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Evaluation Factors Influencing Construction Price Index in Fuzzy Uncertainty Environment*

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Abstract

In recent years, Vietnam's economic growth rate has been attributed to the growth of many well-managed industries within Southeast Asia. Among them is the civil construction industry. Construction projects typically take a long time to complete and require a huge budget. Many socio-economic variables and factors affect total construction project costs due to market fluctuations. In recent years, crucial socio-economic development indicators of construction reached a fairly high growth rate. Also, most infrastructure and construction projects have a high degree of complexity and uncertainty. This makes it challenging to predict the accurate project price. These challenges raise the need to recognize significant factors that influence the construction price index of civil buildings in Vietnam, both micro and macro. Therefore, this paper presents critical factors that affect the construction price index using the fuzzy extent analysis process in an uncertain environment. This proposed quantitative model is expected to reflect the uncertainty in the process of evaluating and ranking the influencing factors of the construction price index in Vietnam. The research results would also allow project stakeholders to be more informed of the factors affecting the construction price index in the context of Vietnam's civil construction industry. They also enable construction contractors to estimate project costs and bid rates better, enhancing their project and risk management performance.

Keywords: Construction Management, Price Index, Fuzzy Logic, Project Management, Uncertainty Environment

JEL Classification Code: G32, L74, O18

1. Introduction

The economic growth rate of a developing country like Vietnam in recent years has been attributed to the development and growth of many industries including the construction industry due to rapid globalization and international market integration (Nguyen & Bui, 2020; Nguyen et al., 2018; Phong et al., 2017). However, between 1996 and 2011, more than 70% of the 975 completed projects encountered cost deviations exceeding 10% (Zhang et al., 2019). Fluctuations in construction costs is a major risk to the contractor and the budget of the owner (Akanbi et al., 2019; Ashuri et al., 2012; Memon et al., 2010; Nguyen & Likhitruangsilp, 2017; Sy et al., 2017; Wang & Mei, 1998; Xie & Fang, 2018). Since construction projects take a long time to complete, the construction costs are subject to market fluctuations. For instance, the cost of building in civil engineering and construction projects varies over time due to the complexity and high risk involved. (Dong et al., 2020; Long et al., 2019; Nguyen & Nguyen, 2020; Thong et al., 2020; Tran et al., 2018). For the success of civil construction projects,

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a construction price index is of paramount importance. The construction price index acts as an optimal solution to cost-related issues of infrastructure and construction projects (Elfahham, 2019; Nguyen & Nguyen, 2020). Many developed countries, such as the United States and the European Union (EU) have made substantial use of the construction price index because it helps to reliably predict project costs, prepare the budget at the initial planning level, and track and monitor costs over the life of the construction project (Saar et al., 2019; Wang & Ashuri, 2017). Therefore, this paper addresses important assessment factors that influence the construction price index using the fuzzy extent analysis process (FEAP) to precisely estimate it.

2. Literature Review

The construction price index is an efficient solution for controlling construction costs, allowing contractors to better predict costs and plan budgets to ensure winning bids (Cao & Ashuri, 2020; Dong et al., 2020; Elfahham, 2019). The construction price index has been extensively used by developing nations (i.e., the United States and the European Union). In the United States, Shahandashti and Ashuri (2013) indicated some factors influencing the construction price indexes, including the consumer price index, the gross domestic product, the permits for construction, the currency supply, the production cost index, the price of crude oil and the rate of jobs in the construction industry. The interest rates, investment intention, new empowerment of architects, drawing production, specifications, orders, planned job volume, and construction costs are leading factors that influence construction price indices (Akintoye et al., 1998). In Vietnam, construction price indices are published by the Department of Construction and determined for five types of construction work (civil, industrial, transport, waterworks, and technical infrastructural works). In Vietnam, nine critical factors impacting the construction price index were discussed by Nguyen and Nguyen (2020). Based on in-depth interviews of construction experts, the unemployment rate and population are added to the framework of those factors. Besides, construction contractors in Vietnam also consider other price indicators in addition to the construction price index, such as the building price index, labor cost index, equipment cost index, material price index, etc. In essence, these price indices are subcomponents of the construction price index, as such, their discrete influence partly affects the overall construction price index.

3. Research Methodology

The fuzzy extent analysis process (FEAP) is a systematic instrument for assessing variables or factors (Chang, 1996; Hsieh et al., 2004; Nguyen et al., 2020). It integrates the principles of fuzziness and the analytical hierarchy process (AHP) method (Huynh et al., 2018; Lee, 2014). Fuzziness is a common characteristic of issues related to decision-making problems, along with the benefits of fuzzy logic (Duong et al., 2020; Jocic et al., 2020; Nguyen, 2020; Tomaševic et al., 2020; Vesković et al., 2020). Fuzzy logic is a mathematical logic algorithm that solves the problem of imprecise input data values or uncertainty to make an exact judgment. Fuzzy Logic is an approach to variable processing that allows for multiple values to be processed through the same variable. Fuzzy logic attempts to solve problems with an open, imprecise spectrum of data that makes it possible to obtain an array of accurate conclusions. (Ahad et al., 2017; Nguyen et al., 2017, 2019, 2020; Stanujkic et al., 2015). The fuzzy logic and analytical hierarchy process were conducted based on the group decision evaluation of construction experts in Vietnam. In other words, we developed all the pairwise comparison matrices based on expert input data Therefore, using the FEAP, a set of values instead of a fixed value determines a problem (Stanujkic et al., 2017, 2019). Three main steps are presenting the calculation process of the weights of factors affecting construction price index based on fuzzy logic and analytical hierarchy process are given below (Kwong & Bai, 2003; Phong & Quyen, 2017; Thipparat et al., 2009; Zhu et al., 1999):

Let

$Z = \{z_1, z_2, \ldots, z_n\}$ be an object set, and

$V = \{v_1, v_2, \ldots, v_m\}$ be an objective set.

Then, the extent analysis values for each i^{th} object for goals are obtained and shown as follows:

$\tilde{M}_{g_i}^{j}$

where $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$

Step 1: Obtain priority weights

The value of fuzzy extended analysis synthetic on the i^{th} is expressed as:

$$S_i = \left(\sum_{i=1}^{m} a_i, \sum_{i=1}^{m} b_i, \sum_{i=1}^{m} c_i\right) \otimes \left(\frac{1}{\sum_{i=1}^{n} c_i}, \frac{1}{\sum_{i=1}^{n} b_i}, \frac{1}{\sum_{i=1}^{n} a_i}\right) \quad (1)$$

Step 2: Comparing degrees of possibility

The degree of possibility of $N_2 \geq N_1$ is expressed as follows:

$$V(N_2 \geq N_1) = \begin{cases} 1 & \text{if } b_2 \geq b_1 \\ 0 & \text{if } a_1 \geq c_2 \\ \dfrac{a_1 - c_2}{(b_2 - c_2) - (b_1 - a_1)} & \text{otherwise} \end{cases} \quad (2)$$

Step 3: Obtaining the weight vector
Assume that

$$d'(B_i) = \min V(S_i \geq S_k) \quad (3)$$

for $k = 1, 2, \ldots, n$; $k \neq i$.
Then, the weight vector is given by:

$$W' = (d'(B_1), d'(B_2), \ldots, d'(B_n))^T \quad (4)$$

where
B_i (i = 1,2,…, n) are n elements.
Step 4: Calculate the normalized weight vector

$$W = (d(B_1), d(B_2), \ldots, d(B_n))^T \quad (5)$$

Step 5. Ranking of the factors
After having components weights, the ranking of all factors is known.

4. Results and Discussion

Experts' synthetic fuzzy pairwise comparison matrices would be created. The weights of the critical factors influencing the construction price index are then calculated using the fuzzy scale. The normalized weight vector gained from the matrices of synthetic pairwise comparison is:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m}\tilde{M}_{gi}^{j}\right]^{-1} = \left(\frac{1}{184.4710}, \frac{1}{136.2661}, \frac{1}{99.3572}\right)$$

After applying equation (1), it is possible to evaluate the fuzzy synthetic extent values:

$\tilde{S}_{F_1}$ = (0.0474, 0.0893, 0.1686);

$\tilde{S}_{F_2}$ = (0.0431, 0.0814, 0.1583);

$\tilde{S}_{F_3}$ = (0.0542, 0.1035, 0.1947);

$\tilde{S}_{F_4}$ = (0.0641, 0.1197, 0.2167);

$\tilde{S}_{F_5}$ = (0.0493, 0.0910, 0.1656);

$\tilde{S}_{F_6}$ = (0.0460, 0.0822, 0.1492);

$\tilde{S}_{F_7}$ = (0.0465, 0.0834, 0.1516);

$\tilde{S}_{F_8}$ = (0.0401, 0.0737, 0.1404);

$\tilde{S}_{F_9}$ = (0.0588, 0.1086, 0.1951);

$\tilde{S}_{F_{10}}$ = (0.0516, 0.0981, 0.1845);

$\tilde{S}_{F_{11}}$ = (0.0376, 0.0690, 0.1319).

And

$d'(B_1) = \min V(S_1 \geq S_k) = 0.775;$

$d'(B_2) = \min V(S_2 \geq S_k) = 0.711;$

$d'(B_3) = \min V(S_3 \geq S_k) = 0.890;$

$d'(B_4) = \min V(S_4 \geq S_k) = 1.000;$

$d'(B_5) = \min V(S_5 \geq S_k) = 0.779;$

$d'(B_6) = \min V(S_6 \geq S_k) = 0.694;$

$d'(B_7) = \min V(S_7 \geq S_k) = 0.707;$

$d'(B_8) = \min V(S_8 \geq S_k) = 0.624;$

$d'(B_9) = \min V(S_9 \geq S_k) = 0.922;$

$d'(B_{10}) = \min V(S_{10} \geq S_k) = 0.848;$

$d'(B_{11}) = \min V(S_{11} \geq S_k) = 0.572.$

Therefore, after normalization, the weight vector of critical factors influencing the construction price index is:

W = (0.0909; 0.0834; 0.1044; 0.1173; 0.0915; 0.0815; 0.0829; 0.0732; 0.1082; 0.0995; 0.0671)

As shown in Table 1, the fuzzy weights for the construction price index factors can be found. The research results indicate that the consumer price index is the most significant factor shaping Vietnam's construction price index.

The research results show that the consumer price index is the most crucial factor affecting Vietnam's construction price index. The consumer price index is a percentage value reflecting the relative deviation of consumer goods prices over time. The consumer price index correlates with construction price indices. This is understandable as the fluctuations in market prices directly affect the price of construction materials, which drives construction price index volatility. The consumer price index affects construction price indices as it relates to construction materials, labor, and machinery. The discussion of other related factors is entirely consistent with Nguyen and Nguyen (2020). Although crude oil is not ranked highly, it affects the construction price index during the economic recession or epidemic (for example, the Covid-19 epidemic). It is a strategic commodity being traded every day in international financial markets. Oil price fluctuation impacts the global economy and energy security of a wide range of countries, including Vietnam. Indeed, oil price fluctuations have an effect on people's consumption and enterprises' operations. Falling oil price leads to a decrease in transportation costs, thereby boosting consumption. It helps in cost reduction and profit increase for enterprises, thereby increasing spending capacity and vice versa. In construction, the change in the price indexes of materials, labor, and construction machinery depends on how extensively the oil price fluctuates.

Table 1: The Weights for Factors Affecting the Construction Price Index

Factors affecting the construction price index	Rank
Total construction investment capital	6
Vietnam's stock price index	7
Basic interest rate	3
Consumer price index	1
Total export and import	5
The geographical location of the construction project	9
Crude oil prices	8
Unemployment rate	10
Gross domestic product	2
Foreign exchange rate	4
Population	11

5. Conclusions

The construction industry plays a critical role in Vietnam's national economy (Nguyen, 2020; Pham et al., 2019; Vo et al., 2019, 2020). The success of a civil construction project is primarily influenced by cost estimation. The construction price index is a means of support to estimate and adjust the overall cost of construction. Its prediction helps to foster coordination between the construction contractor and the project stakeholders (Ashuri, 2016; Xie & Fang, 2018). Moreover, it also helps state agencies efficiently enforce and regulate macroeconomic regulations (Ashuri & Lu, 2010; Zhang et al., 2019). Therefore, it is inevitable to determine the essential factors that affect the construction price index to boost the precise cost and overall investment calculation for buildings. The study's findings show that eleven indicators impact the construction cost indices; however, the most significant one is the consumer price index.

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