

## Providing a model for procurement of construction projects in perspective of reducing the construction risk

Seyed Mohsen Moghaddasi <sup>1,\*</sup>, Saleh Salehi Fereidouni <sup>2</sup>

<sup>1</sup>Department of Civil Engineering, Nour Branch, Islamic Azad University, Nour Iran

<sup>2</sup>Department of Civil Engineering, Shoushtar branch, Islamic Azad University, Shoushtar Iran

**Abstract:** Today, employers access to a wide range of procurement forms which have been created in response to increase of construction projects complexity and inadequacy of the previous predominant methods; nonetheless, most of employers continue applying a few procurement systems among the wide range of existing systems. The main objective of this research is to provide a model for procurement of construction projects in perspective of reducing the construction risk. In this research, it is attempted to detect the key variables related to procurement of construction projects including the project employer's requirements, procurement criteria, systems, and selection methods. The concept of risk and risk management is one of the most used terms in construction industry. For responding to risk, providing choices for employers to response to risk, allocating risks to procurement systems and making relation between risk allocation and prices, it is emphasized on the importance and prioritization of risks. The results showed the validity of hypotheses related to prioritization of risks and strategies of responding to risk used in the stage of qualitative evaluation of model.

**Key words:** Procurement; Construction projects; Construction risk

### 1. Introduction

The assessment of previous researches show that the most used terms regarding the research topic include Procurement Methods, Procurement Route, Procurement System, Contract Strategy, and Procurement Strategy.

The terms "contract strategy" and "procurement system" are used as synonymous (Love, Skitmore and Earl, 1998). Also, in procurement systems, the terms of "pricing mechanisms" and "contract forms" are considered as terms which are close to each other and sometimes used as synonymous (Flouse, 1993; Hibberd and Basden, 1996). Developing different definitions regarding procurement system has become a frequent and common issue in construction industry (Love, Skitmore and Earl, 1998).

Frances (1984) describes a combination of employer's activities to achieve a structure as the construction procurement system. In fact, the term of "construction procurement system" explains the applied method or organizational structure to obtain a product such as a construction project. Masterman (1992) defines the term "construction procurement system" as an organized structure accepted by the employer for managing the design and construction of a building project.

Love, Skitmore and Earl (1998) define "construction procurement system" as an organizational system specifying the responsibilities

and authorities granted to individuals and organizations and determining the relations between different components of a project. This definition is used by researcher in this study, because it is the most used definition in recent sources of construction procurement.

"Contract strategy" and "procurement strategy" are used as common terms to explain the role of procurement in construction industry.

Smith (1998) defines the term "contract strategy" as the process of main components for determining how to apply a project procurement system. He has also stated that the contract strategy for each project must be developed based on results obtained from evaluating the available choices regarding the application and management of design and construction.

In trade and industry, the term "procurement" is defined as the maintenance and selection process of required systems to provide goods and services. Traditionally, the term is defined as purchasing specialized goods, services, materials, machineries and the other items related to production. However, this definition has been used in production industry for a long time; in fact, in recent years, the term of procurement strategy has been developed and become common in construction sources. Anyhow, Mac Dermott and Jaggar studies have showed that in spite of common application of the term "procurement" in construction industry, there is not a common agreement regarding its meaning in industrial society.

\* Corresponding Author.

## 2. Main body

Based on each project nature, it includes certain unavoidable risks called project specific risks. These risks have sometime been analyzed and classified by different analysts. The following examples are obtained from Abrahamson analyses:

- Physical actions: including physical conditions, the cost of tests and samples, weather, preparing the place, labor force, materials, devices, time, financial issues, and so forth.
- Delays and arguments: including arguments regarding ownership, ambiguity of information, ineffective implementation of activities, and plan as well as delays beyond the control of parties.
- Orientation and supervision: in this regard, it is needed to avoid greed, impatience, deficiency, irrationality, prejudice, weak communications, and the errors in documentation, incomplete plans, improper selection of consultants or contractors, and the changes in required conditions.
- Persons or properties damages:
- External factors: government policies on taxes, labor forces, adopting new laws; refusal of planning permission; financial constraints; payment constrains; boycotts; strikes; threats; war or civil unrest; and so forth.
- Payment: in this regard, it is needed to consider decline in the value of the country currency, legal restrictions on profit growth, the contractor's or employer's inability to pay debts, funding constraints, fluctuations in exchange rates, inflation, replacement cost of machinery and equipment, and so forth.
- Law and arbitration: in this regard, it is possible some problems to be emerged as delays in resolving disputes, ambiguity of contract, decision making under pressure, new interpretations of laws

It is possible to detect a lot of other risks through different classification systems. Actually, any factor significantly affecting the outcomes of a project can be considered as a risk. In each project, the selected procurement system can only help for detecting and managing the effective risks and it cannot provide the accurate nature or features of them.

Any construction project includes some risks and is affected by uncertainty. In fact, the cost of risks must be accepted and managed by parties. The main goal of procurement system is to share the risks among different parties involved in the project. Therefore, each procurement system provides different choices for transferring risks and accepting them by involved parties.

The employer decides how to share the risks among the parties through contract conditions. The decisions made regarding the risks include accepted risks, risks transferred to contractors or insurers, and risks shared among parties. Usually, risks are transferred to the party who is able to control them better. This encourages the parties to make decisions according to the project objectives. Anyhow, the

party who is responsible for the risk is encouraged to do the best actions and provide the best financial values for employer. To obtain effective procurement criteria, it is needed to accurately define them and specify their quality. To begin the procurement logically, it is needed to separate criteria from each other. Also, it is needed to develop a rating system to show the importance of each criterion. This can be considered as an important part of decision making framework applied for procurement strategies selection.

Considering the procurement criteria separately can help for simplifying the complicated relations between them. The complicity of criteria can be resulted from factors such as contractor's performance or uncertainty of risk when choosing the procurement strategy.

All risk management methods emphasize detecting the risks sources at the beginning. To do this, it is needed to specify the existed risks and classified them appropriately. The classification process is important, because the risks affecting project or organization can be organized through it. Different methods are proposed for classifying the risks.

Hayes and Perry (1985) have provided a comprehensive list regarding the risk factors including risks collected from different sources and the risks being realized by contractors, consultants and employers. Chapman and Cooper (1987) classified the construction risks according to their nature and importance. Their classification included two groups of risks as primary and secondary risks. Tah et al. (1994) applied the structure of risk breakdown according to its origin and impact position. Verba (1996) developed a combined method using Tah's as well as Chapman's and Cooper's methods.

In this research, the hierarchical risk breakdown structure (HRBS) is used. The hierarchical risk breakdown structure (HRBS) allows risks to be separated into those that are related to the management of internal resources and those that are prevalent in the external environment. External risks are known as relatively uncontrollable risks while internal risks are relatively more controllable. External risks such as inflation, fluctuations in exchange rates, natural disasters, and so forth are needed to be assessed and predicted because of their uncontrollable nature. Therefore, it is needed to develop a project strategy for managing and controlling the effects of external factors.

## 3. Methodology

In this research, the methodology includes following stages:

### 3.1. Assessment of resources

The beginning stage of this research includes studying the available resources regarding risk management and construction procurement. This

was necessary to allow a clear understanding of the issues found in both studied fields. Data sources used in the research include articles published in journals in relation to the fields of research, World Wide Web, books, construction industry reports, journals and theses related to research topic, database, libraries, and construction industry procurement sector activists' opinions.

### **3.2. Developing procurement selection model**

In this stage, the data collected through assessing the resources are applied to develop procurement selection model for engineering and construction projects based on identification and management of risks.

### **3.3. Case study and a sample of procurement selection model**

In this stage, it was attempted to show the efficiency of research through a case study and developing a sample of procurement selection model for a construction project.

### **3.4. Comparison of results, conclusion and research suggestions**

The model of decision making for procurement selection was compared with the case study of a real project, and then the conclusions were drawn from the findings as well as suggestions were provided for future researches regarding procurement selection model.

## **4. Discussion and results**

Risk management and analysis are paid attention during recent decades (Tah and Carr, 2000). Risk management focuses on evaluating investment and reduction of costs. It is also applied for major projects as an important part of project management to achieve financial goals of the project.

In spite of the fact that the risk management is considered as an increasing component in major projects, there is no standard to be referred regarding its methods and factors. Therefore, in recent years, it is seriously paid attention to development of formal processes for risk management. Hence, Association for Project Management (APM) has developed Project Risk Analysis and Management (PRAM) according to Chapman and Ward (1997).

Some organizations and institutes have developed several methods for describing the process of risk management. Most of them have identified 3-5 stages regarding the process of risk management. Buchan (1994) has defined three stages as risk identification, analysis and reaction for the process of risk management. Bostwick, Nummedal et al., (1987), Namdal et al. (1996), and Aluf et al. (1993) have detected 5 process regarding

risk management. Also, Project Management Institute (PMI) has detected 3 processes for risk management through PMBOK (Project Management Body of Knowledge). In this research, PMBOK has been selected as the system describing process of project risk management and the role of procurement in responding to risk.

### **4.1. Project risk management- PMBOK system**

The processes defined by PMBOK include identification, analysis, and reaction. The objectives of these processes are to maximize the results of positive events as well as minimize the outcomes of negative events.

### **4.2. Risk identification**

Risk identification includes determining the risks affecting the project. In risk identification process, it is paid attention to both external and internal risks. Also, the process should classify the risk primary sources according to their effects on project costs, scheduling, and objectives.

Risk identification is a necessary process and it should be done based on the project historical and current data before analyzing process. Also, it is needed to perform risk identification regularly throughout the project. The most used methods of risk identification are as follows:

- Identifying the potential sources of risk through the reactions of other projects and assessing the lists containing the risks.
- Providing notification lists as a general structure according the project management aspects as.
- Analyzing the hypotheses to discover underlying hypotheses in terms of being valid and practical.
- Interviewing with experts.
- Meeting the project team with experts and shareholders.
- Applying Delphi method to set future perspectives.
- Applying knowledge-based systems which have experienced project risks.

### **4.3. Risk analysis**

Risk analysis includes evaluating the risk and its interactions to evaluate the possible outcomes of the project which it helps for determining the risk events ensuring the reactions. The results of risk analysis process include a lists of opportunities which should be followed and threats which should be paid attention. This process should document the risk sources and events for which the project management team can make decision.

#### **4.3.1. Responding to risk (reaction)**

In this process, the opportunities are reinforced and the threats are responded. Response to threats can be done through one of the following reactions:

- Prevention

- Reduction
- Acceptance

Procurement is one of the tools to respond to risk and it is usually considered as a proper response. For example, the risks related to application of a new technology can be decreased through contracting with an organization experienced those risks. In such circumstances, procurement usually means to exchange a risk for another one.

#### 4.3.2. Classification of procurement systems

There are many approaches regarding classification of procurement systems. Masterman (1992) suggests classifying the procurement systems according to the follows:

- 1- The risks accepted by parties
- 2- The extent of integration of design and construction
- 3- The contractor's payment approach
- 4- The approach proposed by NEDO (National Economic Development Office)
- 5- The approach proposed by Bennett (1985) after Mintzberg
- 6- Perry's classification

First and third approaches classify procurement systems according to their single features; therefore, they cannot provide sufficient basis for selection. Regarding the second approach, although it deals with vital components such as design and construction, it is limited. The approach proposed by NEDO detects 4 different procurement systems that each one includes some varieties, but it does not classify the systems according to their common features.

Bennett (1985) proposed 3 distinct patterns according to the project management perspective for organizing a project that each pattern has constant relations with different kinds of projects. The patterns are as follows:

- 1- Organizations related to standardization that they are planned for the project.
- 2- Professional organizations that are related to traditional construction.
- 3- Problem-solving organizations for project which is related to innovative construction.

Masterman (1992) has stated that the Bennett's approach is too academic for classification objectives and has no relation to main features of procurement systems. Masterman has recommended Perry's as a more appropriate approach for describing main aspects of procurement systems.

Perry (1985) has classified the procurement systems according to the follows:

- 1- Segregated management of design and construction
- 2- Cooperative management of design and construction
- 3- Integrated management of design and Construction
- 4- Special emphasis on management

In this research, Perry's approach is considered as an appropriate approach for classifying

procurement systems, because it includes the main interactions between design and construction processes. However, project management and some modern procurement approaches such as the ones based on cooperation or combined approaches are not included in Perry's classification method.

The recent evaluations done by Mac Dermott and Jaggard regarding the activities of W92 commission of CIB (International Council for Research and Innovation in Building and Construction) showed that in spite of identification of many procurement systems, they can be divided into three general types as follows:

- Conventional or traditional methods
- Design and Construction methods
- Management methods

Above mentioned types are used to detect the organizational form resulted from procurement, but they do not describe the procurement systems accurately. Ayrland (1984) believed that distinction among procurement systems were meaningless; anyhow, it was not proved. Today, many sub-classifications have developed in above mentioned types. Fig. 1 shows the modern classifications of procurement systems (Turner, 1997 and Perry, 1985).

#### 5. Selecting an appropriate procurement system

There are different methods for selecting an appropriate procurement system. Due to the expansion and complexity of these methods, it is needed the selection process to be done based on a regular and targeted manner considering the framework of strategic projects general objectives. According to Skitmore and Marsden, The major problems for selecting an appropriate procurement system include the followings:

- (a) There is no one to be familiar with all primary procurement methods.
- (b) There is no agreement among the experts regarding systematization of procurement selection process.
- (c) There is no exclusive set of criteria to perfectly determine the appropriate procurement method.

According to NEDO, it is needed employers correctly determine the project requirements and objectives to ensure the success of procurement selection process. However, it is difficult to detect the most important needs and objectives. Also, it is needed to set aside some needs for some other purposes.

NEDO provides a list of features which are included in the best methods of procurement. Although the list helps for deleting inappropriate alternative methods, it makes it difficult to decide the appropriate method.

Franks (1990) used a rating system based on the ability of each procurement system to evaluate the appropriate criteria. He used a scale of 1-5 in which 1 and 5 meant the minimum and maximum rate, respectively. Masterman (1992) believes that the

application of this method is valid for determining the employers' requests, but there are shortages subjectively.

Skitmore and Marsden (1988) as well as Sing (1990) have applied a multi-criteria approach which is a method for measuring the degree of objectivity. They used NEDO procurement decision making diagram to assist the decision making process.

Bennett and Grice (1990) did the similar activities regarding the decision making process. Also, Skitmore and Marsden (1990) used general analysis within the framework of their theory. General analysis is used to measure the experts' ratings stability for each system against predetermined criteria.

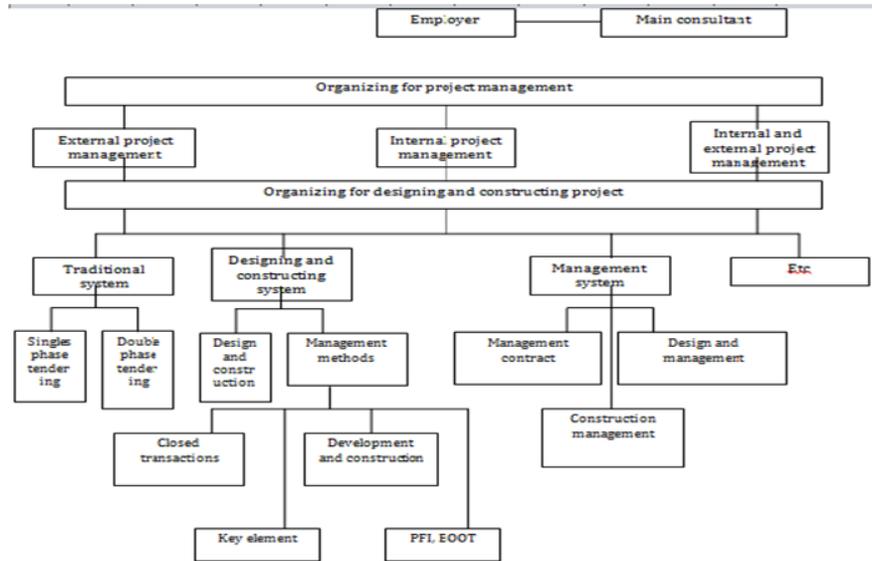


Fig. 1: the modern classifications of procurement systems

Differentiating analysis is used to assess the data collected through criteria forming features which require different procurement systems. Therefore, it helps for differentiate the procurement routes based on the decision making goals.

Liu (1994) proposed the diagnostic approach for selecting procurement system. In the approach, the organizational behavior is modeled as the process of "performance to results". The routes of "performance to products" and "products to outcomes" are known as project diagnosis and post-settlement stages, respectively. Liu (1994) has stated that the organizational behavior is controlled by organizational objectives and the project objectives affect the process of "performance to results". A number of intermediaries such as ability, complexity of activities, and situational constraints affect the relation of "objective-performance"; therefore, they affect the processes of "performance to products" and "products to outcomes". Liu (1994) believes that in selecting the appropriate method of procurement, decision maker should consider the impact of these intermediaries using joint analysis.

There is a software package "ELSSI" including different offerings regarding the most appropriate procurement methods. The software provides questions about parameters of scheduling, quality, design costs, and other features of the project. After evaluating the given information, the software provides recommendations and rates the available methods meeting the employer's needs.

Hayes et al., (1987), believed that developing the appropriate strategy of procurement should be based on the reaction to a risk. Each risk can be rated according its out comings. Therefore, the reaction to a risk can be considered as an important part of project procurement system.

Hibberd and Basden (1996) believed that contracting should be done based on the risk transfer between the parties. This can determine the nature of procurement method so that the employer's objectives are realized. In fact, Hibberd and Basden believed that risk is an outstanding criterion determining the selection of procurement method. The essential goal of this research is to create the main hypothesis applying risk analysis and managing it in the process of procurement selection for construction projects.

### 5.1. Procurement selection model

Fig. 2 shows the procurement selection model designed by the researcher. The model provides the probabilistic method of risk management involvement in process of selecting procurement system for construction projects. The model includes 3 distinctive stages:

- Phase 1: including the entries for selecting a procurement system
- Phase 2: including qualitative evaluation and modeling the project

- Phase 3: including quantitative evaluation and making decision regarding the procurement

### 6. Phase 1: the entries for selecting procurement

This phase includes detecting the necessary entries for selecting a procurement system. In fact, the entries include the employer's required conditions, project risks, and procurement criteria

used for selecting proper procurement system. The other external factors significantly affecting the project out comings should be considered in this stage. It is emphasized on correctly selecting the entries, because they provide the basis for qualitative and quantitative evaluations determining the decisions made regarding the selection of procurement system.

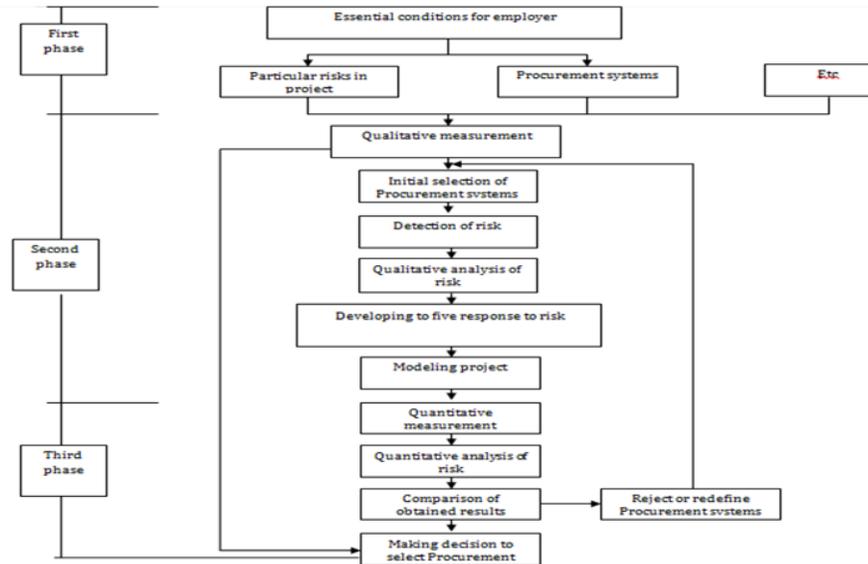


Fig. 2: Procurement selection model based on the risk management

### 7. Phase 2: qualitative evaluation and modeling the project

This stage is after primary selection of several procurement systems. It is possible to upgrade the selected systems to other stages of this phase to develop project model or accept them as project procurement systems in this stage. The qualitative evaluations of procurement systems could be according to the general principles. The next stages leading to develop the project model includes risk identification. The stage is very important, because it detects the specific risks and their relation with other new risks in procurement system. In this stage, it is possible that some risks are deleted or reduced while some risks and their probabilistic impact increase.

After detecting the project risks and applied procurement system, it is needed to quantitatively analyze their impact on the project. This stage is the prerequisite for developing appropriate risk response strategies using the selected procurement system. The objective of "developing risk response" stage is to obtain the desired strategy for risk allocation through the procurement system and contract conditions. The desired strategies of risk allocation are determined according to the economic parameters used for describing financial values for employers.

The next stage includes creating risk simulation model for each project. Each selected procurement system includes a different network of activities for project application in comparison with other systems. Also, different risk parameters are determined for different activities. This creates a basis for project modeling. Regarding each selected procurement system, modeling risk response strategies is considered as a unique feature of that model. This causes more flexibility regarding the comparison of different procurement systems or strategies of risk allocation.

### 8. Phase 3: quantitative evaluation and making decision regarding the procurement

This stage requires quantitative analysis of risk through the project model, comparing the obtained results with other models of project, and making decision regarding adaptation, redefinition or rejection of a procurement system for the project.

The quantitative analysis methods can be probable or definite, but mostly simulation done based on Monte Carlo analysis is preferred, because it is more practical regarding the evaluation of possible outcomes for a project cost. Project outcomes are usually based on the speed of construction, final costs, economic criteria such as NPV and IRR, cash payback period, cash balance, and profit. These variables are samples of variables used in economic analysis and employers can apply them

after comparing the project results through procurement systems.

The final stage of this phase includes comparing the results obtained from alternative project models through the risk allocation strategies and procurement systems. Therefore, it is possible to make decision for adaptation, redefinition or rejection of a procurement system for the project.

Actually, in this stage, the results of quantitative analysis are compared with other factors (such as costs, risk allocation, and the strategy of responding to risk) affecting the decision making for procurement selection. The effective factors should be compared with probable advantages of saving time and money which can be provided through each procurement system.

## 9. Conclusion

In this research, the key variables of procurement systems applied for construction projects were discussed. The variables include project requirements, features, environment and constraints, risks, and procurement criteria. The findings show that the procurement selection is a complicated process because of many considered variables in the selection process.

The main features of procurement systems and the available methods have been assessed. The procurement system is an important research field which is considered as a key component of project success. The research showed that there is no certain theoretical framework to be used for developing an ideal method for procurement selection.

There are different methods for selecting an appropriate procurement system. Due to the expansion and complexity of these methods, it is needed the selection process to be done based on a regular and targeted manner. The research results showed that most employers and their consultants randomly select the procurement systems without considering an appropriate scheduling, logic and order.

In recent years, many authors have tried to propose the alternative methods to standardize and improve the available procurement selection methods. One of these methods suggested by the researcher is based on identification and management of project risks. For several decades, risk management is successfully applied and there are many resources which consider the issue of risk and risk management in construction, but it is less emphasized on the procurement selection.

The concept of risk and classification of project risks were studied in detail. The assessment of risk management process showed the vital role of procurement selection in developing response to risk. Also, the research showed the importance of prioritization of risks, risk allocation through procurement systems and the relation between risk allocation and price.

In the research, employers' requirements, project features and procurement criteria were assessed

through a selected model. Since the decision making for procurement selection should be based on the qualitative evaluation of the project and procurement criteria, it was attempted to apply a logical pattern regarding the qualitative evaluation of selected model.

In qualitative analysis, each risk was considered by itself and was rated based on its probability and effect on the project. Also, the strategy of responding to risk was proposed using each choice of procurement.

The results showed the validity of hypotheses related to prioritization of risks and strategies of responding to risk used in the stage of qualitative evaluation of model.

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