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Impact of contractor's optimized financing cost on project bid price

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Abstract

The financing cost depends on the incoming and outgoing cash flow throughout the project, and can differ greatly from project to project. This study proposes a model that calculates the expected financing cost based on the cash flow forecast. This approach is more realistic than assuming an approximate percentage of the total cost. The proposed model calculates the bid price using an optimized financing cost that is obtained by selecting an optimum combination of available financing alternatives offered by different lenders. The proposed model minimizes financing cost, reduces the bid price, enhances the competitiveness of the bidder, increases the contractor`s negotiating power with a lender by providing an optimum financing schedule, and eliminates the risk of financing surprises during construction. This study investigates the impact of different financing considerations on bid price in three cases to prove the effectiveness of the proposed model.

Keywords: Bid price; Financing alternatives; Project financing cost; Cash flow forecast; Work schedules; Lines of credit; Loans

1. Introduction

Financial factors are the most common causes of contractor failure (Arditi et al., 2000). Excessive financing cost may reduce profitability. One of the reasons why contractors need financing throughout a project is the fact that in many projects a portion of the intermediate payments is withheld as retainage by the construction owner, causing a deficit at the end of each payment period. Even if an owner does not withhold retainage, financing is still necessary when the periodic owner payments are delayed (Lu et al., 2016). Therefore, as Elazouni and Gab-Allah (2004) state, it is critical for construction contractors to procure sufficient cash with minimum financing cost in a timely manner to execute construction operations on schedule. Cost estimating and control should include financing considerations to represent the situation realistically. Since cash should not be consumed faster than the rate agreed with the lenders, cost control constitutes an important part of financial management in the construction stage. Cost control should be executed in the most effective way to make sure that the costs including financing cost are within budget (Turner, 2008). However, most researchers who have worked on scheduling problems (e.g., Abeyasinghe et al., 2001; Leu et al., 2001; Sunde and Lichtenberg, 1995; Zhang et al., 2006) and cost control (e.g., Aliverdi et al., 2013; Pajares and Lopez-Paredes, 2011; Peng et al., 2016; Ying, 2016) did not consider financing cost in their models.

Because the execution of construction projects demands large investments, contractors seldom use their own savings to perform projects (Elazouni and Metwally, 2005). They borrow money from banks or alternative lenders. Since contractors have to pay interest on borrowed money, some contractors consider a percentage of the total cost when preparing their bid. This practice is based on an approximate assumption and may result in overestimating or underestimating of the bid price. If the bid price is overestimated, the contractor may cease to be competitive, and if, as a result, the

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contractor is not awarded the contract, they forfeit the money they spent preparing the bid, around 0.2 to 0.5% of the total bid amount (Clough et al., 2005). If the bid price is underestimated, the contractor may well win the contract, but may see a decline in profits or may even incur a loss because the actual financing cost is higher. Therefore, when preparing a bid, it is important to correctly estimate the financing cost based on the project`s cash flow forecast instead of assuming an arbitrary percentage of the construction cost. In addition, a financing plan developed at the bidding stage and be refined at the design stage is likely to make cash flow management and cost control in the construction stage more effective and on-budget completion more likely (Jackson, 2002; Sears et al., 2015; Bode, 2003). Although cost control is quite important at the construction stage, this study focuses on the impact of financing cost at the bidding stage. The objective of this study is to reduce the bid price by using an optimized financing cost based on the project`s cash flow forecast.

Some models have been developed to calculate and minimize the bid price (e.g., Chou et al., 2015; Kuyzu et al., 2015), but none of them consider financing cost based on a cash flow forecast. Some other models have been proposed that calculate the financing cost based on a cash flow forecast (e.g., Alghazi et al., 2013; Ali and Elazouni, 2009; Al-Shihabi and AlDurgam, 2017; El-Abbasy et al., 2016, 2017; Elazouni and Gab-Allah, 2004; Elazouni and Metwally, 2005; Elazouni et al., 2015; Fathi and Afshar, 2010; Gajpal and Elazouni, 2015; Liu and Wang, 2010), but these models can be used only after the contract is signed to find the schedule that satisfies cash availability constraints, not to calculate the bid price. In addition, past studies considered only one financing alternative (i.e., only a line of credit) in their models. Therefore, a model is needed not only to calculate the actual financing cost based on the cash flow forecast, but also to minimize the financing cost in order to reduce the bid price.

According to Turner (2008) and Sears et al. (2015), costs are estimated to determine whether the project is worth undertaking, to prepare a bid price, to obtain financing, to manage cash flow, and to perform cost control. The financing cost is calculated based on a cash flow forecast, which in turn is created based on a work schedule. Since the line of credit is one of the most common financing methods in construction projects (Ahuja, 1976), the construction financing cost is usually calculated using only a line of credit. The contractor that uses a line of credit can borrow money on an as-needed basis up to the credit limit and pays interest on the amount of funds borrowed (Fathi and Afshar, 2010; Al-Shihabi and AlDurgam, 2017). The reason why other financing alternatives are not as common as the line of credit, is because no methods exist that can provide a financing schedule that makes use of an optimum combination of different financing alternatives, each with an optimum amount, and an optimum timing of borrowing and repaying money.

This research proposes a model that (1) minimizes the expected financing cost of a contractor by using a financing optimization method that considers different financing alternatives (i.e., short-term loans, long-term loans, and lines of credit); (2) provides an optimum financing schedule of borrowed and repaid moneys; and (3) reduces the bid price of the contractor, hence enhancing their competitiveness. Three scenarios are tested and analyzed in this research. In Scenario 1, the financing cost is calculated by considering a percentage of the total cost. In Scenario 2, only a line of credit is considered (as was the case in past studies). In Scenario 3, the model proposed in this research is adopted to minimize the expected financing cost by selecting the right combination of financing alternatives out of many available. This optimized financing method is expected to lower bid price and enhance competitiveness compared to the models in Scenarios 1 and 2.

2. Methodology

As shown in Fig. 1, the proposed model is developed in three steps: (1) a scheduling model, (2) a cash flow model, and (3) a financing optimization model. A work schedule is needed to create a cash flow forecast, the cash flow forecast is needed to find the minimum financing cost, and the minimum financing cost is needed to reduce the bid price. The proposed model begins by creating a work schedule and developing a cash flow forecast using work schedule information. Then, the proposed financing optimization model is activated to calculate the optimal financing cost, to develop the optimal financing schedule, and to calculate the bid price for the project using optimized financing. The proposed computational model that is presented in Fig. 1 is executed by an automated system using MATLAB 2013a.

2.1. Scheduling model

The project starts when a customer provides a statement of work and when a project charter is defined. The project charter is an important input when the work schedule is planned. To create a work schedule, the activities are first defined using the schedule management plan and the scope baseline. Then, an activity list, activity attributes, and a milestone list are prepared and used to sequence activities and create a project network schedule. Afterwards, activity resource requirements and activity duration estimates are calculated to create a project schedule (Project Management Institute, 2013). It should be noted that the overall product lifecycle should also be considered ahead of the project management process to obtain higher quality estimates (Laporte et al., 2016). It should be noted that this study assumes that the activity list, activity attributes, the milestone list, the activity sequences, and the project network schedule are prepared based on product-based planning after performing overall product lifecycle analysis of the system.

The start and finish times of activities are needed to create a cash flow forecast. CPM is widely used to calculate the early start, early finish, late start, late finish, and total float of activities. Even though financing cost may be lower if activities start and finish as late as possible, this situation creates a schedule composed of mostly critical activities. In order to avoid such a situation, all activities are scheduled at their early times in this study.

Although, linear programming or dynamic programming are used to analyze the network and to find the critical path, Shankar and Sireesha (2010) proposed the modified Dijkstra's algorithm for CPM since the mathematical approaches (i.e., linear programming

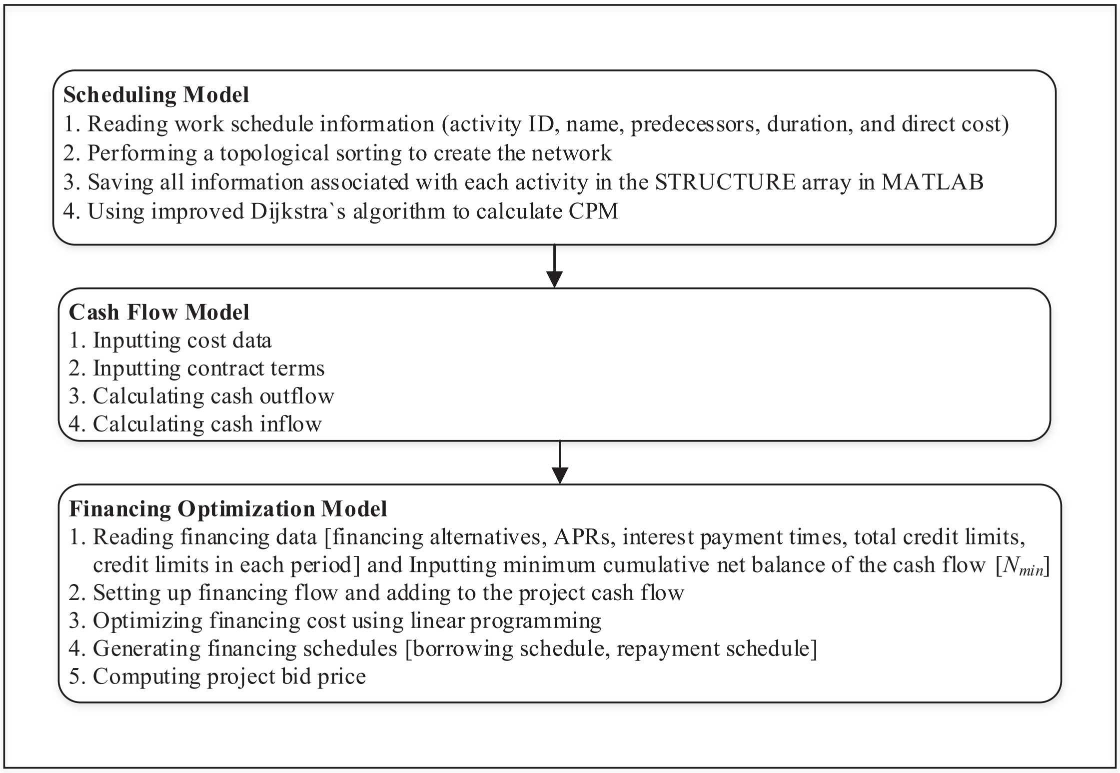

Fig. 1. Model algorithm.

and dynamic programming) can be inefficient. Although Dijkstra's algorithm is a method used for finding the shortest path, Shankar and Sireesha (2010) modified Dijkstra's algorithm for solving deterministic CPM networks. However, Shankar and Sireesha (2010) algorithm uses every arrow regardless of whether activities are connected or not, which results in higher computational time compared to when the computation of unconnected paths is avoided. Therefore, an improved Dijkstra's algorithm for CPM was developed as part of the proposed model to avoid calculating unnecessary paths and just compute those that are joined. This improvement is done using topological sorting and the STRUCTURE array of MATLAB.

As seen in Fig. 1, after the work schedule information (i.e., activity ID, name, predecessors, duration, and direct cost) is read by MATLAB, three functions of MATLAB (i.e., sparse, graphtopoorder, and graph) are used to perform a topological sorting and to create a network based on the work schedule information that is read. After the network is created, all predecessors, successors, duration, and cost that are associated with the ID of each activity are stored in a STRUCTURE array in MATLAB. When Dijkstra's algorithm is used to perform CPM calculations, only those i and j that are connected are checked using the information stored in the STRUCTURE array.

2.2. Cash flow model

According to Turner (2008), the project schedule is used to estimate activity cost estimates. However, it should be noted that the accuracy of the activity cost estimates depends on the information available and on the level of effort spent, both of which are different in the different stages of production. For example, in the design stage, the accuracy of cost estimates is between ±10% and ± 25%, whereas it is between ±2% and ±5% at the bidding stage. Although the accuracy is lowest at the bidding stage, it is not worth to put in the extra effort to partially develop the design hence reaching a higher accuracy in the cost estimate at this stage because the cost of this extra effort is prohibitive and because much of the information necessary to do so is not available at this stage. This study assumes that the costs of activities are estimated with the accuracy of ±5 to 15%, and are input to the proposed model to create the cash flow forecast.

A separate analysis of the cash outflows (expenditures) and cash inflows (incomes) is necessary to create a cash flow forecast. The frequency and magnitude of the costs incurred by the contractor and of the timing and magnitude of the payments made to the contractor by the owner affect the contractor's financing costs and bid price. Therefore, the cash outflows and cash inflows are analyzed separately.

When the start and finish times of activities are computed, the cost data and contract terms are input by the contractor and the cash flow forecast is calculated (see Fig. 1). The cash flow consists of the cash outflows (expenditures) and cash inflows (incomes) for the duration of the project. The cash outflow includes direct and indirect costs. The direct cost is composed of the costs of materials, labor, equipment, and subcontractors, whereas the indirect cost consists of fixed overhead, variable overhead (Fathi and Afshar, 2010; Peterson, 2013), and mobilization and bonding costs. Fixed overhead, which includes administrative expenses, is constant over the duration of the project (Clough et al., 2005; Peterson, 2013), whereas variable overhead, which includes utility costs on the job site, personnel scheduling and management costs, taxes, project insurance, etc., varies with the volume of work during the project (Fathi and Afshar, 2010; Peterson, 2013). The total direct cost (C_{dc}) is the sum of all weekly costs. The fixed overhead cost of a project (C_{foc}) is computed by multiplying the fixed overhead cost per week (O_{foc}) with the number of weeks to complete the project. The variable overhead cost (C_{voc}) is computed by multiplying the weekly direct cost with a percentage dictated by the company's historical records (O_{voc}). The mobilization cost (C_{mob}) is computed by multiplying the mobilization cost percentage (O_{mob}) with (direct cost (C_{dc}) + variable overhead cost (C_{voc})). The estimated profit of a project (P_{est}) is computed by multiplying estimated profit percentage (O_{est}) with (direct cost (C_{dc}) + fixed overhead cost (C_{foc}) + variable overhead cost (C_{voc}) + mobilization cost (C_{mob})). The cost of bonding (C_{bond}) is computed by multiplying the bond premium percentage with (direct cost (C_{dc}) + fixed overhead cost (C_{foc}) + variable overhead cost (C_{voc}) + mobilization cost (C_{mob}) + estimated profit (P_{est})).

On the other hand, cash inflows are the owner payments that include periodic progress payments which are made after the deduction of retainage, if any. The retainage remains in the possession of the owner until the final payment is made (Shim and Kim, 2016). The proposed model allows contractors to reflect the conditions in their particular contract such that the contractor inputs these contractual terms into the model to calculate the cash inflows. These contractual terms are advance payment percentage (O_{AP}) of contract bid price, retained percentage of pay requests, number of months between submitting pay requests, the owner's lag in responding to payment requests, and the lag to return the retained money with the last payment.

2.3. Financing optimization model

Financial institutions like to offer a multitude of financing alternatives including checking accounts, savings accounts, lines of credits, and short and long-term loans (Peterson, 2013). Regardless of whether contractors obtain financing from one or multiple sources, they are inclined to borrow money in a way that best achieves their overall goals. Therefore, for the profitable existence of construction firms, it is in the interest of contractors to consider an optimal combination of financing alternatives offered by financial institutions. The proposed model considers the most popular financing alternatives, namely short-term loans, long-term loans, and lines of credit.

This financing optimization model is developed such that it includes all possible offers by lenders. As far as the timing of borrowing is concerned, the contractor can negotiate a series of loans with lenders as long as the contractor can provide a profitable cash flow forecast including financing costs (Hendrickson and Au, 2000). In the proposed financing optimization model, short-term loans can be taken either quarterly (i.e., every 3, 6, 9, or 12 months) or monthly, whereas the long-term loan is taken once at the beginning of the project. It is of course possible that some of these proposed alternatives are not offered by lenders, or that some of these alternatives do not exist in a specific location. The proposed financing optimization model is flexible enough to consider only those alternatives that are offered by lenders, and disregard those alternatives that are not available.

As far as the timing of repayment is concerned, according to Peavler (2016), loans are usually paid back either semi-annually or annually, but a variety of repayment schedules can be used to pay back loans. In the proposed financing optimization model, the repayments of short-term loans are made 3, 6, 9, or 12 months after the funds are borrowed, and monthly repayment schedules are proposed for long-term loans, hence covering nearly all possible repayment schedules that can exist in a real project.

2.3.1. Short-term loans

In the proposed model, a series of short-term loans can be prearranged with a lender such that the borrowed amounts and the timing of the withdrawals are predefined, and such that the timings of the repayment of the principal and the interest are also predefined. These short-term loans are represented by STL_{ijk} where i = Time of taking the money = Every 1, 3, 6, 9, 12 months, j = Time of repaying the principal = After 3, 6, 9, 12 months, and k = Time to pay interest = Every month or at maturity of loan (j). For instance, if $i = 6$, $j = 3$, and $k = 1$, the contractor can take a series of short-term loans every six months ($i = 6$), pay off the principal of each loan after three months from the time each loan is taken ($j = 3$) and the interest every month ($k = 1$). If the contractor pays the interest at the maturity of a short-term loan (i.e., if $k = j$), the compounded interest rate will be considered in the proposed model using Eq. (1) where i_{ij} and $\hat{i}_{ij}$ are the effective monthly interest rate and the interest rate compounded every j months, respectively.

$$\hat{i}_{ij} = \left(1 + i_{ij}\right)^{j} - 1;\quad i = \text{Time of taking the money} = \text{Every } 1, 3, 6, 9, 12 \text{ months};\quad j = \text{Time of repaying the principal} = \text{After } 3, 6, 9, 12 \text{ months} \tag{1}$$

It should be noted that the reason that i, j, and k are not more than 12 months is because short-term loans are used for short-term financial needs and are repaid in one year or less (Lu et al., 2016; Peterson, 2013). If lenders restrict the total sum of a series of short-term loans, the model considers the limit ($L_{STL_{ij}}$) in finding the optimum results. In short-term loans, the money paid back cannot be reused as is the case with a line of credit. The total sum of a series of loans should not exceed the total limit for the whole project (e.g., for $i = 6$ and $j = 3$, the total sum of a series of loans should not exceed $L_{STL_{63}}$).

Sometimes, a limitation can be placed on the amount withdrawn (not just on the total). For instance, if $i = 6$ and $j = 3$, in addition to the limitation that the sum of the series of withdrawals must not violate the total limit (i.e., $L_{STL_{63}}$), a prescribed denoted by limit $L'_{STL_{63}}$ must not be exceeded in each period either.

2.3.2. Long-term loans

In contrast to short-term loans, only one alternative is considered for the long-term loan where a lump sum is taken at the beginning of the project. Considering the long-term loan, some lenders let the contractor pay off both the principal and compounded interest at the end of the project, whereas most lenders require the contractor to pay a fixed amount monthly, including both interest and principal (Peterson, 2013). The proposed model is able to handle both conditions for the long-term loan. If the contractor chooses to pay the interest of the long-term loan at the end of the project, the proposed model considers the compounded interest rate using Eq. (2) where i_{LTL} and $\hat{i}_{LTL}$ are the effective monthly interest rate and the interest rate compounded over the length of the project, respectively. Also, T_F is the time (in months) when the final payment is made. It should also be noted that if the amount of a lump sum in a long-term loan is limited by the lenders, the proposed model is able to consider a limit (L_{LTL}) for the long-term loan.

$$\hat{i}_{LTL} = (1 + i_{LTL})^{T_F} - 1 \quad (2)$$

2.3.3. Lines of credit

A line of credit alternative is selected based on the desired repayment schedule (i.e., LC_j where j = Time of repaying the interest and principal = After 1, 2,..., 12, T_F months). In other words, in the proposed approach, an interest rate and a credit limit are specified. What amount and when to withdraw and pay back the money are critical questions that define a line of credit. If the withdrawn amount from the line of credit is paid after more than one month, the compounded interest rate is considered using Eq. (3) where i_{LC} and $\hat{i}_{LC_j}$ are the effective monthly interest rate and the interest rate compounded every j months, respectively. In addition, the total debt (sum of all withdrawals plus the interest minus all repayments) must never exceed the credit limit (i.e., L_{LC}) at any time during the project.

$$\hat{i}_{LC_j} = (1 + i_{LC})^{j} - 1; \quad (3)$$
$$j = \text{Time of repaying the principal and interest} = \text{After } 1, 2, \ldots, 12, T_F \text{ months}$$

A limitation on the amount withdrawn each time (as opposed to the total credit limit) can also be imposed. The proposed model allows the contractor to consider such a limitation by restricting withdrawal to a percentage of the total credit limit (i.e., L'_{LC}).

It should also be noted that since some lenders may require the contractor to pay fees for setting up the loan or the line of credit (Peterson, 2013), it is unrealistic to assume an interest rate excluding these costs when financing alternatives are compared with each other. The contractor should consider using an effective APR that includes both interest and lending fees (Prakash, 2015). In this research, it is assumed that such an APR is quoted to the contractor. The effective APRs of the different financing alternatives are input into the proposed model which computes the monthly interest rates of these financing alternatives based on these APRs.

2.3.4. Optimization

As seen in Fig. 1, once a cash flow forecast is calculated for the project, a financing flow should be set up and added to the project cash flow after the financing data are read. The financing flow is set up using the proposed financing model in the preceding sections. Optimization is performed using linear programming to minimize the financing cost while making sure that the cumulative net balance of the cash flow (including financing flow) is always positive and the financing constraints are satisfied. The minimization of the total financing cost (FC) is the objective function and is formulated in Eq. (4) where FC_t is the financing cost at the end of each month (t). The constraints are formulated in Eqs. (5) to (11) and are discussed afterwards.

$$\text{Minimize} \quad FC = \sum_{0}^{T_F} FC_t \quad (4)$$

Subject to:

$$N_t{}' \geq N_{min}; t = 0, 1, 2, \ldots, T_F \text{ months} \quad (5)$$

$$\text{where } N_t{}' = \begin{cases} AP - C_{mob} - C_{bond} + NF_t; t = 0 \\ N'_{t-1} + N_t + NF_t; t = 1, 2, \ldots, T_F \text{ months} \end{cases} \quad (6)$$

For short-term loans:

$$\sum_{0}^{t} B_{STL_{ij_t}} \leq L_{STL_{ij}};$$
$$i = \text{Time of taking the money} = \text{Every } 1, 3, 6, 9, 12 \text{ months};$$
$$j = \text{Time of repaying the principal} = \text{After } 3, 6, 9, 12 \text{ months}$$
$$t = 0, 1, 2, \ldots, T_F \text{ months} \quad (7)$$

$$B_{STL_{ij_t}} \leq L'_{STL_{ij}};$$
$$i = \text{Time of taking the money} = \text{Every } 1, 3, 6, 9, 12 \text{ months};$$
$$j = \text{Time of repaying the principal} = \text{After } 3, 6, 9, 12 \text{ months};$$
$$t = 0, 1, 2, \ldots, T_F \text{ months} \quad (8)$$

For long-term loan:

$$B_{LTL} \leq L_{LTL} \quad (9)$$

For line of credit:

$$\sum_{0}^{t} (B_{LC_t} + FC_{LC_t} - R_{LC_t}) \leq L_{LC}; t = 0, 1, 2, \ldots, T_F \text{ months} \quad (10)$$

$$B_{LC_t} \leq L'_{LC}; \quad t = 0, 1, 2, \ldots, T_F \text{ months} \quad (11)$$

The first constraint (Eq. (5)) is that the cumulative net balance of the cash flow (including financing flow) is greater than or equal to the minimum cumulative net balance of the cash flow (including financing flow) (N_{min}), which is set by the contractor. If the contractor wishes to have some funds as a contingency, N_{min} is set up as such, but if the contractor is comfortable without any contingency funds, N_{min} is set up as zero. N_{min} is never less than zero.

Before this constraint is set up, the cumulative net balance of the cash flow (including financing flow) from time 0 to time t, which is denoted by N'_t, is computed by using Eq. (6), where AP is the advance payment, C_{mob} the mobilization cost, C_{bond} the bonding cost, N_t the net operating cash flow in period t (incomes minus expenditures), and NF_t is the net financing flow in period t (borrowed money minus repaid money minus repaid interest).

The second constraint (Eqs. (7)–(11)) is the limitation on the amount of borrowed money relative to each financing alternative. The total amount of borrowed money relative to each alternative ($\sum_0^t B_{STL_{ij_t}}$, B_{LTL}, and B_{LC_t}) should be less than or equal to the total limit of each financing alternative ($L_{STL_{ij}}$, L_{LTL}, and L_{LC}), respectively (see Eqs. (7), (9), and (10)). For the line of credit, it should be noted that the total debt is composed of the sum of all funds withdrawn, plus all financing cost, minus the sum of all funds repaid (left side of Eq. (10)). This debt should not exceed the total credit limit of the line of credit (L_{LC}). In addition, the amount of money to be borrowed in each period relative to short-term loans and lines of credit ($B_{STL_{ijt}}$, and B_{LC_t}) should be less than or equal to the respective limits of each financing alternative in each period ($L'_{STL_{ij}}$, and L'_{LC}) (see Eqs. (8) and (11)).

2.3.5. Project bid price

The direct cost (C_{dc}), fixed overhead cost (C_{foc}), variable overhead cost (C_{voc}), mobilization cost (C_{mob}), estimated profit (P_{est}), and bonding cost (C_{bond}) are calculated by the cash flow model. The minimum financing cost (FC_{est}) is estimated by the financing optimization model. The project bid price (PBP) is calculated by using Eq. (12). The project bid price should go down when minimum financing cost is used.

$$PBP = C_{dc} + C_{foc} + C_{voc} + C_{mob} + P_{est} + C_{bond} + FC_{est} \quad (12)$$

3. Testing the model using three scenarios

Three scenarios are tested and analyzed in this section using the schedule information of an example project to assess the performance of the proposed model and to prove that the proposed model is superior to the previous models. The network of this example project is shown in Fig. 2 and the schedule information of this project is presented in Table 1. This example network is created by modifying the network used by Ali and Elazouni (2009), adding eight activities and changing some predecessors and successors.

After running the model in MATLAB 2013a, the deterministic CPM network is calculated using topological sorting, activity-on-node method, and the improved Dijkstra's algorithm as described earlier. The output of the schedule calculations is also presented in Table 1. The cost data and contractual terms are input by the contractor, as represented in Table 2 for the three scenarios separately. As shown in Table 2, in Scenario 1, it is assumed that the financing cost is not calculated based on the cash flow forecast; instead, 0.5% of the total cost (i.e., 0.5% of direct cost + fixed overhead cost + variable overhead cost + mobilization cost + cost of bonding) is considered to calculate the financing cost. In Scenario 2, although the financing cost is calculated based on the cash flow forecast, only one financing alternative (i.e., a line of credit) is considered to calculate the financing cost. This is the method that was used in previous research to find the financing cost after the contract is awarded. In Scenario 3, not only is the financing cost calculated based on the cash flow forecast, but also the proposed financing optimization model is used to calculate the minimum financing cost.

The APRs in Scenarios 2 and 3 are based on the market conditions. Traditional banks and alternative lenders offer APRs of 2-28% for loans and 5–40% for lines of credit (McIntyre, 2017; White, 2017). Loans with longer duration are charged lower APRs (Au and Hendrickson, 1986). When they specify APRs for borrowers, lenders consider both financial and non-financial factors in addition to the contractor's ability to repay the required credit with interest. If the contractor satisfies the requirements, lenders are content with a low APR, whereas if the contractor does not meet the requirements fully, lenders will seek higher APRs. In this study, a line of credit is assigned a 16% APR, a long-term loan 7%, and short-term loans higher APRs than 7% depending on the duration of the loans, ranging between 9% for a twelve-month loans and 24% for a three-month loan. This assignment of APRs reflects average market conditions and does not favor one alternative over the other. It should be noted that all other information about cost and contractual terms are identical in all three scenarios.

In Scenarios 2 and 3, the financing cost is calculated based on the cash flow forecast. In Scenario 2, only a line of credit is considered to duplicate the scenario used in past studies, whereas in Scenario 3, all financing alternatives (i.e., short-term loans, a long-term loan, and a line of credit) are considered to illustrate the use of the proposed model. In both Scenarios 2 and 3, it is assumed for simplicity that there are no credit limits negotiated with lenders even though the proposed model is able to consider credit limits for all financing alternatives. Moreover, the APRs of the lines of credit are the same in Scenarios 2 and Scenario 3.

3.1. Analysis of the results of project bid price for three scenarios

In Table 3, the results associated with the financing cost and project bid price are presented for each scenario. All calculations were programmed in MATLAB 2013a. The details of the calculations are also presented in Table 3. As shown in Table 3, the direct cost (C_{dc}), fixed overhead cost (C_{foc}), variable overhead cost (C_{voc}), mobilization cost (C_{mob}), estimated profit (P_{est}), and bonding cost (C_{bond}) are identical in all scenarios. The important difference between the scenarios is the financing cost that affects the real profit, project bid price, and the chance of winning the contract.

It should be noted that the estimated profit (P_{est}) is the same in all scenarios (i.e., \$991,321), whereas the expected profits (P_{exp}) are different. In Scenario 1, where the contractor considers 0.5% of

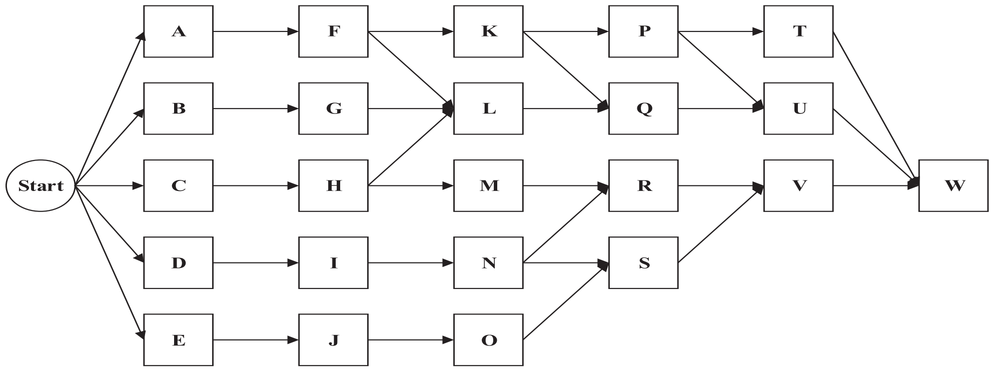

Fig. 2. Network of the example project.

the total cost, the estimated financing cost (FC_{est}) is as low as $83,486. Although the contractor has a better chance to win the contract in Scenario 1 because the project bid price of $17,771,960 is lower than the bid prices in the other scenarios, the financing cost of $83,486 does not reflect a realistic financing cost. Indeed, assuming the contractor uses a line of credit in Scenario 1 (such as in Scenario 2), the expected financing cost (FC_{exp}) will be $273,125, not $83,486. Thus, even if the contract is awarded to the contractor in Scenario 1, the expected profit (P_{exp}) will be $801,682 rather than $991,321. As a result, the contractor's profit goes down by $991,321–$801,682 = $189,639 in Scenario 1. This kind of reduced profitability can have an impact on the performance of a construction company and may result in financial trouble in the long run.

In Scenarios 2 and 3, although the estimated financing cost (FC_{est}) is calculated based on the cash flow forecast, these costs are different in each scenario (i.e., $273,125 in Scenario 2 and $154,949 in Scenarios 3). The reason why a lower financing cost is estimated in Scenario 3 compared to Scenario 2 is because the model proposed in this research (i.e., the optimization of financing cost using different financing alternatives of short-term loans, a long-term loan, and a line of credit) is used to estimate the financing cost. In addition, the expected financing costs in Scenario 2 and 3 are identical to the estimated financing costs in Scenarios 2 and 3 because they both reflect an optimum financing schedule (an optimum financing schedule for only a line of credit in Scenario 2 and an optimum financing schedule for all financing alternatives in Scenario 3).

Table 1
Project schedule data and model output.

Activity ID	Activity name	Predecessors			Duration (weeks)	Direct cost ($/week)	CPM calculations				
		1	2	3			Early start	Early finish	Late start	Late finish	Total float
1	Start	–	–	–	–	–	0	0	3	3	3
2	A	1	–	–	11	20,000	0	11	0	11	0
3	B	1	–	–	11	20,000	0	11	5	16	5
4	C	1	–	–	9	35,000	0	9	3	12	3
5	D	1	–	–	7	55,000	0	7	4	11	4
6	E	1	–	–	8	40,000	0	8	7	15	7
7	F	2	–	–	9	30,000	11	20	11	20	0
8	G	3	–	–	9	75,000	11	20	16	25	5
9	H	4	–	–	9	40,000	9	18	12	21	3
10	I	5	–	–	11	45,000	7	18	11	22	4
11	J	6	–	–	9	75,000	8	17	15	24	7
12	K	7	–	–	8	65,000	20	28	20	28	0
13	L	7	8	9	9	65,000	20	29	25	34	5
14	M	9	–	–	8	45,000	18	26	21	29	3
15	N	10	–	–	7	55,000	18	25	22	29	4
16	O	11	–	–	8	55,000	17	25	24	32	7
17	P	12	–	–	10	60,000	28	38	28	38	0
18	Q	12	13	–	8	65,000	29	37	34	42	5
19	R	14	15	–	14	40,000	26	40	29	43	3
20	S	15	16	–	11	60,000	25	36	32	43	7
21	T	17	–	–	11	80,000	38	49	38	49	0
22	U	17	18	–	7	50,000	38	45	42	49	4
23	V	19	20	–	6	40,000	40	46	43	49	3
24	W	21	22	23	5	30,000	49	54	49	54	0

Table 2
The inputs of cost data and the contractual terms of the project for different Scenarios 1 to 3

Data type	Item	Scenario 1	Scenario 2	Scenario 3
Cost data	Weekly fixed overhead cost O_{foc}	\$100,000/week	\$100,000/week	\$100,000/week
	Variable overhead percentage O_{voc} of (C_{dc})	5%	5%	5%
	Mobilization cost percentage O_{mob} of ($C_{dc}+C_{voc}$)	4%	4%	4%
	Estimated profit percentage O_{est} of ($C_{dc}+C_{foc}+C_{voc}+C_{mob}$)	6%	6%	6%
	Bond premium percentage O_{bond} of ($C_{dc}+C_{foc}+C_{voc}+C_{mob}+P_{est}$)	1%	1%	1%
	Financing cost based on the cash flow forecast	No	Yes	Yes
	Financing cost using optimized financing	No	No	Yes
	APRs	–	Line of credit (16%)	Short-term and long-term loans (vary by duration) and a line of credit (16%)
	Overhead percentage for financing cost O_{fc} of ($C_{dc}+C_{foc}+C_{voc}+C_{mob}+C_{bond}$)	0.5%	–	–
Contract terms	Advance payment percentage O_{AP} of contract bid price	0%	0%	0%
	Retained percentage R of pay requests	10%	10%	10%
	Number of months between submitting pay requests	1 month	1 month	1 month
	Lag in paying payment requests (months)	1 month	1 month	1 month
	Lag to make the final payment and return the retained money (months)	0 month	0 month	0 month

All in all, if one uses an arbitrary percentage of the total cost to estimate the financing cost in Scenario 1, one should be able to generate a bid price that may be low enough to win the job, but the expected profit will be lower than in Scenario 2 where only a line of credit is used as suggested by the current literature. On the other hand, if the proposed model is used in Scenario 3 to estimate the minimum financing cost, the expected profits will be identical to the expected profit in Scenario 2, but in Scenario 3 the bid price will be lower than in Scenario 2.

Another benefit of using the model proposed in this research is the advantage of receiving optimum financing schedules. The optimum schedule of borrowed money is presented in Table 4, and the optimum schedule of repaid money (including the

Table 3
Model outputs for three scenarios.

Data type	Calculation	Scenario 1 (\$)	Scenario 2 (\$)	Scenario 3 (\$)
Direct cost (C_{dc})	Summation of activities' direct costs	10,185,000	10,185,000	10,185,000
Fixed overhead cost (C_{foc})	C_{foc} = 54 weeks × \$100, 000/week	5,400,000	5,400,000	5,400,000
Variable overhead cost (C_{voc})	$C_{voc}=0.05\times C_{dc}=0.05\times \$10,185,000$	509,250	509,250	509,250
Mobilization cost (C_{mob})	$C_{mob}=0.04\times(C_{dc}+C_{voc})=0.04\times(\$10,185,000+\$509,250)$	427,770	427,770	427,770
Estimated profit (P_{est})	$P_{est}=0.06\times(C_{dc}+C_{foc}+C_{voc}+C_{mob})=0.06\times(\$10,185,000+\$5,400,000+\$509,250+\$427,770)$	991,321	991,321	991,321
Cost of bonding (C_{bond})	$C_{bond}=0.01\times(C_{dc}+C_{foc}+C_{voc}+C_{mob}+P_{est})=0.01\times(\$10,185,000+\$5,400,000+\$509,250+\$427,770+\$991,321)$	175,133	175,133	175,133
Estimated financing cost (FC_{est})	Scenario 1 : $F_{est}=0.005\times(C_{dc}+C_{foc}+C_{voc}+C_{mob}+C_{bond})=0.005\times(\$10,185,000+\$5,400,000+\$509,250+\$427,770+\$175,133)$ Scenario 2: based on the cash flow forecast using only a line of credit Scenario 3: based on the cash flow forecast using the proposed financing optimization model	83,486	273,125	154,949
Project bid price (PBP)	$PBP=(C_{dc}+C_{foc}+C_{voc}+C_{mob}+P_{est}+C_{bond}+FC_{est})$ Scenario 1 : \$10, 185, 000 + \$5, 400, 000 + \$509, 250 + \$427, 770 + 991, 321 + \$175, 133 + \$83, 486 Scenario 2 : \$10, 185, 000 + \$5, 400, 000 + \$509, 250 + \$427, 770 + 991, 321 + \$175, 133 + \$273, 125 Scenario 3 : \$10, 185, 000 + \$5, 400, 000 + \$509, 250 + \$427, 770 + 991, 321 + \$175, 133 + \$154, 949	17,771,960	17,961,599	17,843,424
Expected financing cost (FC_{exp})	Scenario 1: using a line of credit to finance the project Scenario 2: using a line of credit to finance the project Scenario 3: using the optimal financing schedules (short-term loans, a long-term loan, and a line of credit) proposed by this study to finance the project	273,125	273,125	154,949
Expected profit (P_{exp})	$P_{exp}=P_{est}+(FC_{est}-FC_{exp})$ Scenario 1 : P_{exp} = \$991, 321 + (\$83,486 − \$273,125) Scenario 2 : P_{exp} = \$991, 321 + (\$273,125 − \$273,125) Scenario 3 : P_{exp} = \$991, 321 + (\$154,949 − \$154,949)	801,682	991,321	991,321

Table 4
Model output for optimized financing inflow schedule (borrowed money) for Scenarios 2 and 3

Month	Scenario 2	Scenario 3			
	LC ($)	STL_{3121} ($)	STL_{691} ($)	*LTL* ($)	*LC* ($)
0	602,903	0	0	2,031,501	0
1	1,156,224	0	0	0	0
2	324,271	0	0	0	0
3	429,416	388,225	0	0	0
4	396,969	0	0	0	301,741
5	272,527	0	0	0	125,116
6	299,584	0	179,172	0	88,308
7	201,707	0	0	0	0
8	195,093	0	0	0	0
9	230,166	0	0	0	0
10	116,726	0	0	0	0
11	344,424	0	0	0	68,313
12	146,816	0	0	0	8,157
13	138,306	0	0	0	21,446
14	202,369	0	0	0	156,426
15	0	0	0	0	0

interest) is presented in Table 5. In Scenario 3, although the long-term loan (*LTL*) has the lowest effective APR of 7%, two short-term loans (STL_{3121} and STL_{691}), and a line of credit (*LC*) were selected in addition to the long-term loan as optimal financing alternatives. Even though the short-term loans and the line of credit have higher effective APRs (10% for STL_{3121}, 9% for STL_{691}, and 16% for *LC*) than the long-term loan (7% for *LTL*), the result of the optimization shows that the expected financing cost is lower, and the bid price is more competitive in Scenario 3, because the optimization depends on many parameters such as the cash flow forecast, the average of the cumulative net balance of the cash flow, the interest rates based on the duration of keeping the money, and the repayment times of interest and principal.

Table 5
Model output for optimized financing outflow schedule (repaid money including interest) for Scenarios 2 and 3

Month	Scenario 2	Scenario 3			
	LC ($)	STL_{3121} ($)	STL_{691} ($)	LTL ($)	*LC* ($)
0	0	0	0	0	0
1	42,224	0	0	141,640	0
2	300,054	0	0	141,640	0
3	189,828	0	0	141,640	0
4	248,945	3,096	0	141,640	0
5	473,439	3,096	0	141,640	170,223
6	337,380	3,096	0	141,640	149,785
7	582,093	3,096	1,291	141,640	204,669
8	405,530	3,096	1,291	141,640	0
9	313,629	3,096	1,291	141,640	0
10	509,939	3,096	1,291	141,640	0
11	190,668	3,096	1,291	141,640	0
12	353,599	3,096	1,291	141,640	61,812
13	274,037	3,096	1,291	141,640	6,451
14	209,189	3,096	1,291	141,640	15,444
15	900,069	391,321	180,464	141,640	174,201

Finally, a large credit limit is required if the contractor uses only a line of credit as opposed to using several financing alternatives in which case the borrowed money is split between alternative sources. Since negotiating a large credit limit is difficult, it makes sense to borrow smaller amounts of money using several financing alternatives, possibly using different financing sources. This way, the contractor not only pays less financing cost and has a higher chance of winning the contract, but also the risk is reduced of being rejected for a line of credit with a high credit limit.

3.2. Sensitivity analysis

The model proposed in this research achieves better results compared to when only a line of credit is considered regardless of the APRs considered in different financing alternatives. A sensitivity analysis is performed for to verify this statement.

If one assumes that the lowest APRs are obtained for a line of credit, a long-term loan, and short-term loans (5% for *LC*, 2.5% for *LTL*, and 7–16% for *STLs*), both financing costs and project bid prices are far lower when all financing alternatives are considered compared to when only a line of credit is considered (see the first row in Table 6). If one assumes that the APRs are at the higher end of the spectrums (40% for *LC*, 20% *LTL*, and 21–28% for *STLs*), again both financing costs and project bid prices are far lower when all financing alternatives are considered compared to when only a line of credit is considered (see the second row in Table 6). In other words, the model proposed in this study achieves a lower financing cost and a lower project bid price irrespective of whether the lowest or highest APRs are considered for financing alternatives.

4. Conclusion

One of the important factors that affect the project bid price is financing cost. Although the financing cost should be calculated based on the cash flow forecast, most contractors estimate the financing cost using a percentage of the total cost. Disregarding the cash flow forecast in the calculation of the financing cost may result in overestimated bid prices that may reduce the chances of being the lowest offer, or underestimated bid prices that may increase the chances of winning the bid, but that may cause a serious decline in actual profitability. Even though researchers proposed models that calculate the financing cost based on a cash flow forecast, all these models concern the construction phase, not the bidding phase. In addition, only a line of credit is considered in all these models. The proposed financing optimization model considers different financing alternatives and achieves optimum results in terms of: (1) incurring less financing cost, (2) reducing the bid price, and hence having a better chance of winning the contract, (3) increasing the contractor`s negotiating power with a lender by providing the lender with optimum financing schedules, and (4) reducing the risk of being rejected for a large credit. Since the project bid price can be reduced further by using time-cost tradeoff, it would be beneficial to expand the proposed model in future research to cover both financing optimization of several financing alternatives and time-cost tradeoff analysis.

Table 6
Sensitivity analysis considering the lowest and highest APRs.

APRs			Scenario 2 (Only a line of credit considered)		Scenario 3 (All financing alternatives considered)	
Line of credit (%)	Long-term loan (%)	Short-term loans (%)	Financing cost ($)	Project bid price ($)	Financing cost ($)	Project bid price ($)
5	2.5	7–16	88,779	17,777,254	59,391	17,747,866
40	20	21–28	632,501	18,320,976	389,463	18,077,938

This study has two limitations. First, although many parameters can affect and reduce the bid price, this study focuses only on financing cost to reduce the bid price. Second, this study considers only the early start and early finish times of activities; however changing the start times of activities may reduce the financing cost, hence reducing the bid price. Since the project bid price can be reduced further by using time-cost tradeoff, it would be beneficial to expand the proposed model in future research to cover both financing optimization of several financing alternatives and time-cost tradeoff analysis.

5. Notation list

The following symbols are used in this article:

AP advance payment;
B_{LC_t} amount of withdrawn money from the line of credit at the end of period t;
B_{LTL} amount of borrowed money for the long-term loan;
$B_{STL_{ijkt}}$ total amount of borrowed money in each period (t) relative to each alternative of short-term loans;
C_{bond} bonding cost;
C_{dc} direct cost of project;
C_{foc} fixed overhead cost of project;
C_{mob} mobilization cost;
C_{voc} variable overhead cost;
FC financing cost of the project;
FC_{est} estimated financing cost;
FC_{exp} expected financing cost;
FC_{LC_t} financing cost of line of credit at the end of period t;
FC_t financing cost at the end of period t;
i_{ij} effective monthly interest rate of short-term loans;
$\hat{i}_{ij}$ interest rate compounded every j months for short-term loans;
i_{LC} effective monthly interest rate of line of credit;
$\hat{i}_{LC_j}$ interest rate compounded every j months for line of credit;
i_{LTL} effective monthly interest rate of long-term loan;
$\hat{i}_{LTL}$ interest rate compounded over the length of the project for long-term loan;
L_{LC} total credit limit of the line of credit;
L'_{LC} credit limit in each period for each withdrawal from the line of credit;
L_{LTL} limit for long-term loan;
$L_{STL_{ij}}$ total limit for each financing alternative of short-term loans;
$L'_{STL_{ij}}$ limit in each period for short-term loans;
LC a line of credit alternative;
LTL a long-term loan alternative;
N_{min} minimum cumulative net balance of the cash flow (including financing flow);
N_t net operating cash flow in period t;
N_t' cumulative net balance of the cash flow (including financing flow) in period t;
N'_{t-1} cumulative net balance of the cash flow (including financing flow) from period 0 to period $(t-1)$;
NF_t net financing flow at the end of period t;
O_{AP} advance payment percentage of project bid price;
O_{bond} bond premium percentage;
O_{est} estimated profit percentage;
O_{fc} overhead percentage for financing cost;
O_{foc} fixed overhead cost per week;
O_{mob} mobilization cost percentage;
O_{voc} variable overhead percentage of the direct cost;
P_{est} estimated profit;
P_{exp} expected profit;
PBP project bid price;
R retained percentage of pay requests;
R_{LC_t} amount of repaid money to the line of credit (including interest) at the end of period t;
STL_{ijk} short-term loan alternatives;
T_F time of final payment.

Conflict of interest

The authors have no conflicts of interest.

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