






# Pricing and Construction Contract Type Selection Model

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**Abstract.** Choosing the pricing of a construction project and the type of construction contract from the perspective of customers is a responsible and complex process. The success of a construction project depends on the correct decisions taken in the preparation of tender documents. This process is complex, and the most mistakes are made in this phase. Disputes between customers and contractors arise during the implementation of a contract, which can have a significant impact on the success of the project. There have been a number of studies on the choice of construction project costs from the point of view of contractors when submitting commercial bids. The main objective of this study is to propose a mathematical model from the point of view of customer, and an online tool for the pricing of a construction project and for the selection of the type of construction contract. The paper analyses scientific sources, presents the algorithm of the mathematical model, the application of the mathematical model in a real construction project, draws conclusions and makes recommendations on the appropriate pricing and type of construction contract.

**Keywords:** Construction Contract · Customer · Pricing · Mathematical Model

## 1 Introduction

Procurement of construction contracts is a process whereby the contractor submits a price bid for the construction work and the customer is able to find the best contractor for the construction work at a competitive price [1]. From the customer's perspective, one of the main objectives of construction contract procurement is to obtain the optimal price bid from the contractor within a competitive bidding ecosystem [2].

The construction industry is one of the most dispute-oriented sectors [3]. Failure to manage the risks during project implementation on time can seriously affect the success of the construction project [4, 5]. Project risk management is a continuous process to identify, assess and control the risks associated with construction projects to mitigate their negative consequences and create a risk-controlled environment [6].

In a global economy, the market is influenced by various factors: economic, social, political, technological and others [7]. When preparing procurement documents for construction works, it is important to properly plan the contract budget for the Customer,

and for the Contractor to properly assess its technical capabilities and the cost of construction materials when submitting a bid for contract works [8]. The success of a construction project depends on the right decisions made in the preparation of the procurement documents for public procurement, a process that is complex and requires many considerations [9]. The high level of uncertainty in construction contracts leads to many contractors going bankrupt each year. Although there are a number of factors that can lead to the failure of a construction business, the most common causes are financial and budgetary factors [10]. The lack of a link between financing and project planning affects the cash flow of the project and creates unworkable work schedules, which often lead to contractors defaulting. Project financing problems not only affect cash flow but can also affect the cooperation between project participants. It increases the likelihood of conflicts between the parties to the contract [11].

The choice of appropriate pricing in the contract documents for construction contracts is one of the most important indicators that can determine the successful completion of the contract, otherwise disputes between the parties to the contract, i.e., between the client and the contractor, may arise. The choice of pricing requires legal and professional knowledge, as well as knowledge of public administration and the public procurement sector. The selection of pricing for the procurement documents for contractual agreements requires professionalism on the part of the technical and administrative staff of the client. In assessing the choice of pricing in the procurement of construction contracts, an analysis of the procurement documents has been carried out, from which it can be concluded that the importance of pricing is either not given sufficient attention by the client's staff or that the staff's competence is insufficient [8]. In the context of pricing, a number of errors are made in the assessment of the provisions of national public procurement laws, in the assessment of building technical regulations, etc. To minimize potential errors, the authors have codified a large part of the legal requirements and have developed a mathematical model to assist clients in the proper selection of pricing for the planned procurement of contract agreements.

Therefore, the main objective of this study is to propose a mathematical model for the pricing of a construction project and for the selection of the type of construction contract from a point of view of customer, and an online tool together with an application for smart phone devices to help the customer to make professional and correct decisions during the preparation of public procurement documents.

The next section reviews research on the pricing of construction projects. Further the mathematical model and its online implementation are presented, application example, conclusions and recommendations are made.

## 2 Literature Review

One of the keys to a successful construction project is the correct pricing of the construction contract. The selection of the pricing of a construction contract is directly proportional to the contractors' price bid. In practice, the contractual price consists of the contractor's estimated costs of the construction work and profit. Researchers who have studied contractors' cost and profit planning have developed models to help contractors manage the cost of project financing [12].

To ensure that construction projects are delivered in a timely, transparent and efficient manner, it is important to choose the right model of construction contract and the right pricing for the works in the terms and conditions of the contract. The selection of construction pricing requires a considerable amount of legal and technical knowledge. Incorrect pricing can have a significant impact on the success of a construction project and can also lead to disputes between the customer and the contractor. The customer can decide the type of pricing to be used in the contract, which decides the form of payment. Contract pricing can be based on a fixed price or a fixed rate [13]. Fixed price pricing is the price quoted by the contractor for a specific construction work in its tender and the contractor is paid for the work actually carried out according to the approved price, whereas fixed price pricing is where the contractor is paid the price stipulated in the contract, the risk of additional work is borne by the contractor and the risk of work not actually carried out is borne by the customer. Different pricing methods are chosen for different types of procurement. For example, the Joint Contracts Tribunal [14] has found that fixed price contracts are one of the main procurement pricing methods in contractual agreements. A fixed price contract is defined as an agreement where the contract sum is fixed before the start of the construction work. In addition, the researcher Rodriguez [15] found that in fixed price contracts, the customer transfers all the risk to the contractor, who in turn charges a higher proportion of the price, thus hedging in case of any unforeseen circumstances. The sharing of risk between the parties largely depends on the choice of pricing and the content of the contract forms [16].

A lot of research has been carried out on the selection of the cost of a construction project when bidding commercially from the contractors' perspective. Researchers have explored mathematical models that allow the contractor to estimate the cost of a planned project more quickly and efficiently. Many researchers have investigated the problem of bid price decision [17, 18]. These studies can be divided into four groups [19, 20]: statistical models; artificial intelligence (AI)-based models; multiple-criteria decision making (MCDM) models; and operations research (OR) models. Statistical models calculate the price offer from a statistical analysis of the prices offered by competitors [21]. AI-based approaches are newer than other approaches, with initial trials of AI in the 1990s [22]. AI-based methods use case logic [23]. In the MCDM method for cost estimation, researcher Chou et al. [24] proposed a combination of AHP and simulation to assist construction contractors in their decision making to submit a bid. Operations Research (OR) models use mathematical programming models. Recently, game theory has been used [25].

Following the sophisticated pricing models of previous studies, all the studies were carried out in terms of pricing and commercial bidding from the contractor's perspective. In the next section, a proposed model for pricing and construction contract type selection is presented from the viewpoint of customer, which can be applied to customer's decision making.

### 3 Model for Selecting the Type of Pricing and Construction Contract

Previous research has analyzed the procurement documents for construction contracts published on the public procurement portal between 2019 and 2021. The study analyzed the general and specific requirements of the procurement documents for 384 units of construction contract works. The study found that the most frequent pricing in the procurement documents is fixed price with revision, with 355 procurements, and fixed price pricing in 29 procurements [8]. Most of the procurement documents provide for fixed price pricing. Proper selection of pricing for the customer's staff in a construction project can lead to successful project implementation and minimize potential disputes between the contractor and the customer. To facilitate the selection of appropriate pricing for customers, a mathematical model has been developed to select the most appropriate pricing and the most accurate contract model, and an online tool was created for users.

The user of the tool who chooses the most appropriate pricing and construction contract model has to answer eight questions (Table 1) by selecting Yes or No.

**Table 1.** The questionnaire.

Question	Notation
Does the Contracting Authority know the scope of the works but cannot determine the exact quantities?	Q1
Has the Customer prepared a technical project for the building?	Q2
Does the Contracting Authority transfer all the risk of possible increases/decreases in quantities to the supplier?	Q3
Does the Contracting Authority pay the price quoted in the supplier's tender for the whole of the subject-matter of the contract as set out in the contract documents and contract?	Q4
Are the Bills of Quantities drawn up by the Contracting Authority approximate and not to be regarded as the actual and exact quantity of work to be carried out by the contractor?	Q5
Will the Contracting Authority use a third party for the performance of the construction contract (the Contracting Authority hires a FIDIC Engineer for contract administration and maintenance)?	Q6
Will the Contracting Authority pay the supplier for the actual quantity of work carried out in accordance with the contractual rates?	Q7
Is the duration of the construction contract 6 (six) months or more?	Q8

The algorithm for selecting the pricing and construction contract model is calculated according to Eqs. (1), (2), (3), (4), (5) and (6):

$$\begin{aligned} \sum FK &= IF(Q1 = \text{“True”} = 1; \text{“False”} = 0) \\ &+ IF(Q2 = \text{“True”} = 0; \text{“False”} = 1) \\ &+ IF(Q3 = \text{“True”} = 1; \text{“False”} = 0) \\ &+ IF(Q4 = \text{“True”} = 1; \text{“False”} = 0) \\ &+ IF(Q5 = \text{“True”} = 1; \text{“False”} = 0) \\ &+ IF(Q7 = \text{“True”} = 0; \text{“False”} = 1) \end{aligned} \quad (1)$$

$$\begin{aligned} \sum FIK &= IF(Q1 = \text{“True”} = 0; \text{“False”} = 1) \\ &+ IF(Q2 = \text{“True”} = 1; \text{“False”} = 0) \\ &+ IF(Q3 = \text{“True”} = 0; \text{“False”} = 1) \\ &+ IF(Q4 = \text{“True”} = 0; \text{“False”} = 1) \\ &+ IF(Q5 = \text{“True”} = 0; \text{“False”} = 1) \\ &+ IF(Q7 = \text{“True”} = 1; \text{“False”} = 0) \end{aligned} \quad (2)$$

$$\begin{aligned} \sum SRS_B &= IF(Q2 = \text{“True”} = 1; \text{“False”} = 0) \\ &+ IF(Q6 = \text{“True”} = 0; \text{“False”} = 1) \end{aligned} \quad (3)$$

$$\begin{aligned} \sum SRS_s &= IF(Q2 = \text{“True”} = 0; \text{“False”} = 1) \\ &+ IF(Q6 = \text{“True”} = 0; \text{“False”} = 1) \end{aligned} \quad (4)$$

$$\begin{aligned} \sum FIR &= IF(Q2 = \text{“True”} = 1; \\ &\text{“False”} = 0) + IF(Q6 = \text{“True”} = 1; \text{“False”} = 0) \end{aligned} \quad (5)$$

$$\begin{aligned} \sum FIG &= IF(Q2 = \text{“True”} = 0; \\ &\text{“False”} = 1) + IF(Q6 = \text{“True”} = 1; \quad \text{“False”} = 0); \\ &IF(Q8 = \text{“True”} = \textit{The contracting authority must specify in} \\ &\textit{the contract at least one rate revision} \\ &\textit{due to circumstances other than a change in taxes}). \end{aligned} \quad (6)$$

The possible results of the mathematically calculated pricing type and construction contract model are presented in Table 2. A visualization of the mathematical model is presented in Fig. 1. The mathematical model has also been adapted for smartphones with Android software.

**Table 2.** Results of the mathematically calculated pricing and construction contract model.

Criteria	Notation
Fixed pricing	FK
Fixed rate	FIK
Standard contract without design	SRS <sub>B</sub>
Standard contract with design	SRS <sub>S</sub>
FIDIC Red book	FI <sub>R</sub>
FIDIC Yellow book	FI <sub>G</sub>

Calculator for pricing and construction contract model
Home Contract recalculation

Does the Contracting Authority know the scope of the works but cannot determine the exact quantities?	<input type="radio"/> Yes	<input type="radio"/> No
Has the Client prepared a technical project for the building?	<input type="radio"/> Yes	<input type="radio"/> No
Does the Contracting Authority transfer all the risk of possible increases/decreases in quantities to the supplier?	<input type="radio"/> Yes	<input type="radio"/> No
Does the Contracting Authority pay the price quoted in the supplier's tender for the whole of the subject-matter of the contract as set out in the contract documents and contract?	<input type="radio"/> Yes	<input type="radio"/> No
Are the Bills of Quantities drawn up by the Contracting Authority approximate and not to be regarded as the actual and exact quantity of work to be carried out by the contractor?	<input type="radio"/> Yes	<input type="radio"/> No
Will the Contracting Authority use a third party for the performance of the construction contract (the Contracting Authority hires a FIDIC Engineer for contract administration and maintenance)?	<input type="radio"/> Yes	<input type="radio"/> No
Will the Contracting Authority pay the supplier for the actual quantity of work carried out in accordance with the contractual rates?	<input type="radio"/> Yes	<input type="radio"/> No
Is the duration of the construction contract 6 (six) months or more?	<input type="radio"/> Yes	<input type="radio"/> No
<input type="button" value="Clear"/> <input type="button" value="Calculate"/>		

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**Fig. 1.** Visualization of the mathematical model (accessed on internet: <https://www.kainodara.lt>).

## 4 Application Example

The authors provide an example of pricing and contract type selection for a real construction project to illustrate the usefulness of the mathematical model in practice. A construction contract for the reconstruction of the largest sewage treatment plant in Lithuania, Vilnius, is analysed.

Details of the construction project:

- Project - reconstruction of Vilnius sewage treatment plant;
- Contract duration – 36 months;
- The customer has not prepared a design for the building;
- The customer does not have technical staff (technical supervisor and contract administrator);
- Construction quantity sheets have been prepared, but the quantities of works are not precisely counted and specified in sets;
- The Employer passes on to the Contractor all the risk of increases or decreases in the quantities of work;
- The Employer has an accurate budget for the implementation of the contract;

- The client plans to pay the contractor for the work according to the approved quantities, i.e., the quantities are in sets;
- The contract will be partly financed by the European Union support budget and by public funds, therefore the terms of the contract are foreseen in accordance with the terms of the FIDIC contract.

The mathematical model is available on the website <https://www.kainodara.lt>. To select the pricing and contract type, it is sufficient to answer the 8 questions in the mathematical model. The answers for the example given, i.e., the reconstruction project of the Vilnius sewage treatment plant, are shown in Fig. 2:

Question	Yes	No
Does the Contracting Authority know the scope of the works but cannot determine the exact quantities?	<input checked="" type="radio"/>	<input type="radio"/>
Has the Customer prepared a technical project for the building?	<input type="radio"/>	<input checked="" type="radio"/>
Does the Contracting Authority transfer all the risk of possible increases/decreases in quantities to the supplier?	<input checked="" type="radio"/>	<input type="radio"/>
Does the Contracting Authority pay the price quoted in the supplier's tender for the whole of the subject-matter of the contract as set out in the contract documents and contract?	<input checked="" type="radio"/>	<input type="radio"/>
Are the Bills of Quantities drawn up by the Contracting Authority approximate and not to be regarded as the actual and exact quantity of work to be carried out by the contractor?	<input checked="" type="radio"/>	<input type="radio"/>
Will the Contracting Authority use a third party for the performance of the construction contract (the Contracting Authority hires a FIDIC Engineer for contract administration and maintenance)?	<input checked="" type="radio"/>	<input type="radio"/>
Will the Contracting Authority pay the supplier for the actual quantity of work carried out in accordance with the contractual rates?	<input type="radio"/>	<input checked="" type="radio"/>
Is the duration of the construction contract 6 (six) months or more?	<input checked="" type="radio"/>	<input type="radio"/>

Clear Calculate

The most appropriate contract model for the construction contract - *FIDIC Yellow Book and Fixed price pricing*  
The contracting authority must specify in the contract at least one price revision due to circumstances other than a change in taxes

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**Fig. 2.** Selected pricing example (accessed on internet: <https://www.kainodara.lt>).

Based on the mathematical algorithm detailed in Sect. 3 of this article, the programme selects the most appropriate contract type and pricing. The result of the contract under consideration is: FIDIC yellow book and Fixed price pricing. Also, the contracting authority must specify in the contract at least one price revision due to circumstances other than a change in taxes. The mathematical model will help procurement managers without legal or procurement document expertise to select the most appropriate contract type and contract pricing.

## 5 Conclusions

Based on the literature analysis, considering that pricing is analyzed in scientific publications from the contractor's perspective, and to facilitate customer's employees in selecting the most appropriate pricing and the most appropriate type of contract, the authors have proposed a mathematical model that would help customers to select the right pricing and the right type of construction contract when preparing tender documents. The mathematical model has also been adapted for smartphones running Android software. The developed mathematical model and the phone app are versatile and can

be adapted for practical use without requiring the user to have a high level of professional training and specific legal knowledge. The user of the model answers a simple set of eight questions by selecting ‘yes’ or ‘no’ at the touch of a button, and the system automatically selects the most appropriate contract price and contract type.

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