

Research Article

# Creative Method for Cash Flow Designing of Urban Construction Projects Using Break-Even Point

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## Abstract

**Aims:** This study aims to establish a structured analytical framework that integrates macroeconomic variables specifically inflation, expected profit margins, cost components, advance payments, and payment schedules into a unified profitability assessment model. The central objective is to provide a more accurate and uncertainty-informed foundation for financial decision-making, addressing the shortcomings of traditional deterministic cash-flow approaches widely used in the construction industry.

**Methodology:** The research employs Monte Carlo simulation framework specifically tailored to model the stochastic nature of economic indicators affecting construction project cash flows. Probabilistic distributions derived from historical inflation and cost data are used to generate a realistic spectrum of economic scenarios. The methodology incorporates inflation-adjusted cash-flow calculations to preserve the time value of money and embeds break-even analysis to identify profitability thresholds under varying conditions.

**Findings:** The simulation results demonstrate that excluding inflation and expected profit margins during contractual and financial planning leads to systematically distorted profitability estimations. Such omissions increase the likelihood of cash-flow deficits, reduced net margins, and elevated financial risk throughout the project lifecycle. The proposed model captures variability and stress points that deterministic analyses fail to identify, revealing that financial exposure is significantly higher under realistic economic fluctuations. The integration of probabilistic modeling with inflation-adjusted cash-flow analysis enables a more robust understanding of risk patterns and strengthens the contractor's capacity to manage liquidity and capital allocation.

**Conclusion:** This research offers a comprehensive and methodologically advanced framework for profitability assessment in construction projects, combining break-even analysis with Monte Carlo simulation grounded in empirical economic behavior. The proposed approach enhances the reliability of financial forecasts and provides meaningful guidance for contractors within economically volatile environments. Although its effectiveness depends on forecast quality and computational capacity, the framework marks a substantive improvement over conventional financial evaluation techniques and contributes to more resilient economic planning and decision-making in construction project management.

**Keywords:** Cash Flow, Inflation Rate, Expected Rate, Monte Carlo simulation, Break-Even point, Financial Risk

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## 1. Introduction

One of the most critical challenges in the construction industry is enhancing infrastructure and optimizing project execution. The choice of implementation method and project financing plays a pivotal role in achieving project success, as stakeholders continually seek ways to execute projects at minimal cost, in the shortest duration, and with maximum efficiency. Accurate financial estimation and informed decision-making regarding project feasibility are among the most influential factors in this process. Due to their specific objectives, projects inherently face various constraints that can affect their success. Moreover, these constraints often introduce uncertainties, which are the primary source of project risk. Unexpected events such as economic fluctuations or adverse environmental conditions can significantly impact project costs and execution timelines. Therefore, identifying potential risks and developing appropriate mitigation strategies before a crisis emerges is essential for ensuring project resilience. [1-3]. Risk management is a systematic approach to identifying, assessing, and mitigating risks. This process supports decision-makers in selecting optimal responses under critical conditions by leveraging data analysis and historical insights. Effective risk management planning involves identifying potential crises, forecasting their consequences, and developing models to address them. Conducting simulations and modeling prior to the onset of a crisis serves as a valuable strategy for minimizing damage and achieving favorable outcomes. Ultimately, the insights gained from successful modeling can be utilized as frameworks for managing future crises in the construction industry. This, in turn, contributes to enhanced service quality, reduced costs, and improved project execution efficiency [4, 6]. Shifting client requirements, planning errors, and environmental changes significantly contribute to the complexity of construction projects. The intricate nature of project activities, coupled with their dependence on environmental and social conditions, exposes them to a broad spectrum of risks. These risks encompass economic factors (e.g., inflation and currency fluctuations), political factors (e.g., regulatory and legal changes), environmental factors (e.g., challenges arising from climate change), technological factors (e.g., inefficiencies of traditional methods in adapting to emerging technologies), and occupational hazards. Each of these risks can result in project delays, increased costs, or reduced quality. A structured risk management approach entails systematically identifying potential risks, assessing their probability and impact, evaluating mitigation strategies, and developing comprehensive response plans. Techniques such as sensitivity analysis, Monte Carlo

simulation, and risk assessment matrices enable project managers to anticipate challenges and implement proactive solutions. By employing these strategies, construction projects can progress with minimal disruptions, thereby ensuring efficiency and the successful achievement of project objectives [6, 10]. Urban construction projects encounter significant challenges including high land acquisition costs, stringent regulatory frameworks, and reliance on public-private partnerships which exacerbate financial risks and potential delays, underscoring the necessity for customized cash flow models to ensure project sustainability. Numerous studies have been conducted to enhance profitability and forecast financial risks in construction projects. These studies have developed analytical models to evaluate project returns by considering variables such as tax rates, discount rates, initial investments, and annual revenues. In the environmental sector, break-even analysis has been utilized to assess pollutant reduction efforts by incorporating production costs and raw material supply expenses. This method has also been applied across various industries including wood, petrochemicals, and construction to determine minimum profitable production levels and evaluate the economic feasibility of projects. In the wood industry, the analysis has primarily focused on minimizing labor and variable costs, whereas in construction projects, economic models have been developed to support investment management and profitability assessment, particularly in urban renewal initiatives. Within the private sector, variables such as sales prices and housing subsidies have played a critical role in the economic evaluation of projects. While risk management techniques like sensitivity analysis and Monte Carlo simulation have been applied in diverse sectors such as wood and petrochemicals, this study focuses on urban construction projects, where economic volatilities (e.g., inflation) and urban-specific dependencies exacerbate financial uncertainties, weakening direct linkages to project profitability [6-10]. By centering on urban contexts, the model enhances relevance to high-density infrastructure challenges. Monte Carlo simulation has emerged as a widely adopted tool for risk management and construction cost forecasting. By identifying uncertainties, such as material prices, human resource costs, and construction duration, this method enables a more realistic analysis of project conditions. Moreover, research has introduced economic models for estimating financial risks by utilizing historical data and defining probability distribution functions [2, 11-15]. In addition to the aforementioned methods, various algorithms based on artificial neural network analysis and regression models have been developed for predicting and

optimizing project duration, costs, and cash flows. Recent studies on project financial management have focused on designing models for forecasting cash flows, maximizing profitability, and optimizing expenses. These models, developed using simulation and numerical methods, enhance financial performance by mitigating risks and minimizing their adverse effects. Despite advancements in profitability forecasting through break-even analysis and Monte Carlo simulations across industries, a key research gap remains: prior studies inadequately integrate inflation rates and expected profit margins into urban construction cash flows, often overlooking comprehensive risk assessments tailored to volatile urban environments [2, 11-15]. The proposed model addresses this by embedding these variables to preserve the time value of money and mitigate financial risks in Iranian urban projects. As previously discussed, construction projects are significantly influenced by macroeconomic conditions and market fluctuations. Financial crises such as declines in housing demand, economic recessions, or crashes in financial markets can lead to project delays, increased unemployment, and reduced investor participation. The consequences of such crises include diminished confidence in the construction sector, corporate bankruptcies, and heightened financial volatility, all of which negatively impact project performance. Therefore, simulating financial crises enables project managers to anticipate a range of economic scenarios and develop effective strategies to preserve resources, manage liquidity, and mitigate potential damages. [11, 12]. The theoretical framework is grounded in Time Value of Money (TVM) principles and financial risk management theory, hypothesizing that integrating inflation-adjusted cash flows with expected profit rates will sustain contractor profitability amid economic uncertainties [11, 12]. This approach posits that neglecting these factors leads to liquidity crises, offering a robust basis for urban project evaluations. Therefore, this study proposes an economic model based on the project's cash flow to ensure the financial stability of the project and prevent the impact of economic crises on its financial performance, thereby safeguarding stakeholder capital. The model calculates the contractor's profit by considering both the expected profit rate and the interest rate. By integrating the expected profit rate with the inflation rate and applying these factors to project costs, the model protects the time value of capital and the contractor's income throughout the project duration. Additionally, to assess various economic conditions, the Monte Carlo simulation method is used to calculate the potential economic events. This process allows the model to evaluate multiple economic scenarios and provide the contractor with a comprehensive set of results.

## 2. Cash flow parameters

In the highly competitive construction industry, achieving project sustainability and success requires a comprehensive understanding of cash flow management and strategic planning. Cash flow refers to the maintenance of a balanced movement of funds both incoming and outgoing at specific intervals throughout the project lifecycle. These flows are generally categorized into two main types: outgoing cash flows (expenditures) and incoming cash flows (revenues). To accurately forecast and visualize a project's cash flow profile, it is essential to analyze these two components separately over the duration of the project [2, 8, 9]. Outgoing cash flows represent the expenses incurred during a project and are divided into two main categories: direct costs and indirect costs. The timing of these outflows is typically determined based on the project schedule and the associated expenditures for each activity. Direct costs include expenditures on materials, labor, equipment, and subcontractors, all of which are directly involved in project execution. On the other hand, indirect costs, such as fixed and variable overhead expenses, site setup costs, and performance bonds, are not tied to a specific activity but are essential for project completion [4, 16, 17]. Incoming cash flows represent the payments made by the client to the contractor based on the completion of predefined project milestones. These payments are typically processed on a monthly basis, with the contractor submitting a progress statement at the end of each month to request payment. It is important to note that these payments are issued after deducting the performance guarantee retention and are generally subject to a delay of one month or more. When calculating incoming cash flows, several key factors must be taken into account, including advance payments, the retention deduction percentage, the sequence of progress statement submissions, and the delay in refunding retained amounts. Given that the present study examines the profitability of contractors in the urban construction industry, the project cash flow parameters are defined in accordance with Table 1.

**Table 1.** Cash Flow Parameters of Proposed Model

parameters	Description
NP	Net Profit
AP	Advance Payment
CS	Contractor statement
MC	Material Cost
DoC	Direct Overhead Cost
AC	Activity Cost
MbC	Mobilization Cost
HC	Human Cost

### 3. Proposed model

This study presents a novel economic model for calculating the contractor's net profit based on project cash flow. The proposed model accounts for the inflation rate and the contractor's expected rate of return to preserve the time value of money while ensuring profitability. The model is formulated as shown in Eq. (1).

$$NP = \left( AP + \sum_{i=1}^n CS \times (1 + e_r) \right) - \left( \sum_{i=1}^n ((MC + D_oC + AC) \times (1 + i_r)) + MbC + HC \right) \quad (1)$$

In this study, Eq. (1) defines the contractor's net profit (NP) as the difference between the certified progress payments and the total project costs. The advance payment (AP) refers to the amount provided by the client at the beginning of the project to cover initial expenditures such as site mobilization, material procurement, and other startup costs. The contractor's statement (CS) represents the monthly valuation submitted by the contractor based on the executed works. Other cost components considered in the model include the material cost (MC), direct overhead costs (DoC), activity execution costs (AC), mobilization and setup costs (MbC), and human resource costs (HC). These parameters are incorporated into the model to provide a comprehensive assessment of the project's cash flow dynamics. It should be noted that, the model incorporates monthly adjustments for inflation and expected profit rates to capture cumulative economic impacts on project cash flows, thereby preserving the time value of money. However, since payment delays are determined by contract-specific provisions and varying coefficients, the project's financial manager should identify and integrate such delays into the model to enhance. In addition to the previously defined parameters,  $e_r$  and  $i_r$  factors represent the contractor's expected rate of return and the inflation rate, respectively. The inflation rate coefficient is applied exclusively to the cost of materials and direct overhead expenses, excluding all other amounts. Moreover, the contractor's expected rate of return is incorporated into each progress statement to ensure the time value of the contractor's capital is preserved in accordance with the inflation rate. The contractor's progress statements may be submitted on a monthly or quarterly basis, or at the completion of each stage of construction, depending on the contractual terms. It is important to note that the inflation rate must be incorporated into the proposed model based on the intervals of progress statements. Also, The proposed model incorporates key assumptions such as deterministic baseline costs and independent treatment of inflation and

expected profit rates to maintain tractability. While these simplifications may limit capturing extreme cash flow volatility or heterogeneous inflation effects across cost components, they establish a coherent framework for analyzing contractor profitability under inflationary conditions. The break-even point and other theoretical constructs serve as useful benchmarks rather than exact reflections of diverse market realities. Incorporating taxation, financing, and contractor-specific risk profiles remains an area for future enhancement. The proposed model is developed based on the contractor's progress statements and project costs. Failure to incorporate inflation rate in the initial contract estimation may result in actual project expenses surpassing the agreed contract value, leading to Insolvency for the contractor. By applying the proposed model, project cash flow can be modeled before contract execution, allowing for total cost estimation while considering the time value of money. This model enhances financial assessment accuracy and mitigates the risk of liquidity crises for contractors. Finally, presented model is designed for practical applicability, supporting contract negotiation and project decision-making by simulating scenarios reflecting diverse economic and contractual conditions. It can be applied to urban construction projects with similar cash flow patterns, subject to parameter recalibration. By integrating inflation and profit expectations with stochastic analysis, it enhances traditional break-even methods and, through visualization tools such as the contractor's indifference curve, aids managers in balancing profitability and risk.

### 4. Sample data

Cost management and financial conditions play a crucial role in project management, where risk-taking is an inherent aspect of any project. The primary financial risk in construction projects arises from uncertainties, particularly price fluctuations, which have a direct impact on cash flow. As the level of uncertainty increases, the complexity of monitoring, controlling, and mitigating financial risks also escalates.

Therefore, this study gathers and analyzes statistical data on key financial parameters (Table 1) to evaluate the effects of price fluctuations on project cash flow management. In this study, the cash flow for a concrete structure is simulated. The modeling process focuses on the period from the project's initiation to the completion of the structural phase. Accordingly, the cash flow parameters for the simulation are based on the activities and costs required for typical urban concrete buildings, as outlined in Table 2.

**Table 2.** The Employer’s Payment in Each statement (IRR)

Cost of statements	Parameters					Number of statement
	DoC	MC	AC	HC	MbC	
14’043’492’500	874’075’000	9’423’330’000	2’487’587’500	300’000’000	937’500’000	1
6’403’155’000	821’575’000	3’819’330’000	1’432’250’000	300’000’000	0	2
6’656’655’000	821’575’000	3’819’330’000	1’685’750’000	300’000’000	0	3
6’656’655’000	821’575’000	3’819’330’000	1’685’750’000	300’000’000	0	4
6’526’080’000	739’750’000	3’819’330’000	1’637’000’000	300’000’000	0	5
6’656’655’000	821’575’000	3’819’330’000	1’685’750’000	300’000’000	0	6
7’095’405’000	821’575’000	3’819’330’000	2’124’500’000	300’000’000	0	7
2’269’325’000	126’825’000	953’750’000	858’750’000	300’000’000	0	8

Table 2 presents the initial cost estimation of project work items based on statistical data at the project’s outset, without incorporating inflation rates or the contractor’s expected profit margin. Subsequently, the proposed model simulates cash flow by integrating the actual inflation rate during project execution and the contractor’s anticipated profit margin.

Due to the dependency of estimated parameters on inflation rates and expected profit margins, predicting and controlling financial fluctuations becomes increasingly complex. The significance of the time value of money is particularly evident in long-term evaluations. Therefore, this study adopts a monthly interval for progress payment assessments.

Based on statistical data from 2023, the annual inflation rate for construction inputs was reported at approximately 93%, resulting in an average monthly inflation rate of 7.5%. The contractor’s expected profit margin is defined as an annual rate that ensures financial balance over the project lifecycle.

Given the inherent risks and uncertainties in construction projects, this rate must exceed bank interest rates and is set at 30% in this study. Additionally, according to government procurement regulations, advance payments range between 15% and 25% of the initial contract value, with the exact percentage specified in contract terms. In this simulation, the advance payment is considered 15% of the initial contract value. The detailed calculated values are presented in Table 3.

**Table 3.** Inflation Rate, Expected Rate of Return, and Advance Payment Values

Description	Count (percent)	parameters
Monthly	7.8	$e_r$
Annual	30	$i_r$
Based on the contact price	15	AP

It should be noted that, Inflation is calculated on an annual basis and uniformly distributed across months as a simplifying assumption for the purposes of this study. This approach is justified by the fact that the cumulative annual inflation would be equivalent whether monthly rates vary or remain constant, and the model reflects actual economic conditions accordingly.

### 5. Monte Carlo simulation approach

Monte Carlo simulation is a numerical method used for modeling and analyzing stochastic phenomena by generating random variables that mimic the probabilistic behavior of a system.

This technique enables uncertainty modeling and risk quantification by incorporating probability distributions and random number generation within the [0, 1] interval. Through iterative loops and statistical data integration, Monte Carlo simulation facilitates scenario-based forecasting, making it a valuable tool for uncertainty analysis in numerical models. In financial applications, it estimates probable outcomes based on input data distributions, aligning with expected analytical ranges. In project management, Monte Carlo simulation is widely employed for cost and schedule forecasting, allowing for the identification and modeling of key influencing parameters to assess the potential impact of variations on project performance [2, 5].

Monte Carlo simulation is an effective method for modeling real-world systems by incorporating stochastic calculations and future uncertainties.

It enables scenario evaluation and risk quantification, ultimately minimizing decision-making risks through the analysis of model output. Despite its effectiveness in handling uncertainty, its practical implementation requires careful consideration of both financial and non-financial factors. Although Monte Carlo simulation is

recognized as a valuable tool in project management applications, it remains underutilized by project managers in real-world conditions. In this study, since the proposed model is parameterized and simulated using real data, a large statistical dataset is required for accurate estimations, which is often impractical. Therefore, Monte Carlo simulation is employed to expand the dataset, facilitating a more precise evaluation of the proposed model [2, 18].

Hence, Monte Carlo simulation is employed to effectively address parameter uncertainty by generating probabilistic outcomes based on defined input ranges. Sensitivity analysis further identifies critical parameters influencing results, validating the robustness of the model within the scope of selected assumptions.

Nonetheless, the quality of simulation outcomes depends on careful parameter range selection, which is acknowledged as a limitation.

## 6. Simulation process

The comparison of actual project costs and the assessment of financial management performance are essential for preventing financial failures and achieving project financial objectives. An effective measurement approach must enable timely and accurate evaluation of project activities, scheduling, and costs. Establishing a performance measurement baseline provides a reference against which project performance is assessed. This baseline should be defined based on project execution expectations and objectives (time, cost, and quality) throughout the project lifecycle. It allows investors to gain a clear perspective on their investment status during periodic evaluations.

In this study, project modeling follows a simulation process, as illustrated in Figure 1.

The performance evaluation process in project financial management requires accurate cost calculation to prevent financial failures and achieve financial objectives. This study focuses on modeling and simulating cash flow to assess project Profitability and cash flow analysis. The proposed process, as shown in Figure 1, establishes a performance measurement framework based on the project's execution goals (time, cost, and quality), enabling timely and accurate evaluation of activities, scheduling, and costs. It provides investors with a clear perspective on the investment status.

This study aims to implement a practical model for calculating project costs and contractor profits with minimal error. The selected parameters are designed to cover all aspects of project costs. The initial cost modeling was conducted for four general scenarios, considering

inflation rates and the contractor's expected profit margin. The results of the modeling are shown in Table 4.

Table 4 presents the results of the proposed model's simulation and processing for four different scenarios. The findings indicate that considering inflation and profit rates significantly impacts project costs. As observed, neglecting inflation rates at the contract signing stage can lead to financial challenges and hinder the achievement of the project's financial objectives.

To compare the four modeled scenarios, the cash flow diagram is presented in Figure 1. The results indicate that economic conditions significantly influence project cash flow. Predicting monthly inflation rates and incorporating them into each progress statement enhances cost estimation accuracy. In the next phase, Monte Carlo simulation will be employed to refine the analysis.

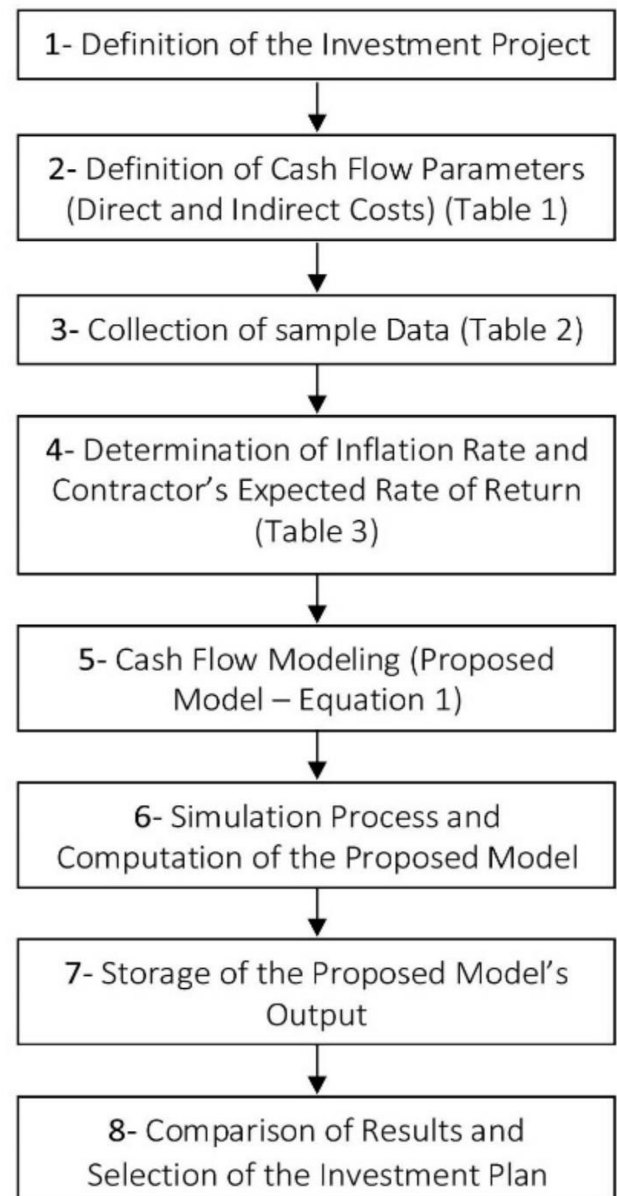
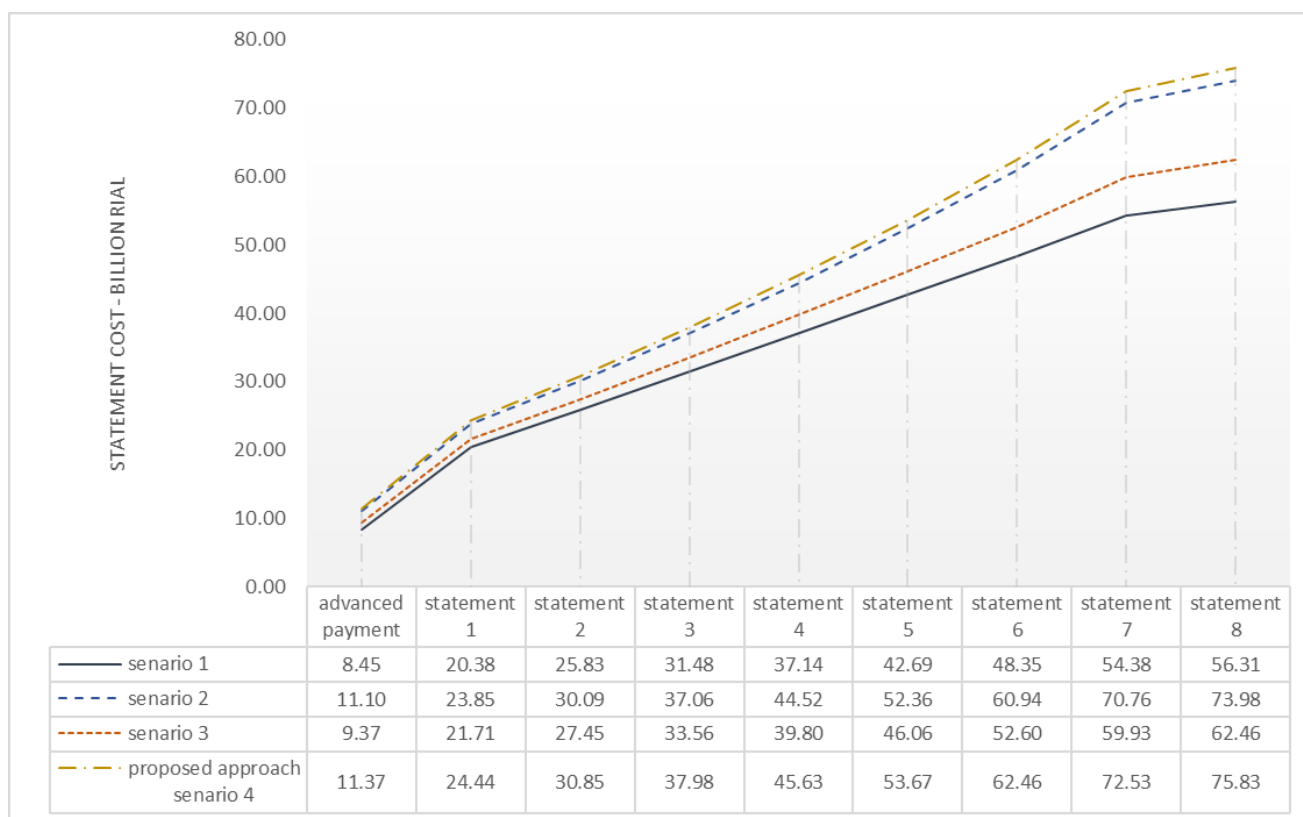


Figure 1. Cash Flow Simulating Process

**Table 4.** Output of project statement amounts based on the proposed model

Scenario four proposed approach	Scenario three	Scenario tow	Scenario one	Statement number
$i_r - 7.5\%$	$i_r - 0\%$	$i_r - 7.5\%$	$i_r - 0\%$	
$e_r - 2.5\%$	$e_r - 2.5\%$	$e_r - 0\%$	$e_r - 0\%$	
11'374'534'229	9'369'017'083	11'097'106'633	8'446'113'375	Advanced Payment
13'070'224'101	12'340'732'809	12'751'438'147	11'936'968'625	1
6'402'197'442	5'737'773'302	6'246'046'285	5'442'681'750	2
7'135'174'830	6'110'972'645	6'961'146'175	5'658'156'750	3
7'648'749'504	6'244'478'019	7'462'194'638	5'658'156'750	4
8'037'520'108	6'257'217'376	7'841'483'032	5'547'168'000	5
8'794'342'013	6'542'278'446	8'579'845'867	5'658'156'750	6
10'066'543'906	7'326'853'395	9'821'018'445	6'031'094'250	7
3'300'942'0456	2'530'790'814	3'220'431'664	1'928'926'250	8
75'830'228'659	62'460'113'889	73'980'710'886	56'307'422'500	Total



**Figure 2.** Cumulative project cash flow in four modeled scenarios using the proposed model

Figure 2 illustrates the cumulative project cash flow based on progress statements. The results indicate that inflation and the contractor's expected profit rate significantly impact the project's final cost.

Initially, the differences between scenarios are minimal; however, as the project progresses, the compounding effect of inflation leads to greater cost deviations in each

subsequent statement. To account for inflation's impact on capital value preservation and contractor profitability, the proposed model integrates both inflation and expected profit rates.

Additionally, Monte Carlo simulation is employed for sensitivity analysis and risk assessment of construction project profitability [19, 20].

## 7. Simulation the proposed integrated model

Monte Carlo simulation is utilized to analyze various economic scenarios relevant to the construction industry. To achieve this, inflation rate, profit rate, and advance payment percentage are selected as key uncertainty factors affecting cash flow.

These uncertainties pertain to future conditions and are inherently difficult to predict. In contrast, other model parameters are determined at the project's outset based on market price inquiries, ensuring a realistic baseline for initial cash flow modeling (Scenario 1). By simulating inflation rates, profit rates, and advance payment percentages, the final project cost and contractor's expected profit are estimated. The range of uncertainty parameters for the simulation process is presented in Table 5.

**Table 5.** Annual Variation Characteristics of Uncertainty Parameters

Parameter	Minimum	maximum
$e_r$	23 %	30 %
$i_r$	50 %	75 %
AP	15 %	25 %

For the proposed model simulation using the Monte Carlo method, the mean and standard deviation of the selected parameters must be calculated. Since progress statements are issued monthly, these statistical values are computed for each month. The resulting mean and standard deviation for the parameters are presented in Table 6.

**Table 6.** Features of Uncertainty Parameters

Parameter	mean	standard deviation
$e_r$	2.2 %	0.412 %
$i_r$	5.2 %	1.472 %
AP	20 %	7.071 %

This study aims to simulate the proposed function to accurately estimate contractor profit while accounting for uncertainty factors. Additionally, it seeks to determine the contractor's breakeven point by considering the time value of money throughout the project lifecycle. To achieve this, the proposed model must be simulated under prevailing economic conditions in the construction industry and banking sector.

In this scenario, inflation rates are set according to government announcements, and the expected profit rate aligns with bank-declared interest rates. This ensures that the contractor remains indifferent between investing in the project or depositing capital in a bank with an equivalent return. The contractor's breakeven points are presented in Table 7.

**Table 7.** Break-even Values of Uncertainty Parameters

Parameter	Break-Even point
$e_r$	23 %
$i_r$	50 %
AP	15 %

According to Table 7, if the contractor adopts the specified profit rate, inflation rate, and advance payment percentage, they will be indifferent to undertaking the project. In other words, a project with the parameters outlined in Table 7 results in neither profit nor loss for the contractor. Based on these conditions, the project's cash flow has been calculated using the proposed model, and the results are presented in Table 8.

**Table 8.** Proposed Model Output under Contractor Indifference Conditions

cost	Statement number
10'474'163'378	Advanced Payment
12'900'659'474	1
6'246'090'876	2
6'173'964'561	3
7'295'0860'635	4
7'579'419'789	5
8'198'493'943	6
9'275'933'453	7
3'024'636'657	8
71'168'448'767	Total

In volatile economic conditions, accurately estimating the profitability of construction projects is a critical concern for contractors. Proper cash flow analysis and cost estimation during the initial project planning phase are essential. The proposed method serves as a valuable tool for analyzing cash flow dynamics in the construction industry.

Furthermore, by identifying the project's breakeven point, the financial failure risk can be evaluated under different economic scenarios. Given the need for extensive statistical data, Monte Carlo simulation provides reliable approximations that closely reflect real-world conditions. In this study, random number generation and Monte Carlo-based simulation of the proposed model are utilized to assess project profitability risk. Finally, based on the defined uncertainties and random number generation, the probability of financial failure ( $P_f$ ) is calculated using Eq. (2).

$$P_f = \frac{n}{N} \quad (2)$$

In Eq. (2),  $N$  represents the total number of simulations performed, while  $n$  denotes the number of simulations in which the results, based on the proposed model, fall below

the breakeven point or contractor indifference threshold [2]. The proposed model was simulated under various economic scenarios based on the parameter ranges specified in Table 5. To ensure a comprehensive assessment of all possible economic conditions and contract terms related to advance payments, the simulation was performed using 100,000 randomly generated data points. Any outcome falling below the breakeven point, as determined by the proposed model, was classified as a financial failure. Subsequently, using Eq. (2), the contractor’s profitability risk was calculated under different economic conditions. The breakeven point was derived from Table 7, and the simulation results are presented in Table 9. Based on the simulation results, the number of outcomes below the breakeven point is presented in Table 9. According to Eq. (2), the profitability risk is calculated at 30.123%.

**Table 9.** Results of the Proposed Model Simulation

Number of simulation	below the breakeven point	Risk of Profitability
100’000	30’123	30.123 %

It is important to note that under indifference conditions, both the interest rate and inflation rate are taken into account.

If the contractor carries out a project based on the economic conditions outlined in Table 7, they would achieve a 23% profit while considering a 50% inflation rate in their calculations. In this scenario, the contractor is only able to preserve the real value of their capital, in line with prevailing bank interest rates and the inflation affecting the construction industry. The contractor’s indifference curve for profitability in the construction sector is depicted in Figure 3.

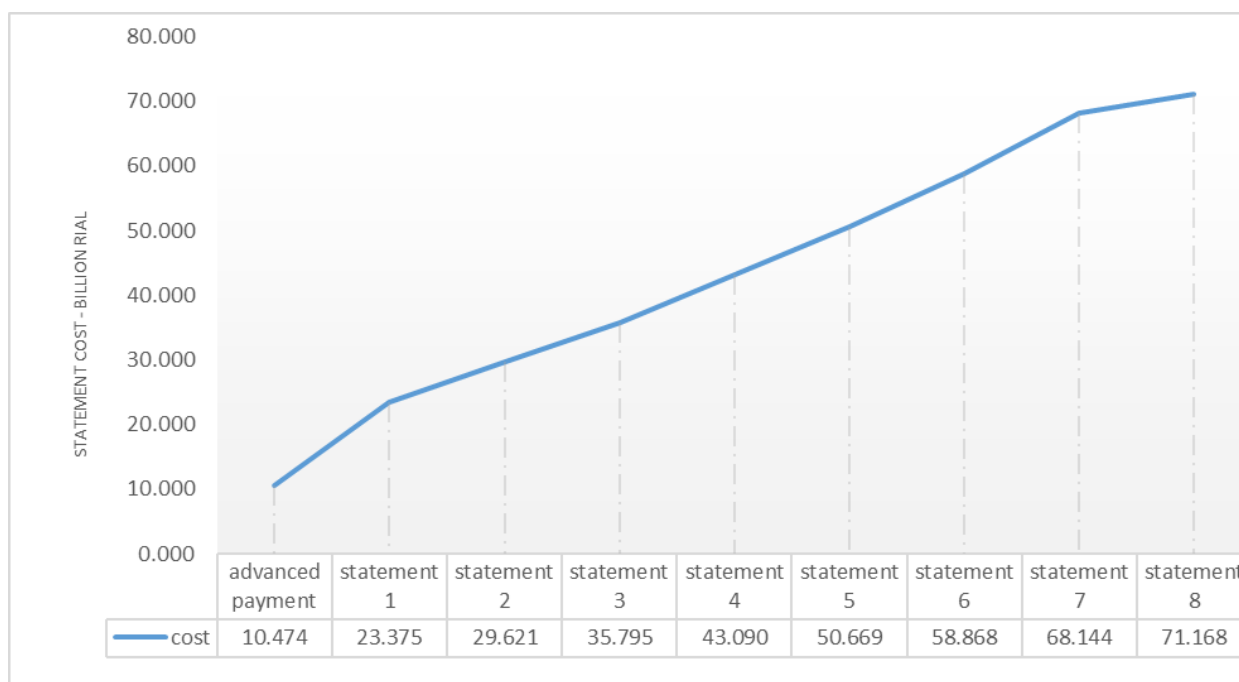


Figure 3. Cumulative Indifference project Cash Flow Using the Proposed Model

Figure 3 illustrates the indifference curve for the construction industry, generated using the proposed model based on the economic conditions in Table 7.

If the project’s cash flow exceeds this curve, considering the contractor’s financial capacity, expected profit rate, and prevailing inflation rate the contractor not only maintains the value of their capital over time but also achieves a profit aligned with their financial expectations. Conversely, if the cash flow falls below the indifference curve, the contractor’s profit is lower than the bank interest rate, leading to a reduction in the real value of their capital due to inflation rate.

### 8. Sensitivity analysis of the proposed model

To assess the impact of uncertainty parameters on project cash flow, this study conducts a sensitivity analysis alongside the proposed model’s simulation based on the economic conditions in Table 7.

The analysis follows a stepwise approach: in each simulation iteration, one parameter is held constant to determine its individual influence on project profitability risk.

Additionally, a second phase of analysis fixes two parameters at a time to further isolate their effects.

Ultimately, the sensitivity analysis is conducted according to the scenarios outlined in Table 10.

**Table 10.** Simulation Scenarios for Sensitivity Analysis

Advanced payment	Expected rate	Inflation rate	Simulation Scenarios
variable	variable	variable	Scenario 1 Possible Economic Conditions
constant	constant	variable	Scenario 2
constant	variable	constant	Scenario 3
variable	constant	constant	Scenario 4
constant	variable	variable	Scenario 5
variable	constant	variable	Scenario 6
variable	variable	constant	Scenario 7
constant	constant	constant	Scenario 8 Break-Even point

The sensitivity analysis of cash flow is conducted based on the parameters defined in Table 5, considering real-world economic assumptions. In each simulation iteration, fixed parameters are set at their minimum values (indifference point from Table 5), while variable parameters are simulated within the ranges specified in Table 6. It is assumed that fixed parameters remain constant throughout the project. These fixed values are assigned according to Table 5. The results of the simulation are presented in Table 11.

**Table 11.** Sensitivity Analysis Results of the Proposed Model

Risk of Profitability	outcome falling below the breakeven point	Simulation Scenarios
30.122 %	30'122	Scenario 1 Possible Economic Conditions
100 %	100'000	Scenario 2
24.335 %	24'335	Scenario 3
0	0	Scenario 4
30.122 %	30'122	Scenario 5
100 %	100'000	Scenario 6
24.335 %	24'335	Scenario 7
Break-Even point	Break-Even point	Scenario 8

Table 11 illustrates the project profitability risk based on data from Table 5 and potential economic scenarios outlined in Table 10. In Scenario (1), all parameters are considered variable, reflecting fluctuating economic conditions. Conversely, in Scenario (8) (the indifference

point), all parameters remain fixed, meaning the investor is indifferent to project execution. In this case, the capital grows only in line with inflation and bank interest rates, without generating additional profit, preserving its time value over the project duration. Similarly, in Scenario (4), the advance payment percentage is variable, while inflation and expected profit rates remain constant. This scenario closely resembles the indifference point, as the fixed economic parameters limit financial fluctuations, while the increased advance payment strengthens the contractor's financial position at the project's outset, enhancing liquidity and improving cash flow management in the early construction phases.

Given that a fixed advance payment percentage does not impact project profitability risk, Scenario (5), where only the advance payment percentage remains constant while inflation and expected profit rates vary, reflects real economic conditions. This is because the key price-influencing parameters are considered variable. Therefore, whether the advance payment percentage is fixed or variable, it does not affect the overall profitability risk of the project.

Consequently, the fixed or variable nature of the advance payment percentage does not influence the contractor's profitability risk; rather, it primarily strengthens the employer's financial position. Based on this, Scenarios (2) and (6) yield identical sensitivity analysis results due to the fixed profitability rate, while Scenarios (3) and (7) produce similar outcomes as the inflation rate remains constant.

## 9. Discussion

This study introduces an economic model for optimizing cash flow management in construction projects, incorporating inflation and expected profit rates to calculate the contractor's net profit. The proposed model considers key variables, including direct and indirect costs, inflation rate, profit rate, and advance payment percentage. Inflation rate, expected profit rate, and advance payment percentage are treated as adjustable parameters, while direct and indirect costs are assumed to be deterministic, as price fluctuations stem from inflation and interest rates. The model enables contractors to incorporate inflation and profit rate adjustments in each payment request, ensuring financial stability throughout the project. By utilizing this approach at the contract stage, contractors can predict the final project cost while accounting for the time value of money, ultimately securing their expected profit margin within the project's cash flow structure.

To analyze various economic conditions, the Monte Carlo simulation method was employed as a robust analytical

tool. To enhance the accuracy of the simulation process and evaluate potential economic scenarios, 100'000 statistical samples were generated and simulated. Additionally, to assess the sensitivity and impact of profitability risk on the contractor, different contract scenarios and economic conditions were simulated based on Table 10. The simulation results are presented in Figure 4.

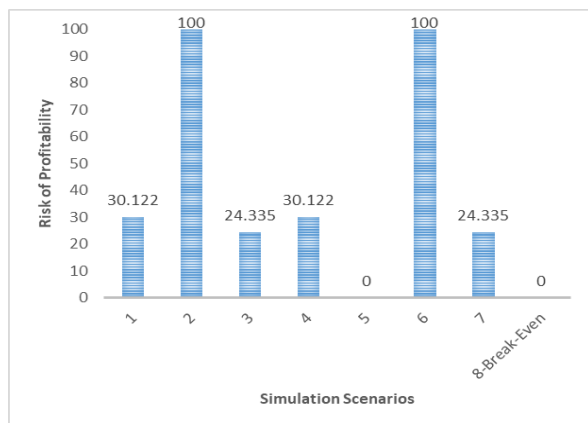


Figure 4. Sensitivity Analysis Results

The sensitivity analysis reveals that inflation and expected profit rates have the most significant impact on project profitability, while the prepayment amount primarily supports initial liquidity without substantially affecting profitability risk. The simulation results indicate that in the early project stages, cash flow variations across different scenarios are minimal. However, as the project progresses, the influence of inflation and expected profit rates becomes more pronounced. These findings underscore the necessity of incorporating inflation and expected profit rates into contracts to mitigate financial losses and ensure profitability.

## 10. Conclusion

This study introduces an economic model focused on the cash flow of urban construction projects, with an emphasis on the time value of investor assets. The model utilizes statistical data from a real construction project and key economic indicators from the Statistical Center of Iran. By incorporating actual project conditions and macroeconomic factors like inflation and interest rates, it addresses practical risks in volatile environments. Validation was performed through scenario-based comparative analysis, running multiple simulations with varying fixed and variable parameters to evaluate their effects on cash flow and profitability risk. This approach ensures internal validity and practical relevance, supporting robust financial decision-making in construction projects. Also, The proposed model

estimates investor profitability by incorporating inflation forecasts and the expected profit rate, aiming to optimize contractor profitability within the construction industry. Unlike traditional deterministic methods, the proposed model integrates inflation-adjusted cash flows and expected profit rates within a Monte Carlo simulation framework to analyze thousands of economic scenarios. This approach enhances risk assessment and financial planning for urban construction projects by accounting for predictable economic fluctuations. The model relies on key assumptions, including access to reliable historical cost and cash flow data, well-defined inflation and profit rate ranges, and stable political and regulatory conditions. Its accuracy may be compromised by incomplete data, unexpected economic shocks, or limited stakeholder cooperation. Therefore, acknowledging these assumptions is critical for effective application in real-world projects. Furthermore, the model supports contractors and project managers in making informed decisions through economic scenario simulations and risk assessments. The key features of the proposed model are as follows:

- Comparison of various investment plans (structural systems) through cash flow analysis.
- Calculation of the breakeven point for investment projects.
- Simulation of economic scenarios to reduce errors in profit estimations.
- Prediction of final project costs to improve financial reliability and prevent stakeholder losses.
- Preservation of capital value by accounting for prevailing economic conditions.
- Reduction of project vulnerability in unstable economic environments.
- Enhanced financial management and improved accuracy in progress payment calculations, thereby minimizing financial risks.

### Authors Contribution

The first author conceived the research idea, conducted the data collection, performed the analyses, and prepared the initial draft of the manuscript. The second author supervised the research process, contributed to the study design and methodology, and critically revised the manuscript. The third author provided technical guidance, contributed to the interpretation of results, and reviewed the manuscript. All authors read and approved the final version of the manuscript.

### Availability of data and materials:

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

### Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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