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Delivery risk analysis within the context of program management using fuzzy logic and DEA: A China case study

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Abstract

The last decades witnessed an increasing number of large construction programs, which have presented a large number of extra risks in terms of management. This is due to the unique characteristics of programs compared to traditional projects. On the basis of definition of a construction program, a mixed approach was employed in this study to explore the management of delivery risk of a construction program. The main contents include (1) build a delivery risk structure for a construction program as the foundation of risk qualitative and quantitative analysis; (2) analyze risk magnitude and assess the efficiency of delivery methods by using fuzzy logic theory and DEA; (3) conduct a case study of the 2010 Guangzhou Asian Games as an example of construction programs to apply and verify the mixed delivery risk assessment approach developed in this study. The result shows that the separate contracting delivery method which was planned to be used for the 2010 Guangzhou Asian Games is not the best choice, which needs to be improved based on the principles of PM contracting and partner contracting. The mixed approach used in the case study can be employed by practitioners to select an optimal delivery method for other construction programs.

Keywords: Construction program; Delivery risk; DEA

1. Introduction

When multiple related projects are undertaken within organizations, the conception of program management is usually used to achieve the benefits that would not be realized if these projects are managed independently (Lycett et al., 2004). Take China as an example, the 2008 Beijing Olympic Games construction program, the 2010 Shanghai EXPO construction program and the 2010 Guangzhou Asian Games, are all examples of programs. These practices of program management introduce new elements into its concept constantly. General definition of program defines it as an extension of general project or as a coordinated management of related projects (APM, 2006; Project Management Institute, 2006). Strengthening on the characteristics of program, to a further step, some specific definitions focus on the peculiar natures of program, such as its learning skill (Thiry, 2002), complex compatibility (Aritua and Smith, 2009) and non-additive effect (Pellegrinelli, 1997). Furthermore, some definitions of program are management oriented, such as from the perspective of value creation processes (Winter and Szczepanek, 2008), and on the basis of becoming or related social constructionist ontology (Pellegrinelli, 2011). However, there is lack of clarity and consistent definition of program as a foundation to achieve the greatest benefits from it (Shehu and Akintoye, 2009). Apart from coping with the concept change from project management to program management, there are other challenges to program managers. They have to deal with the shortage of relevant techniques, effective organizational processes and other uncertain issues derived from the implementation of

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program (Shehu and Akintoye, 2010; Shi et al., 2012; Winch, 2013).

The selection and use of an appropriate delivery method are fundamental to the success of a construction project (Rwelamila and Meyer, 1999). There are a variety of delivery methods that have been used in construction practices such as Traditional General Contracting, Design–Build Method (D–B), Separate Contracting, Construction Management Approach (CM), Design–Manage (DM), Build–Operate–Transfer (BOT), and some other innovative approaches such as cooperative procurement (Maa et al., 2009). There have been extensive studies that investigated factors affecting the choice of delivery methods, and means of selecting and assessing these methods. For instance, Odeh and Battaineh (2002) pointed out that owner interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, and subcontractors are among the top ten most important factors for delivery method selection from contractors' and consultants' point of view.

There are a number of tools to assist decision making process to evaluate delivery methods. For instance, a prototype case-based procurement advisory system and a multi-criterion decision-making methodology using the analytical hierarchy process are both useful methods for decision making during the bidding and tendering stage (Luu and Ng, 2003; Mahdi and Alreshaid, 2005). In addition, multi-attribute assessment and optimization methods are applied as well, such as the multi-attribute utility approach (Ambrose and Tucker, 1999), analytical hierarchical process (Chan et al., 2001), etc.

Among these methods, risk assessment plays a crucial role in selecting delivery method for construction projects (El-Sayegh, 2008). In general cases, a construction project involves some factors that can hardly be described accurately (Pinto et al., 2010). Furthermore, the process of selecting a delivery method should take the efficiency of risk response into account. Fuzzy logic theory and DEA are effective methods to deal with the multiple inputs and outputs because these factors are involved in a typical construction project. Baloi and Price (2003) pointed out that fuzzy logic theory provided a useful way to deal with ill-defined and complex problems in a decision-making environment that incorporates vagueness. Similarly, DEA is a nonparametric linear programming approach that produces a single measure of efficiency for each unit relative to its peers (Charnes et al., 1978).

This research addresses the issue on how to evaluate and select a delivery method based on a case study of the Guangzhou Asian Games as a construction program practice, from the perspective of risk management. Section 2 summarizes the definitions of construction program management into three aspects and analyzes the delivery risks derived from these aspects. Section 3 reviews risk management for a delivery method and its characteristics with reference to a construction program. Section 4 introduces the mixed approach for analyzing delivery methods from the perspective of risk management based on a specific construction program management practice. Section 5 describes the details of the mixed analysis of delivery risk management of the 2010 Guangzhou Asian Games construction program. The results are shown in Section 6. This is followed by conclusions and future research opportunities presented in Section 7.

2. Construction program and its delivery difficulties

2.1. Summary of definitions for a construction program

Shehu and Akintoye (2009) claimed that the lack of clarity and understanding of program management is the biggest barrier to implement program management, which is also the root of other challenges. A clear concept of a construction program management is the precondition for selecting an appropriate delivery method. Generally, program management combines key aspects and achievements of project management with the internal complex compatibility and related external social attributes.

A construction program, aiming for developing and improving project management, is consisted of several single projects. The first aspect of a construction program is based on its basic structure. This basic structure was defined by the Project Management Institute as "Combining value and project management into an effective program management model" (Project Management Institute, 2006) and by the Association for Project Management as "Coordinated management of related projects, which may include related business as activities that together achieve a beneficial change of a strategic nature for an organization" (APM, 2006). Furthermore, since internal projects of a construction program are interactive and restrictive (Alam et al., 2008; Buuren et al., 2010; Lycett et al., 2004), a problem of any one of these projects could lead to a serious issue of the entire program in the end. On the contrary, these interactions and restrictions could also promote the coordination of organizations, and the realization of final goals. Therefore, the second aspect of a construction program should take internal complex compatibility into account. In addition, in manufacturing context, Winter and Szczepanek (2008) utilized practices adopted by a large integrated food group in the UK to illustrate that project management should consider demands of first-level customer as well as demands of second-level customer (i.e. customer's customer). This statement can be extended to a construction program field as well. A construction program not only should pay attention to the demands of the owner or investor for construction itself, but also should attach importance to the requirement of final users in order to realize the social attributes and social values of the construction. This has not been fully considered by the existing definition of program management. In order to fill this gap, external social attributes should be considered as the third aspect of construction program. In summary, a comprehensive concept of a construction program should contain three aspects, i.e. basic structure, internal complex compatibility and external social attributes.

2.2. Difficulties of construction program procurement

Similar to projects, the lifecycle of a construction program can be divided into the following stages: initiation, planning, bidding and tendering, implementation and termination. Among