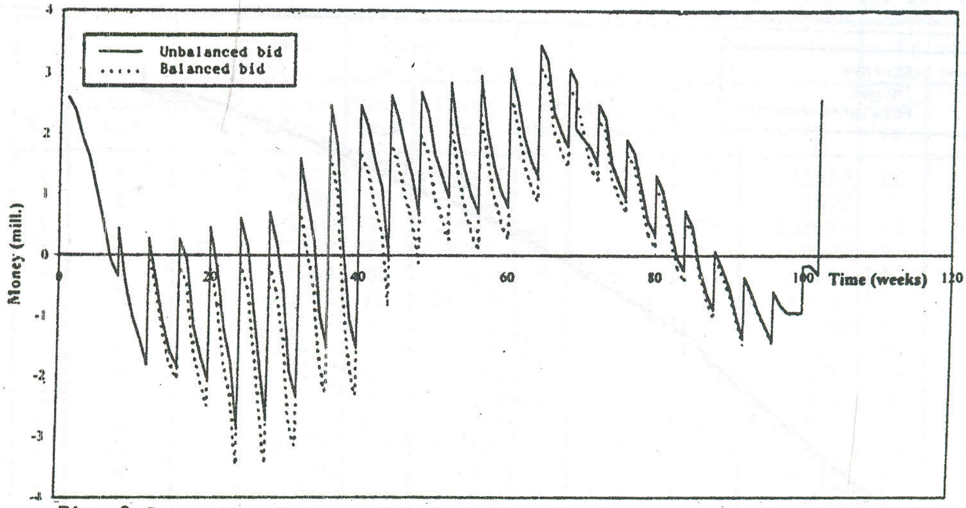

Fig. 2 Comparison between Net Cash Flow for Balanced and Unbalanced Bids

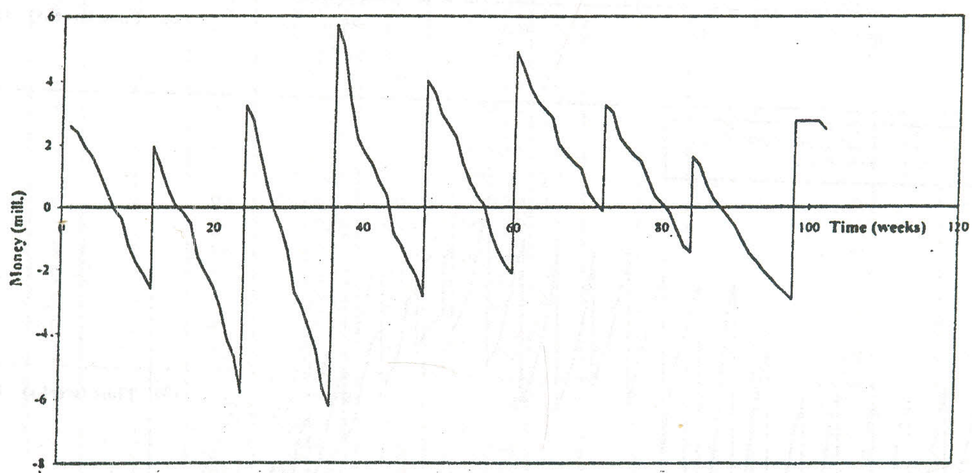

Fig. 3 Net Cash Flow - Case of Lump Sum Contract

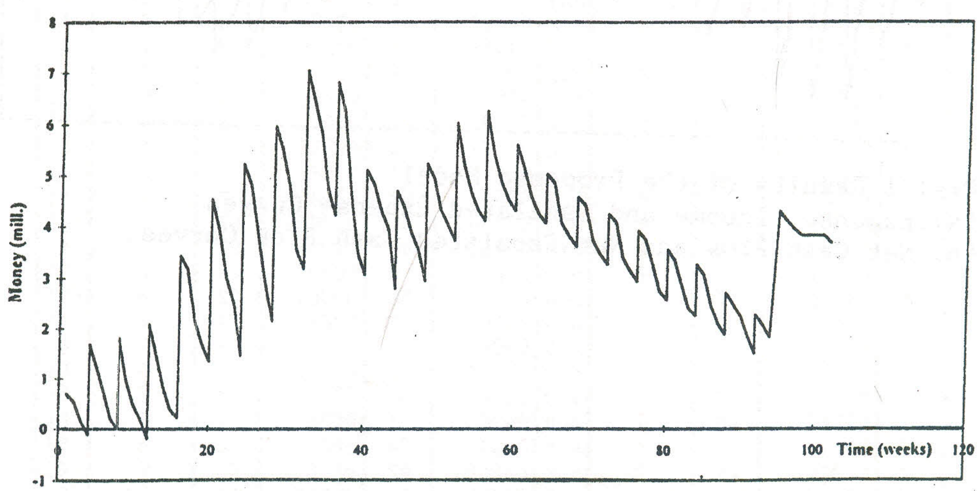

Fig. 4 Net Cash Flow - Case of Cost-Plus Contract

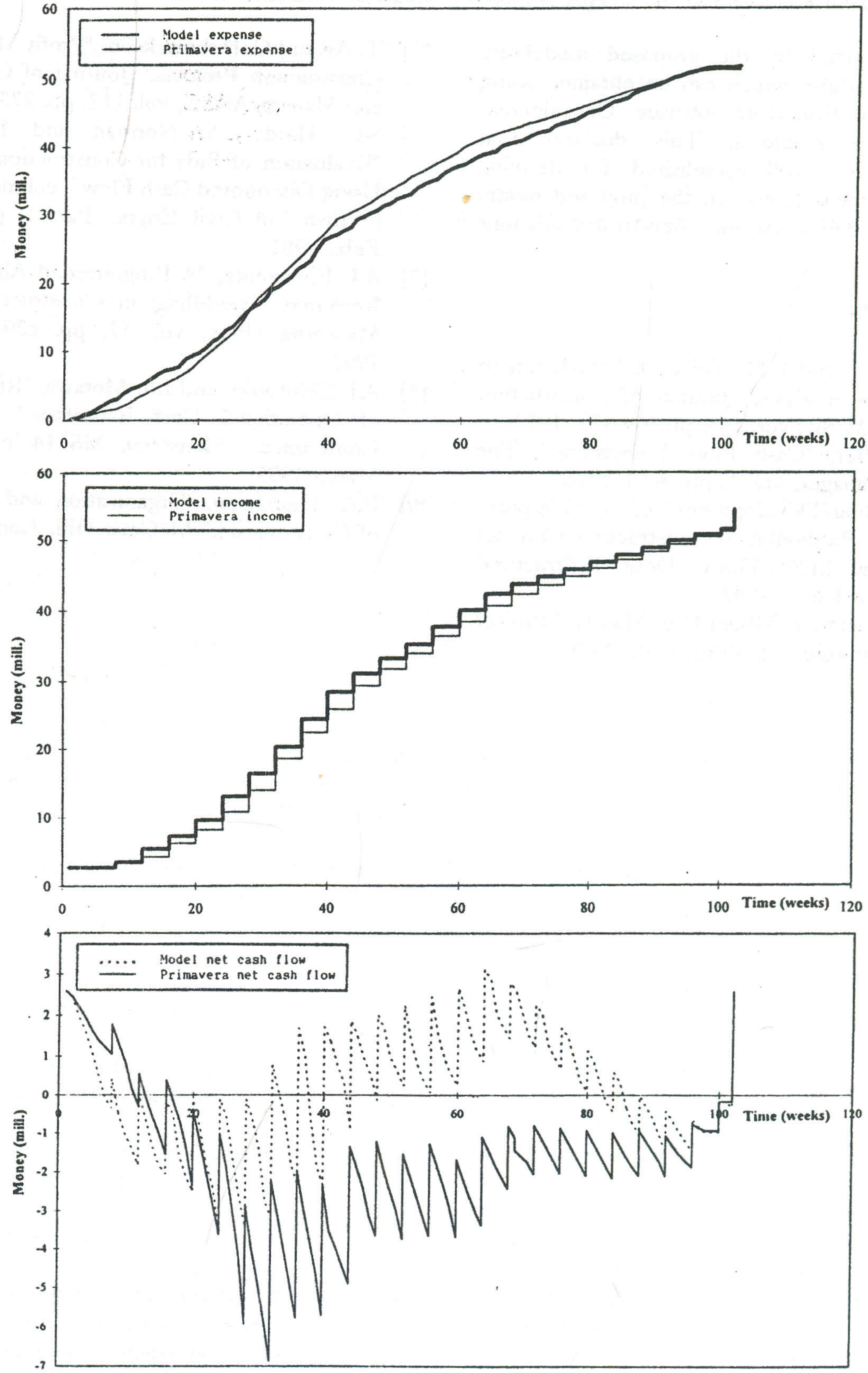

Fig. 5 Comparison with Primavera Results
(a) Expense Curves (b) Income Curves (c) Net Cash Flow Curves

Cash flows derived by the proposed model are compared with those which can be obtained using the widely-used Primavera software. Considerable differences are recorded. This declares that Primavera is not well established for deriving contract cash flows. However, the proposed model would be extended to use the calendar day as a unit of time.

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