AN INTERACTIVE COST-SCHEDULE/PAYMENT-SCHEDULE PROTOTYPE INTEGRATION MODEL FOR COST-FLOW FORECASTING AND CONTROLLING

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Abstract: One of the most important aspects of running a construction business is cash flow management. More and more construction companies collapse due to deficiency of liquidity to support their daily activities instead of the failure of the engineering knowledge and skills. Hence, the need for cash flow management has become the consensus among researchers and practitioners alike. Nevertheless, to develop a successful automatic cash flow forecasting and controlling system is highly difficult due to the compatibility of different factors in a project as well as a dynamic process caused by deviations in the progress of a project underway, initiations or terminations of other activities. Insofar, the most fundamental problem is the integration between money and time, that is, integrating the cost database and billing activity payments of subcontractors and supplies along with those of the schedule, and yet there is no such a model existing. The purpose of this paper is to provide a new discrete model to solve the cognitive problem of integrating money and time. This model presented here is unique because it integrates the cost database, billing activity payments, and those of the schedule as a whole.

Keywords: integration model, cost-flow, cash-flow, forecasting, controlling

1.INTRODUCTION

The construction industry has one of the highest failure rates. Many bankruptcies occur, which is not because of a lack of profits, but the real cause is a lack of cash. A company can survive for a transitional period without showing profit, or even with a loss, but it may collapse due to lack of cash even if it has a very positive balance (Peer and Rosental, 1982). Kirkpatrick (1994) states that without cash flow projections, accurate and reliable estimates of the many variable factors of a project cannot be made. That is, knowing when these cash outlays will occur enables businesses to make plans accordingly, thereby protecting them from having to borrow on short notice to satisfy cash requirements (Sidford 1997). Accordingly, a cash flow forecasting and controlling system is an indispensable tool for the construction industry.

However, to generate accurate cash flow forecasts is not an easy task. The most fundamental problem is the integration of money and time, that is, integrating the cost database along with the schedule of the project. Insofar, there are two existing different approaches for time and costs integration, mathematical models and cost/schedule integration models. Even though there are a number of weaknesses in the approaches, they have been widely applied to the construction industry. And, there are reports that mathematical models and cost/schedule have been used successfully.

This paper begins with literature reviews about mathematical models and cost/schedule integration models for cost-flow forecasting. It then describes the guiding principles and assumptions of the Interactive Cost-Schedule/Payment-Schedule Prototype Model. Finally, it depicts the development of the model. This model presented here is unique because it integrates the cost database, billing activity payments, and those of the schedule as a whole, it is accurate, and it is different from mathematical models and cost/schedule integration models.

2. LITERATURE REVIEW

Several methods have been utilized to forecast cost flows. These models vary widely in the degree of complexity and accuracy. Generally speaking, they can be categorized into mathematical models and cost/schedule integration models, and the endmost purpose of them is to forecast cash flows.

Most of the mathematical models are developed for cost-flow forecasting only, while cash-flow forecasting mathematical models are based on forecasting cost flow first and later translating it into cash flow (Ashley and Teicholz 1977; Gates and Scarpa 1979). These models, generally mathematical with multi-level polynomial, are normally used for those projects that are data limited. The minimum data available for these models to forecast cost flows are project duration, total project cost, and general data. Nevertheless, the mathematical models are inaccurate due to the following drawbacks:

1) Most of them do not take time lags into account (Novan, 1996). Although some of these models do consider time lags, they are only generic. The precise cost flow cannot be generated because the difference of time lags exists in varied resources.
2) The breakdowns of direct costs are too gross. Most of these models break down direct costs based on the percentage of the total cost; consequently, they are not able to generate accurate cost flow forecasts.

In spite of weaknesses above, there are reports that mathematical models have been used successfully (Bathurst and Buttler, 1980).

The other type for cost-flow forecasting is cost/schedule integration methods. There is an extensive discussion in the literature regarding cost/schedule integration (e.g., Carr, 1993; Harris and McCaffer, 1990; Mawdesley, 1989; Novan, 1994; Sears, 1981; Teicholez, 1987). Thus, there is a matter of consensus about the importance and applications of these models among researchers, cost engineers, developers, and contractors alike. The major assumption of these modes is that the detailing levels of the bill of quantities, associated with the physical elements of the project (e.g., columns, beams, etc.), and the schedule are identical. The relation between activities and cost items could be: one to one, one to many, or many to many, and each different resource has a different schedule, sometimes a resource may be involve in more than two schedules. The cost/schedule integration methods first link between activities and associated cost items. Next, they assign resources to the cost items and generates cost flows. More about how to solve the compatibility problem can be found in Navon (1994), Sears (1981), and Teicholz (1987).

Regardless the imperfections of achieving the integration of cost and schedule, these models still have flaws as follows:

1) The subcontractors and suppliers bill the contractor based on work in place, and the contractor, when billed on certain dates, will examine whether the lists of applying payments match work in place and the standards of contracts. Nonetheless, The results sometimes neither meet the qualities of the contracts or the completed percentage of work in place. Either one of such situations always produces inaccurate cost flows in terms of cost/schedule integration, generating cost flows by activities associated with cost and schedule on sites.
2) The cost/schedule integration models assume that the activity schedule of the project is exactly the same as the activity cost schedule of the project work in place. Nevertheless, the former one sometimes differs from the latter one. For instance, the formwork activity schedule occurs before the placing concrete activity schedule; however, the formwork costs are not paid until the placing concrete activity is done, which verifies that the formwork activity is totally completed and safe. In such a case, the cost/schedule integration model is unable to produce accurate cost flow forecasts due to ignoring this phenomenon.

Insofar, a number of existing cost flow forecasting models have been discussed in terms of their methodologies as well as weaknesses and merits. This paper is, in an effort, to alleviate and solve the cognitive weaknesses of mathematical models and cost/schedule integration models, discussed above, by developing a new discrete cost-flow model, the Interactive Cost-Schedule/Payment-Schedule Prototype Integration Model. It will be discussed in the next sections.

3. THE GUIDING PRINCIPLES OF THE MODEL

The followings are the guiding principles of the development of the Interactive Cost – Schedule / Payment - Schedule prototype integration model:

1) The model has to be able to distinguish resources from different time lags and then to generate cost flow projection of resources.
2) The model has to be capable of summing up the cost flows of the identical attribute of resources, which have the same time lag.
3) The model must have the capability of designating project activities to the system, called subcontractor billing system which, while billed, automatically generates all subcontractors' billing payments of the project and then projects the payment cost flows of every single subcontractor on time axis.
4) The model has to be able to sum up the cost flows of the identical attribute of resources of each subcontractor's bill, as has the same time lag.
5) The model has to be able to generate the

actual and forecasting activity cost flows of the individual project accurately, and the transformation between the actual and the forecasting would be triggered automatically.
6) The model must spontaneously replace the cost flows generated by the activities with the cost flows generated by subcontractor billing system on certain days.
7) The model has to be compatible to all individual projects, and it must be flexible enough to accommodate different time lags of individual activity combined by different resources.
8) The project schedule undergoes constant changes due to the changing condition of the project; consequently, the model has to provide for constant updating system.
9) The model has to have the sub-model, in which it receives feedback data of activities.
10) The model has to be capable of integrating projections of cost flows of all individual projects as a whole.
11) The model has to be simple and easy to operate, requiring minimal time investment as well as human involvement.

4. THE ASSUMPTIONS OF THE MODEL

The Interactive Cost – Schedule / Payment - Schedule Prototype Integration Model receives the following as input: detailed estimate (resource-based), detailed bill of quantity, detailed project schedule, the details of subcontracts (including payment method, billing period, billing schedule, and time lags). The assumptions of this model are as follows:

1) A detailed estimate (resource-based), detailed bill of quantity, and detailed project schedule are available.
2) Detailed subcontracts of the project, including payment method, billing period, billing schedule, and time lags have to be defined to fit the contractor and to be available.
3) All the activities of the project in the schedule, having cost items, can be designated to all subcontractors of the project. In other words, all the activities having cost items are equal to the direct cost of the project.

5. THE DEVELOPMENT OF THE MODEL

The Interactive Cost – Schedule / Payment - Schedule Prototype Integration Model is described in Fig. 1. The model performs the integration in major four steps. First, it searches the activities over the schedule and then filters them associated with budget. Next, input the relevant data based on the coding system. The model then automatically categorizes cost flows difference from time lags. Then, once the project is undergoing and billed by the subcontractors, the model will examine the billed quantity and then integrates it with the payment schedule. The model will then generate payment activity cost flows. Finally, The model will switch cost flows form forecasting activity resource level to actual activity resource level, and then it will switch cost flows again from actual activity resource level to payment activity cost flows. The major four steps are necessary to complete generating cost flows, as explained below.

The Activity Cost-Item Filter (ACIF) is done by the systematic search over the schedule. The ACIF

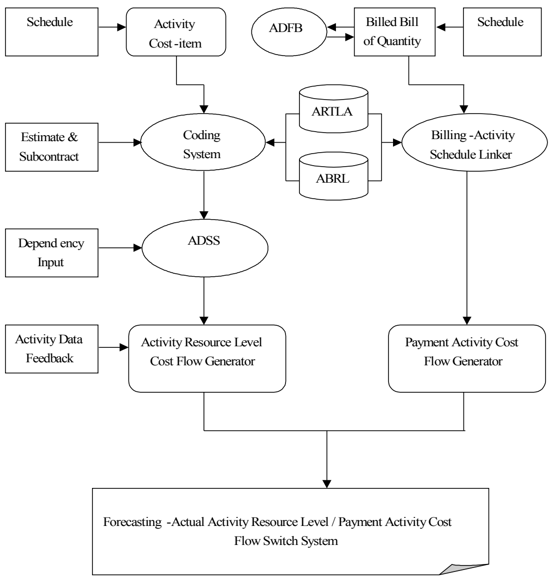

Figure 1. The Interactive Cost-Schedule/Payment-Schedule Model

examines each activity in the schedule and looks for those which have cost items. At the next stage, the Coding System, inputted relevant estimate data of filtered activities, designates time lags and monthly certain billed dates to activity resources. This is done with the aids of the Activity Resource Time Lag Attribute (ARTLA) and the Activity Breakdown to Resource Level (ABRL). The ARTLA examines activities and then allocates time lags to the resources. The data fabrication of the ARTLA is always related to the construction company policies towards subcontractors and suppliers; hence, the more it adapts to the generality and simpleness, the less trouble responded by the subcontractors and suppliers as well as the easier to generate the cost flows are. The ABRL provides the resource proportion share of each activity based on each single subcontract. At the third stage, the Activity Dependency Switch System (ADSS) changes the dependence relationships of activities in the network schedule. At the final stage, the Activity Resource

Level Cost Flow Generator (ARLCFG) projects the forecasting and actual resource levels cost flows. This is done with the aid of the Activity Data Feedback (ADFB). The ADFB, a feedback machine of quantity of activity, is updated daily.

As the project is in progress, the model which, when billed by subcontractors and etc., utilizes the ADFB to examines each billed activity quantity from the subcontractors to see whether or not it fits work in place, and if not, then ADFB revises it automatically. And, the Billed Bill of Quantity checks over the schedule to see whether or not it is right time to be billed by the subcontractors. At the next stage, the Billed-Activity Schedule Linker (BASL) computes payments and designates time lags to each payment. This is done with the aids of the Activity Resource Time Lag Attribute (ARTLA) and the Activity Breakdown to Resource Level (ABRL), which is discussed in the previous paragraph. At the final stage, the Payment Activity Cost Flow Generator (PACFG) projects the payment activity cost flows.

The Forecasting-Actual Activity Resource Level / Payment Activity Cost Flow Switch System (FAARLPACFS) transforms cost flows, from forecasting cost flows with estimated quantity of each activity to actual cost flows with the aid of ADFB interactively, and then from actual cost flows to a payment activity cost flows interactively. This procedure is spontaneously triggered with the aid of the embedded database.

The Interactive Cost – Schedule / Payment - Schedule Prototype Integration Model could be simply expressed as the following formulas:

$$
\begin{aligned}
\sum_{i=1}^{n} PDCF &= \sum_{i=1}^{n} [PDC + TL] \\
&= \sum_{i=1}^{n} \Bigg[\sum_{j=1}^{m} [Labor + TL] \\
&\qquad + [Equipment + TL] \\
&\qquad + [Material + TL] \\
&\qquad + [Others + TL] \Bigg]
\end{aligned}
$$

Where:

PDCF: project direct cost flows
PDC: project direct costs
LP: a labor payable in an activity
MP: a material payable in an activity
EP: an equipment payable in an activity.
TL: time lag, which varies at different scenarios

6. CONCLUSION

This paper discusses the topic of cost-flow forecasting models in construcition. It begins with the description of background and the reviews of literature, which state the drawbacks of current models of cost-flow forecasting. It then describes the development of the Interactive Cost - Schedule / Payment - Schedule Prototype Integration Model.

This paper describes a unique cost-flow forecasting model. Its uniqueness is due to the following points:

1) It introduces the conception of managing cost activities and payment activities as a whole. Current existing modes, such as mathematical modes and cost / schedule integration models focuses mainly on activities in the network schedule, and the fundamental assumptions of theirs, like payment schedule and activity schedule are identical, are oversimplified. In practice, the payment schedule and activity schedule are not necessary the same.
2) It integrates the cost database, activities of the schedule, and billing activity payments of subcontractors and suppliers along with those of the schedules as a whole. Hence, while projects are underway, the cost - flow forecasting deviations caused by the difference between payment schedule and activity schedule are able to be modified.
3) The most important effect above all is that this paper opens a new distinct way to approach accurate cash flow forecasts.

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