ISSN: 1687-1006 p
ISSN: 2682-3640 e

The Egyptian International Journal of Engineering Sciences and Technology

https://eijest.journals.ekb.eg/

Vol. 46 (2024) 91–104

DOI: 10.21608/EIJEST.2023.214103.1234

Investigating the significance of Material Price Indicators in Egyptian Construction Projects

Suad Hosny [a], Elshaimaa Elsaid [b,*], Hossam Hosny [c]

[a] *Assistant professor of construction Engineering and Management, Department of Construction Engineering and Utilities, Faculty of Engineering Zagazig University, Egypt*
[b] *Department of Construction and Building Engineering, Zagazig Higher Institute of Engineering and Technology, Zagazig, Egypt*
[c] *professor of construction Engineering and Management, Department of Construction Engineering and Utilities, Faculty of Engineering Zagazig University, Egypt*

ARTICLE INFO

Article history:

Received 29 May 2023
Received in revised form
5 August 2023
Accepted 31 August 2023
Available online 10
September 2023

Keywords:

1st Construction materials
2nd Construction Industry
3rd Prices
4th Building
5th Resource management

ABSTRACT

A country's economic conditions and the success of its construction industry are strongly interrelated. The construction sector is vital to any country's societal and financial development. Prices are known to fluctuate during the implementation phase of construction projects. Construction Material Prices (CMP) represent a large percentage exceeding 60% of the total project cost in Egypt. CMP fluctuate and these fluctuations can be significant enough to threaten the financial conditions of the construction project parties, especially owners, contractors, and suppliers. This research is concerned with identifying the main indicators affecting the CMP and evaluating them in terms of their importance and impact from the perspective of construction experts. The most critical indicators affecting the CMP were identified as thirty-seven indicators. Thirty-three indicators were identified from a literature review, and the remaining ones were identified through interviews with construction experts and brainstorming sessions. These indicators were then categorized into five categories: macroeconomic, economic, market, government, and energy. The questionnaire survey was conducted to rank the indicators according to the calculated relative importance weight. The collected data was analyzed using the SPSS statistical package. The results indicate that the inflation rate, the exchange rate, the interest rate, the local taxes, and transportation costs are critical factors with a mean value of more than 4.

1. Introduction

Large-scale construction projects are becoming more widespread, and their construction costs have been a major area of concern. The success of any construction project depends on accurate cost estimation throughout the planning process. Over the long period from the project's startup to completion, many factors have a considerable effect on the final project cost. Oladipo and Oni (2012) explained that a major restriction to improve construction procurement was building material prices rising. Chakraborty et al. (2020) stated that any construction project can attain its final aim using a wide range of design, material, and method combinations. Construction material are an important contributor to the rate and quality of construction work, as the material cost can represent as much as one-fourth of the total project cost (Hwang et al., 2012). The construction industry's capability to deliver projects within budgeted budgets, on time, and with adequate quality has been jeopardized by rising material costs.

Construction Industry Institute (CII) 2013 mentioned that, construction materials represent a large percentage (50–60) of the total project cost. Construction material pricing is considered one of the most critical tasks in

* Corresponding author. Tel.: +201280259352
E-mail address: shaima.said60@yahoo.com

project budget creation. Al-Hammad (2006) studied the fluctuation in steel bars price in Saudi Arabia. The study indicated that steel prices rose with a sudden change by nearly double what they were. This sudden change in bars prices had a consequential effect on many prices of construction materials. In Egypt the CMP represent more than 60% of the total construction cost as shown in Table 1. According to the construction projects performed throughout the period (2007–2017) in Egypt based on the available data of the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS), which publishes yearly reports containing the quantity of construction work performed and the construction materials used at the republic level.

Table (1): Quantities and materials prices for Egyptian construction projects (CAPMAS)

Year	Quantity of construction work (Millions)			Materials prices (Millions)		
	Public	Private	Total	Public	Private	Total
2007	13967	18021	31988	10381	11334	21715
2008	19241	28356	47597	14300	18761	33061
2009	23158	30730	53888	17369	11334	28703
2010	21691	29181	50872	14606	18806	33412
2011	14778	28274	43052	9995	17422	27417
2012	14017	23224	37241	10690	14742	25432
2013	15676	25742	41418	12449	15300	27749
2014	20580	31333	51913	15951	17073	33024
2015	23928	39828	63756	18758	24049	42807
2016	27132	56438	83570	19454	35062	54516
2017	32363	96939	129302	23508	67928	91436
∑Total Quantity of construction work			**634597**	∑ Total Materials prices		**419272**

$$\%\ \textbf{Material prices} = \sum \textbf{Total Materials prices} \Big/ \sum \textbf{Total Quantity of construction work} \times 100 = 66\%$$

Kholif (2015) established a study covering 102 educational buildings in Egypt throughout 2007 and 2011 and conducted that 32.35 percent of the projects had cost overruns due to two key causes: political uncertainty and material prices escalation.

Hwang et al. (2012) revealed that structural steel prices tripled in Korea from 2001 to 2008. As a result, the profitability of general contractors decreased over the last 5 years or more for most large scale projects, which are awarded by a lump-sum contract. The construction market in Egypt is affected as a result of the rapid and enormous changes occurring worldwide in CMP. The fluctuation in CMP reduces Growth Domestic Product (GDP), which leads to high prices and low market demand for buildings and has a resounding effect on the real world. The fluctuation in CMP become enormous and rapid in such a way that a contractor who offers a fair offer becomes unable to meet the technical requirements and specifications of the various construction items. Volatile and fluctuating prices of resources could create tensions, conflicts, and/or friction in a generally static project. Fig. (1) Presents a closer look at the steel and cement prices as an example for CMP fluctuation, over the last 10 years between 2011 and 2020, according to CAPMAS, which publishes monthly reports containing adjustments in material prices.

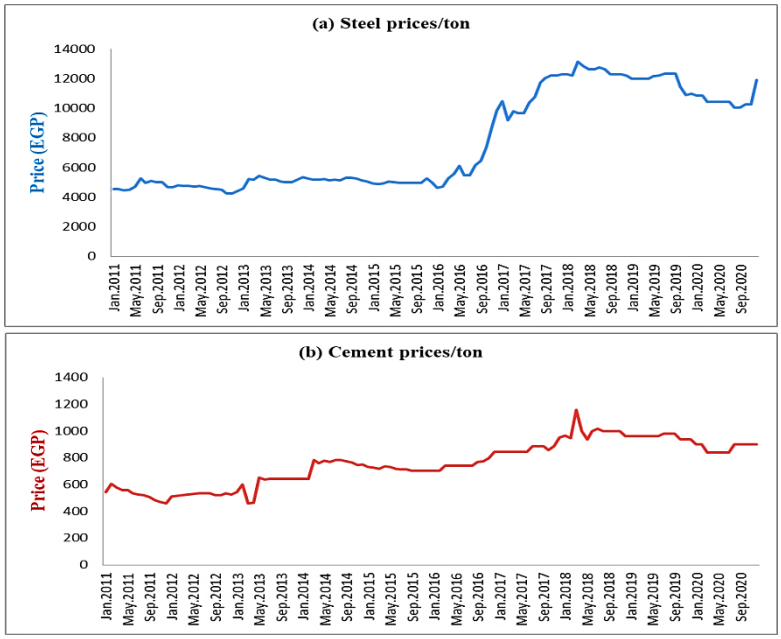

Fig. (1). Material prices (Jan. 2011 - Dec. 2020) (CAPMAS): (a) Steel (b) Cement.

2. Study Objectives

Several studies have discussed factors that affect CMP in various ways; some articles identified only macroeconomic factors, while other searchers discussed only economic factors. The distinction of this search is identifying all types of indicators affecting CMP in Egyptian construction public and private projects and determining the percentage of this effect on the construction materials. This study is a part of the existing body of knowledge that treating effectively the causes of fluctuations in the CMP. The goals of this study are to:

[1] Discover and analyze fluctuations in actual material prices.
[2] Identify the indicators affecting price fluctuations.
[3] Evaluate the effect of each indicator.
[4] Identify significant material price indicators in the Egyptian construction market.

To satisfy the research objectives, this study is organized as follows. The subsequent section is a literature review on studies interested in material prices. The next section describes the recommended research approach and the steps taken in this study.

3. Literature Review

3.1 Studies for material price factors

Oladipo and Oni (2012) have analyzed macroeconomic factors' impact on material prices in Nigeria. Architects, quantity surveyors, builders, engineers, and bankers (economists) were among those who received questionnaires. According to the study, inflation, exchange rates, imports, interest rates, and money supply all have a substantial impact on building supplies prices. It was discovered that the exchange rate, inflation rate, and interest rate all had a strong association with the prices of construction materials. According to the research, import taxes should be reduced, the exchange rate should be kept as low as possible, and interest rates on bank loans should be reduced, while the government should maintain a stable inflationary trend.

Windapo and Cattell (2012) studied the building material prices trends in South Africa. The study explored if there are differences in perceptions of important factors influencing building material pricing. The research concluded that building material prices particularly; cement, copper, and reinforcing steel, are escalating rapidly in South Africa. Stakeholders in the built environment were aware of and well-informed about the building material that are subject to volatility in price, and the factors affect them, such as transportation costs; crude oil prices; labour costs; and energy costs. According to the findings to solve the problem of rising building material prices in the South African, additional attention should be made to certain factors, such as transportation costs, crude oil prices, labor costs; and energy costs, as well as highly volatile building materials like steel; copper; and cement.

Abdel-Wahab et al. (2018) identified the primary factors that are likely to influence the accuracy of the construction materials cost estimate in Egypt, 46 factors have been identified from literature review, twelve factors have been

identified as most critical factors. These factors included: fluctuation in raw material prices, project materials monopoly by some suppliers, fraudulent activities by subcontractors, standard procedure for updating cost information, poor contractor experience for project type, improper planning and errors during construction, engaging in adequate labour skill, and waste control during material usage location of the project, improper construction methods, and improper supervision at site and control.

Rajaprabha et al. (2016) investigated factors influencing building material costs in construction projects. The study conducted in India using a questionnaire survey to identify the most important elements and factor categories that influence cost overrun and cost escalation in building projects. The research results were that design issues; client issues; contractor issues; site issues; labour and equipment issues; store issues; external issues; and market condition issues are all responsible for cost overruns in building construction projects. Design errors and market conditions were the two most significant factors that cause cost overruns.

Obeng and Danso (2020) figure out the elements that impact building material pricing decisions in Ghana. To obtain data, self-administered questionnaires were distributed to construction specialists and building material suppliers. The primary elements that influence pricing decisions for building supplies were identified using factor analysis. The six significant factors have been recognized as market, producer, economic, political, and environmental issues. It has been suggested that identified factors must be regulated by stakeholders to avoid rising building material prices.

Adegbembo and Adeniyi (2015) explored the impact of several macroeconomic parameters on building material prices. Inflation, exchange rates, and interest rates are all crucial macroeconomic variables that have a great effect. The study's hypothesis is that these macroeconomic factors have no substantial impact on building material pricing. Quarterly data for this study were acquired from published sources over a period of 11 years, from 2003 to 2013. Multiple regressions were utilized in the research, and the results revealed that interest rates, inflation, and exchange rates all had a significant positive impact on building material prices. They recommended that import taxes have to be reduced, the exchange rate is kept as low as possible, and interest rates on bank loans be reduced, while the Nigerian government and central bank devise measures to control and stabilize key macroeconomic indicators.

3.2 Studies for cost and price predictions

Shiha et al. (2020) suggested three models that use Artificial Neural Networks (ANNs) to forecast future costs of major construction materials, such as steel reinforcing bars and Portland cement six months forward in Egypt. The proposed models were trained, tested, and validated using historical data of steel and cement prices, and macro-economic factors. The selected indicators, such as gross domestic product, unemployment rate, and Consumer Price Index, are used as inputs to the suggested ANN models (CPI).

Oghenekevwe et al. (2014) established a relationship between the inflation and CMP in order to develop a model for predicting the impact of inflation. Data was acquired from more than official source like Nigerian Institute of Quantity Surveyors (NIQS) publications, the Central Bank of Nigeria (CBN), and National Bureau of Statistics (NBS) records. The data was subjected to regression analysis, and the results revealed that the inflation rate and material costs have a third-order polynomial equation relationship. The substantial level of correlation found in the results led to the conclusion that the inflation rate could be used to predict construction materials prices. Other macroeconomic parameters, such as importation; interest rates; GDP; and political regimes are also found to contribute to the increasing tendency in price movement, according to the study.

Wang et al. (2017) created a novel methodology to determine conceptual costs of construction projects. The proposed model combines four mathematical methods, or "sub-models," including (1) the component ratios sub-model, (2) a regression sub-model, (3) a multi-factor evaluation sub-model, and (4) a sub-model based on a fuzzy adaptive learning control network (FALCON) and fast messy genetic algorithm (fmGA). This work also does sensitivity analysis and evaluates two modified models without taking fmGA into account to closely explore the behaviour of the proposed model. The evaluation results show that the proposed model is highly likely to increase estimation accuracies more than the three traditional methods, i.e., average unit cost, component ratios, and linear regression methods, due to its capacity to respond to the project characteristics in a more thorough manner.

Chakraborty et al. (2020) compared the prediction accuracy of six different machine learning (ML) algorithms: linear regression, artificial neural network, random forest, extreme gradient boosting, light gradient boosting, and natural gradient boosting. It was shown that, based on the prediction accuracy, uncertainty estimate, and model training speed, a hybrid light gradient boosting and natural gradient boosting model offers the most desirable construction cost estimates of structural assemblies. The hybrid model not only provides estimates of forecast uncertainty but also more precise building cost estimates. With the suggested model, we may assess the upper and lower bounds covering 95% of the prediction distribution.

Swei et al. (2017) proposed a method for cost estimation that combines least angle regression for dimensionality reduction with a maximum likelihood estimator for data transformations. The proposed technique is used by the authors for 15 different pavement bid items in five different US states. The study's findings show that the suggested method frequently yields reliable parametric estimates that deal with the structural bias and heteroscedasticity that hamper the present methods for cost estimation. For large-scale building projects, when conventional approaches routinely underestimate anticipated construction costs and overestimate the associated variance, both of these factors are especially crucial.

Elmousalami (2019) constructed a system for conceptually estimating project costs. The suggested methodology can retain cost prediction uncertainty while automatically identifying major cost drivers. The proposed methodology is validated using a case study of Field Canal Improvement Projects (FCIPs). The recommended methodology has employed quantitative approaches to identify the primary cost drivers. The methodology has also implemented a genetic fuzzy model that produces fuzzy rules automatically in order to estimate the conceptual cost. The results also demonstrate that the genetic fuzzy model outperforms the conventional fuzzy model in terms of performance. Additionally, this study provides a publically accessible dataset for FCIPs that may be used for the analysis and validation of future models.

4. Research Methodology

During the conceptual stage of a building project, it can be difficult for the project estimator to estimate costs accurately (Wang et al., 2017) .Construction material prices are very critical in estimating a construction project's budget. Estimating a budget for a future projects in an accurate manner is a hard mission because of the fluctuations in material prices. This study examines the relationship and influence of the most significant indicators on CMP in Egypt, in order to fill a defined deficit in the literature. This section outlines all of the measures that were taken to meet the study's objectives. The process map of the procedures used in this research is shown in Fig. (2). Relevant information about the necessary data, where and how the data was collected, and how a sample was chosen is included in the procedures. The following is the sequence in which this research is carried out:

1. A literature review was conducted to investigate recent works in this research area.
2. Identification, modification, and categorization of indicators affecting CMP based on the previous literature review and brainstorming sessions.
3. A questionnaire survey to identify the indicators importance level in the Egyptian construction sector.
4. Data analysis to identify significant indicators.

Fig. (2). Research methodology

As there are limited empirical studies, the available literatures, as well as practitioners' opinions were considered when producing the questionnaire's list of indicators affecting CMP. In order to achieve the study's goals, primary data on the indicators impacting CMP were acquired from previous studies. After the methodical literature review, a list of 33 indicators have a certain impact on CMP was deduced. A method for establishing a communication process for a group of experts to investigate the significance of these indicators is used to consolidate a complete list of possible indicators affecting CMP. This brainstorming strategy enables for conversation among the invited specialists, allowing for the introduction of innovative ideas that go beyond what is currently known or believed. More significantly, the opinions obtained can be modified to reach an acceptable level of agreement. As a result, the invited experts can investigate new aspects from multiple viewpoints and come up with an agreed list of possible indicators affecting CMP for the questionnaire.

A wide sample was gathered, including specialists from owners, contracting, consulting, and academic backgrounds, all of whom had at least 20 years of construction experience and superior project management skills. This approach was divided into two sections. The first one was focused to learn more about the subject and requesting participants to submit potential indicators affecting CMP. The second one was interested in evaluating the impact of these indicators from their point of view. The interviews were semi-structured, with prepared questions and room for digging when

necessary. The most important questions posed to the experts were "Do you think, in your expert opinion, this indicator affects CMP?", "In which category can this indicator fall?" and "Are there any other indicators you might like to add?. This helps the study to look at new indicators that have been neglected in previous research. The indicators outlined in the previous step, as well as those from the literature, were presented to each expert in the second session. The conversation was then resumed in order to reach an agreement, which resulted in the identification of 37 indicators representing five agreed categories; macroeconomic, economic, market, government, and energy (Table 2). Following that, a questionnaire was created to assess the impact of these indicators on CMP. Table (3) indicates the category of each indicator.

Table (2): Construction material prices indicators, and their sources.

NO.	Indicator	Source (Year)
1.	Project Materials monopoly	Abdel-Wahab et al. (2018)
2.	Unemployment rate	Ashuri et al. (2012) Faghih and Kashani (2018)
3.	Industrial gas price (IGP)	Faghih and Kashani (2018)
4.	Employment rate in construction (ER).	Shahandashti and Ashuri (2013) Shahandashti and Ashuri (2016) Faghih and Kashani (2018)
5.	Building permits (BP)	Shahandashti and Ashuri (2013) Shahandashti and Ashuri (2016) Faghih and Kashani (2018)
6.	Housing starts	Shahandashti and Ashuri (2013) Shahandashti and Ashuri (2016)
7.	Cost of labor and plant	Akanni et al. (2014)
8.	Scarcity of building raw materials	Akanni et al. (2014)
9.	Exchange rate	Akanni et al. (2014) Windapo and Cattell (2012)
10.	Interest rate and cost of finance	Akanni et al. (2014)
11.	power supply	Akanni et al. (2014)
12.	Cost of transportation and distribution	Akanni et al. (2014)
13.	Local taxes and charges	Akanni et al. (2014)
14.	Political interference (Government policies and legislation)	Akanni et al. (2014)
15.	Black market	Alfouzan and Khalafallah (2014)
16.	Domestic demand for infrastructure	Alfouzan and Khalafallah (2014)
17.	Average hourly earnings (AVE) Egypt wages	Shahandashti and Ashuri (2013) Shahandashti and Ashuri (2016) Faghih and Kashani (2018)
18.	EGX index	Ashuri et al. (2012) Shahandashti and Ashuri (2013) Cao et al. (2015) Shahandashti and Ashuri (2016)
19.	Producer Price Index	Ashuri et al. (2012) Jiang et al. (2013) Ernest et al. (2019)
20.	National revenue	Jiang et al. (2013) Ashuri et al. (2012)
21.	Balance of Payment	Oladipo and Oni (2012)
22.	External Debt	Oladipo and Oni (2012)
23.	External Reserve	Oladipo and Oni (2012)
24.	Export	Oladipo and Oni (2012)
25.	Import	Oladipo and Oni (2012) Windapo and Cattell (2012)
26.	Supply and demand	Oladipo and Oni (2012) Windapo and Cattell (2012)
27.	Inflation rate	Akintoye et al. (1998) Olatunji (2010) Windapo and Cattell (2012)
28.	Manufacturer's profit	Windapo and Cattell (2012)

29.	Electricity Cost	Windapo and Cattell (2012)
30.	Gross domestic product (GDP)	Olatunji (2010)
31.	GDP-construction	Wong and Ng (2010)
32.	Money supply (MS)	Akintoye et al. (1998)
33.	Building cost index (BCI) (Egypt Construction Output)	Wong and Ng (2010)
34.	industrial production (IP)	Experts' point of view (2020)
35.	Real houses prices	Experts' point of view (2020)
36.	National expenditure	Experts' point of view (2020)
37.	Seasonal change	Experts' point of view (2020)

Table (3): Construction material prices indicators categorization, and description

Category / Indicator		Description
Macro – economic	1)Balance of Payment	Record of all transactions between an organization in a country and organizations around the world over a specific period.
	2)Exchange rate	The amount for which one currency is exchanged for the other, also used to determine the strength of one currency against another.
	3)External Debt	The country's debt which is financed by foreign lenders such as commercial banks, governments, and international financial institutions.
	4)External Reserve	The foreign assets held or managed by the central bank of a country.
	5)Export	Quantity of products and services manufactured in one country and sold to customers in another.
	6)Gross domestic product (GDP)	Measure of a country's economic output and income.
	7)GDP-construction	The added value of the construction sector to GDP.
	8)Import	Imports are goods or services purchased in one country and produced in another country.
	9)Inflation rate	General trend in an economy which measures how the prices of goods and services rise over time.
	10) Interest rate	The amount charged by the lender for the use of the asset, represented as a percentage of the principal.
	11) Money supply (MS)	All currencies and other liquid commodities in the country's economy on the measured date.
	12) Producer Price Index (PPI)	The amount of raw materials and services prices change as they move out of the manufacturing process.
Economic	13) Building cost index	A price index that compares changes in the costs of production elements to average price levels in the base year.
	14) Building permits	Permissions that the government or other regulatory agency must grant to legally construct new or existing buildings.
	15) Housing starts	The number of new residential construction projects that begin at a certain point in time.
	16) Industrial production growth rate	The growth rate of industrial production is closely related and affects the economy, which affects construction prices.
	17) Manufacturer's profit	Margin achieved when a manufactured object or finished product is transferred out of the factory at a price that exceeds the manufacturing cost.
	18) Supply and demand	The term supply refers to the amount that a supplier of a particular product, item, goods, or service wants to be available at a given price. Demand is the amount that consumers of a product or service are interested to buy at a particular price.
Market	19) Average hourly earnings	The hourly average income rate is calculated by dividing the total income earned by the average of the weekly working hours.
	20) Black market	Economic activities that take place outside of government-approved channels.
	21) Cost of labor and plant	All wages paid to employees and permanent establishments are added together.
	22) EGX index	A significant stock market index that tracks the performance of the Egyptian exchange's most liquid stocks. A free float-based weighted index.
	23) Employment rate	A measure of how much work resources available (people available for work) are used. Employment rates affect investment and construction demand.
	24) Project Materials monopoly	A monopoly exists when a company and its product offering dominate a sector or

		industry.
	25) Seasonal change	The construction industry's equipment, personnel, materials, design, and applications affected by temperature change.
	26) Scarcity of building raw materials	Shortage of metal and mineral resources.
	27) Unemployment rate	Percentage of the workforce that is unemployed but actively seeking work.
Government	28) Cost of transportation and distribution	Expenses include the costs associated with the transportation of goods.
	29) Domestic demand for infrastructure	Economically, infrastructure often includes the production process of public goods that support a natural monopoly like: transportation systems; telecommunications networks; sewage; water; and electrical systems.
	30) Local taxes and charges	Taxes are compulsory charges levied on individuals or companies by a government agency at the local, regional or national level.
	31) National revenue	The funds obtained by the government from taxation and non-taxation sources and used to cover government expenditures.
	32) National expenditure	The total amount of government spending.
	33) Political interference	Intentional government interference with the country's economic system through regulatory measures. This refers to situations where the government is actively influencing individual or organizational decisions.
	34) Real houses prices	Is the ratio of the property price index to the deflator of consumer spending in each country.
Energy	35) Electricity Cost	The present value of the price of electricity generated (usually expressed in pounds per kilowatt hour).
	36) Industrial gas price	The price of natural gas used whether by manufacturing companies or mining or other mineral extraction, as well as consumers in the construction industry for heat, electricity or chemical raw materials.
	37) Power supply	The price of energy types needed for both manufacturing, and distribution of raw materials.

5. Questionnaire Survey and Data Collection

The questionnaire survey is the most common and cost-effective method of collecting information about thoughts, opinions, and behaviors among the numerous data collection methods, and it is extensively employed by researchers in the construction management discipline. As a result, a questionnaire survey was chosen as the best tool for this research. The questionnaire was created to assess the degree of significance of the indicators that affect CMP from the specialists' and experts' points of view. For this purpose, the indicators were categorized after a brainstorming session with ten experts who have experiences more than 20 years in the field of construction into five categories. Then the sample size is calculated according to Equation 1.

$$N = \frac{z^2 * P\,(1-P)}{\varepsilon^2} \qquad (1)$$

Where N is the sample size for an infinite population, Z value equals 1.654 when confidence level equals 90%, P is the proportion of the population, i. e., P degree of variance between the elements of the population (the critical value of P is 0.5), ε is the acceptable margin of error = 10% for the confidence level of 90%. According to I Taherdoost (2017), when calculating the sample size for the proportion, the level of greatest variability (P=0.5) is used. This results in a more conservative sample size. By substitution of these parameters in equation (1), for this investigation, a sample size of 68 people is necessary.

The questionnaire is sent to construction-related people who work for either public or private contractors and engineers who hold various positions. This questionnaire, which is used to implement the research plan; is divided into two sections: contextual information about the respondents was requested in the first section, for example, name, years of experience, job title, company name, and company type. Waris et al. (2014) identified confidently that "the value of demographic information for a meaningful quantitative analysis cannot be underestimated". As a result, special attention was paid to the first section of the questionnaire survey to the respondents' histories and general demographic information. The second part of the questionnaire focused on the indicator categories. Two more blank rows were provided to allow the participant to add any additional indicators and therefore confirm the CMP indicator list.

The scale method of questionnaire design introduced a five-point Likert scale that included (1) not important, (2) less important, (3) moderately important, (4) highly important, and (5) very highly important. Any respondent was asked to provide numerical scores (1–5) based on their experience in Egyptian construction projects in front of each key indicator, along with their opinion. Personal meetings, telephone calls, and mailings were often used to complete

the questionnaire template, reaping the benefits of each approach.

5.1 Responses

The information was gathered from a variety of construction industry professionals and specialists in Egypt. The questionnaire was sent to 200 people who work in the construction field and material whether in public or private sector Fig. (3). (a) indicates the demography of the respondents. The survey was answered by a total of 81 responses from construction-related fields. The research achieved an overall response rate of 40.5%. Fellows and Liu (2003) recommend a minimum response rate of 30% to be regarded as satisfactory. The highest response rate was obtained from civil engineers with 34.5% and project managers with 14.8%, as shown in Fig. (3). (a). The collective response from the groups within the construction sector eliminates any bias of opinion that would have emanated if responses had been taken from one group. Out of eighty-one respondents, 37% of them have between one to five years of experience in the field of construction, while 12% of them have more than 20 years of experience, as shown in Fig. (3). (b).

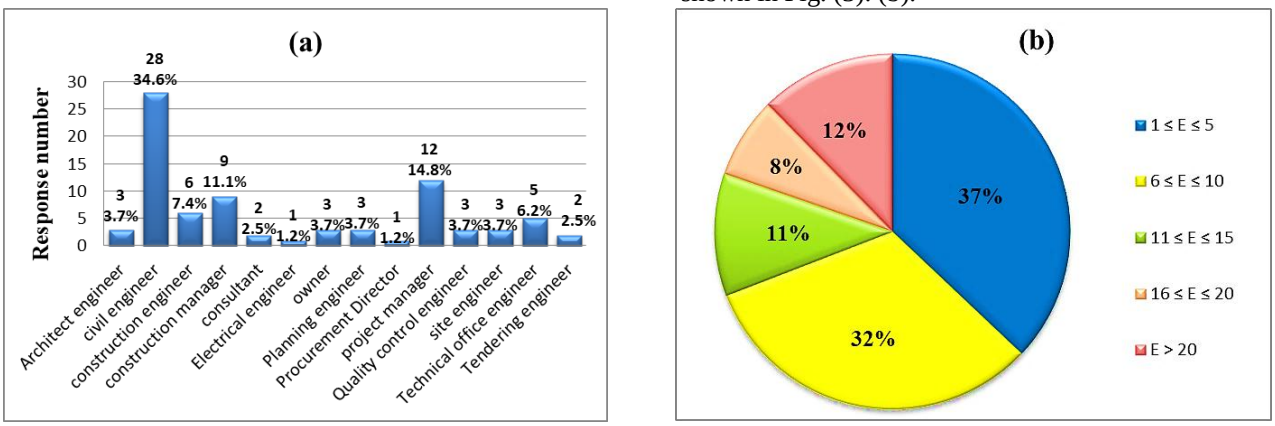

Fig. (3). (a) The demography of respondents **(b)** Questionnaire respondents previous experience (years) in construction

6. Data Analysis

6.1 Reliability

A quantitative analysis approach is used to assess the collected data. Overall, the statistical analyses used in this study analyzed the relationship between 37 indicators and CMP. Reliability analysis was conducted to calculate the Cronbach's coefficient Alpha to satisfy the condition of the accuracy of the data collected. Using SPSS statistics 25, measure the reliability index to calculate Cronbach's coefficient Alpha. The Cronbach's alpha coefficient usually varies from zero to one. The closer the Cronbach coefficient is to 1.0, the greater the target's internal accuracy. The average Alpha coefficient of Cronbach for the variables was found to be 0.894. This importance means the acknowledged accuracy and validity of the questionnaire data. The indicators (unemployment rate, seasonal change, average hourly earnings (AVE), and exchange rates) were found to have the highest values of the Cronbach's Alpha if item deleted of 0.9, 0.896, 0.895, and 0.895 respectively. This implies that this factor has the lowest reliability index. While the factors (building permits (BP) and housing starts) were found to have the lowest value of the Cronbach Alpha of 0.886, this means that these factors have the highest reliability index.

6.2 Analysis of Variance

The following hypotheses were generated in order to help the study achieve its goal.
H0: There is no significant relationship between respondents' experience and responses**.**
H1: There is a significant relationship between respondents' experience and responses.

An Analysis of Variance (ANOVA) was conducted to test the variance between the views of the respondents according to their organization and experience. The first ANOVA was based on the respondents' position. The p values (significant levels) of all indicators were higher than 0.05. The second ANOVA was conducted based on the experience of the respondents. The p values (significant level) of all indicators were higher than 0.05. The third ANOVA was conducted based on the experience and the position of the respondents. The p values (significant level) of all indicators were higher than 0.05, which means the null hypotheses (**H0**) will be accepted. The variables (respondents' experience and responses, as well as respondents' position and responses) have no statistically significant association. In general, the ANOVA tests indicated that the views of the respondents were identical

regardless of their position and experience. As a consequence, the whole sample may be considered.

6.3 Relative importance weight

The relative importance weight (RI_w) will be used to determine the degree of importance once it was established that there is no relation between respondents' experiences and responses. After all of the experts' data had been collected and processed, the (RI_w) technique was utilized to determine the relative importance of CMP indicators. The (RI_w) value indicates the significance of each indicator. Shash (1993) proposed this approach for evaluating ordinal data obtained on a Likert scale, and it was later adopted by other researchers to rate factors similarly. Equations (2) and (3) are recommended to measure the relative importance weight for each indicator.

$$(\text{RIw}) = \frac{\sum_{n=1}^{N} W_n}{A * N} \qquad (2)$$

- W is the weighted total assigned by the respondent ranging from 1 to 5.
- A is the highest score, i.e., 5.
- N is the whole number of responses.

The (RI_w) values vary from 0 to 1, with 0 not being included. In line with Chen et al., (2010), Akadiri (2011) assigns the following RII importance levels:

- Low (**L**): $0 < (RI_w) < 0.2$
- Medium Low (**M.L**): $0.2 < (RI_w) < 0.4$
- Medium (**M**): $0.4 < (RI_w) < 0.6$
- High-Medium (**H-M**): $0.6 < (RI_w) < 0.8$
- High (**H**): $0.8 < (RI_w) < 1.0$

The mean, relative importance weight, rank, and standard deviation of each indicator are shown in Table 4 in descending order. If two or more variables had the same mean value, the one with the lowest standard deviation received a higher rating. All of the indicators' mean scores are greater than 1.0, indicating that respondents were generally in agreement about their effect on material prices. Twenty-four indicators out of thirty-seven indicators have been classified as "High" and "High-Medium" relevance, highlighting their essential importance.

Table (4): Ranking of CMP indicator by Relative Importance weight

Indicator	Mean	Std. Deviation	(RI_w)	%(RI_w)	Rank	Importance Level	Category
Inflation rate	4.44	0.65	0.89	89	1	H	Macro–economic
Exchange rate	4.19	0.90	0.84	84	2	H	Macro–economic
Interest rate and cost of finance	4.14	0.90	0.83	83	3	H	Macro–economic
Cost of transportation and distribution	4.02	0.72	0.80	80	4	H	Government
Local taxes and charges	4.11	0.79	0.75	75	5	H-M	Government
Supply and demand	3.90	0.94	0.78	78	6	H-M	Market
GDP-construction	3.74	0.98	0.75	75	7	H-M	Macro–Economic
Domestic demand for infrastructure	3.70	0.81	0.74	74	8	H-M	Government
Producer Price Index	3.62	1.01	0.72	72	9	H-M	Macro–economic
Electricity Cost	3.60	0.96	0.72	72	10	H-M	Energy
Cost of labor and plant	3.48	1.06	0.70	70	11	H-M	Market
Building cost index (BCI)	3.47	1.04	0.69	69	12	H-M	Economic
power supply	3.43	1.08	0.69	69	13	H-M	Energy
Gross domestic product (GDP)	3.42	0.93	0.68	68	14	H-M	Macro–economic
Political interference	3.35	1.21	0.67	67	15	H-M	Government
industrial gas price (IGP)	3.32	1.06	0.66	66	16	H-M	Energy
EGX index	3.20	0.98	0.64	64	17	H-M	Market
Project Materials monopoly by some supplier	3.11	1.21	0.62	62	18	H-M	Market
Employment rate (ER)	3.10	1.12	0.62	62	19	H-M	Market
Building permits (BP)	3.09	1.27	0.62	62	20	H-M	Economic
Seasonal change	3.05	0.91	0.61	61	21	H-M	Market
National revenue	3.04	0.86	0.61	61	22	H-M	Government
Manufacturer’s profit	2.98	0.79	0.60	60	23	H-M	Economic
Scarcity of building raw materials	2.98	1.11	0.60	60	24	H-M	Market
Balance of Payment	2.83	1.00	0.57	57	25	M	Macro–economic
National expenditure	2.81	0.99	0.56	56	26	M	Government
Average hourly earnings (AVE)	2.80	1.01	0.56	56	27	M	Market
industrial production (IP)	2.79	0.85	0.56	56	28	M	Economic
Import	2.73	1.11	0.55	55	29	M	Macro–economic

Export	2.70	1.04	0.54	54	30	M	Macro–economic
External Reserve	2.70	1.08	0.54	54	31	M	Government
Housing starts	2.68	1.16	0.54	54	32	M	Economic
Black market	2.64	1.17	0.53	53	33	M	Market
Money supply (MS)	2.62	0.94	0.52	52	34	M	Macro–economic
Real houses prices	2.59	1.18	0.52	52	35	M	Government
External Debt	2.54	1.03	0.51	51	36	M	Government
Unemployment rate	2.46	1.01	0.49	49	37	M	Market

7. Results and Discussion

This paper attempted to cover the gap between the listed indicators in previous studies and their associated effects by gathering all possible indicators that affect construction material prices in the Egyptian construction market.

The study identified thirty-seven indicators that influence CMP in Egypt. The indicators are macroeconomic, market, government, economic, and energy-related indicators. The findings in this research confirm that a variety of indicators influence CMP and provide a clearer understanding of the essential indicators that are more closely associated with CMP. This research is unique in taking more than one category of influencing indicator into consideration, unlike previous research that was concerned with the influence of one category of factors, as in Shiha et al. (2020), which studied the relationship between macro-economic factors and construction material prices.

As a macroeconomic category, it has a 29 percent importance weight, while the market condition category, government-related indicators category, economic category, and energy-related indicators category have importance weights of 26%, 24%, 12%, and 9%, respectively, as indicated in Figure 4 (a). The findings confirm that macroeconomic indicators are important CMP indicators. Perceived respondents' views of the 37 CMP indicators were determined.

When looking for CMP indicators in the Egyptian construction sector, qualitative data from the questionnaire survey helped to understand the respondent's beliefs and attitudes. Table 4 provides the relative relevance indices and ranks. It can be determined that some indicators are significantly perceived to have a high impact by looking at the relevant indices for each item. The four most significant indicators that have a RI_w of more than 80% (high impact) are the inflation rate, exchange rate, interest rate, and cost of transportation and distribution. Strengthened by the questionnaire survey results, much consideration has to be given to the macroeconomic, market, and government-related indicators if you want to keep the price of materials under control because these three categories account for up to 70% of the importance level.

The study also indicated that there were no differences in respondents' perceptions of the factors that influence construction material prices based on the type of company they work for or their years of experience in the industry. Inferring that the respondents' perceptions could not be distinguished based on the company where they work or their years of experience.

Construction material price changes have a great effect on the project, so it is necessary to control the influence indicators. This means that the stakeholders who are concerned with the identified indicators that contribute to the CMP have an enormous task to ensure that the indicators are controlled to prevent any increase in prices. To select the most significant indicators, the indicators are then classified through a brainstorming session into quantitative and qualitative indicators. Quantitative indicators mean that indicators have publicly published data on one of the official websites. Nineteen indicators out of thirty-seven are classified as quantitative indicators, as indicated in Table 5. According to the Pareto analysis method, 20% of indicators have the largest impact. Cumulative RII has been calculated, and as a result of this proportion, thirteen quantitative indicators were chosen to have a significance level of up to 80%, as shown in Table 5.

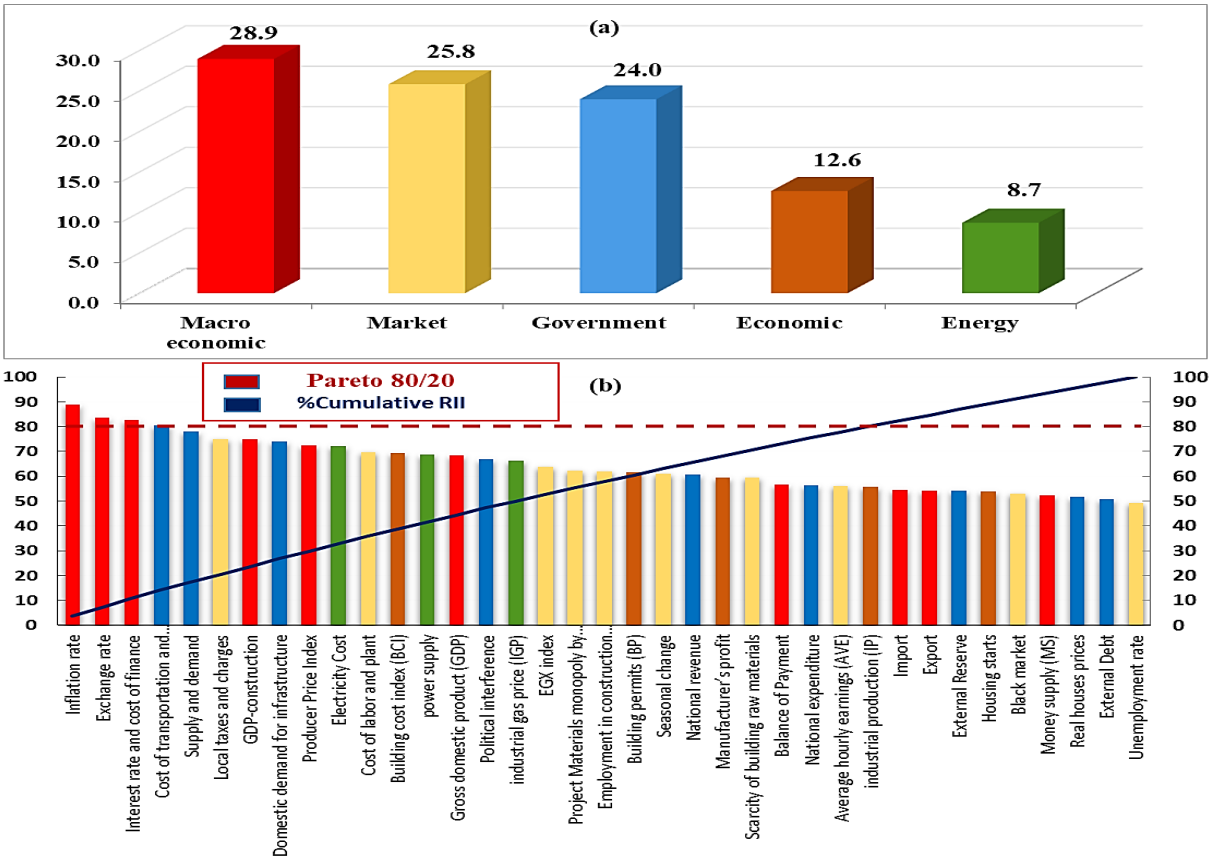

Fig. (4). (a) %(RI_w) of each category, **(b)** %(RI_w) of each indicator

Table (5): Quantitative indicators

No.	Total quantitative indicators	Pareto (80/20)
1.	Inflation rate	✓
2.	Exchange rate	✓
3.	Interest rate and cost of finance	✓
4.	GDP-construction	✓
5.	Producer Price Index	✓
6.	Gross domestic product(GDP)	✓
7.	EGX index	✓
8.	Employment rate (ER)	✓
9.	National revenue	✓
10.	Balance of Payment	✓
11.	National expenditure	✓
12.	Average hourly earnings (AVE) wages	✓
13.	industrial production (IP)	✓
14.	Import	
15.	Export	
16.	External Reserve	
17.	Money supply (MS)	
18.	External Debt	
19.	Unemployment rate	

8. Conclusion

The goal of this study is to investigate and rank the indicators that influence construction material pricing, taking into account the perspectives of all construction project stakeholders.

Based on an extensive literature review and brainstorming sessions with construction professionals, a total of thirty-seven indicators were determined. These indicators are classified into five categories according to experts' points of view; macroeconomic, economic, market, government, and energy. The relative ranking of the indicators was determined using relative weight analysis.

The questionnaire survey was sent to construction-related people who work for either public or private contractors, as well as engineers who hold various positions. According to the ranking analysis, the majority of indicators were recognized at "high" or "high-medium" importance levels. The inflation rate, exchange rate, interest rate, and transportation and distribution costs are the four most important indicators with a RI_w of greater than 80% (strong impact). Those indicators can be identified as critical indicators affecting the price of construction material, while there were 20 indicators highlighted at the "high-medium" important level.

The findings of the questionnaire survey have confirmed that to regulate the prices of materials, close attention must be paid to macroeconomic, market, and government-related factors, which together make up to 70% of the relevance level. Macroeconomic indicators, as indicated in Figure 4 (a), are at the top of the overall indicator ranking. When it comes to construction material prices, the respondents agreed that these are the most essential indicators, while market-related indicators represent 26% of the importance level of the whole set of indicators. As a result, these indicators must be considered in order to keep CMP in Egypt under control.

REFERENCE

[1] Abdel-Wahab, M., Ibrahim, A., Ghatass, H., & Abdel-Galil, E. Factors Affecting the Cost of Construction Materials in Egypt. Port-Said Engineering Research Journal Vol.22, No. 1, PP. 82-89, 2018.

[2] Adegbembo, T. F., & Adeniyi, O. Evaluating the effect of macroeconomic indicators on building materials prices. In The Nigerian Institute of Quantity Surveyors: 2nd Research Conference–ReCon2 1st to 3rd September. PP. 406-413, 2015.

[3] Akadiri, O. P. Development of a multi-criteria approach for the selection of sustainable materials for building projects, 2011.

[4] Akanni, P. O., Oke, A. E., & Omotilewa, O. J. Implications of rising cost of building materials in Lagos State Nigeria. SAGE Open Vol. 4, No.4, PP. 1-7, 2014.

[5] Alfouzan, A. S., & Khalafallah, A. Housing and Construction Cost Escalation: Causes and Effects in Riyadh. In Construction Research Congress: Construction in a Global Network. PP. 2165-2174, 2014.

[6] Al-Hammad, I. A. Treatment of Reinforcing Steel Bars Prices Fluctuations. Journal of King Saud University-Engineering Sciences Vol. 19, No.1, PP.43-62, 2006.

[7] Ashuri, B., & Shahandashti, S. M. Quantifying the relationship between construction cost index (CCI) and macroeconomic factors in the United States. In Vol. 14 of Proc., 48th ASC Annual Int. Conf. Birmingham, UK: Birmingham City Univ, 2012.

[8] Cao, M. T., Cheng, M. Y., & Wu, Y. W. Hybrid computational model for forecasting Taiwan construction cost index. Journal of Construction Engineering and Management Vol. 141, No. 4, 2015.

[9] CAPMAS (Central Agency for Public Mobilization and Statistics). Monthly bulletin of average retail prices of major important building materials. Arab Republic of Egypt: Public Information Center, Printing Office

[10] Chakraborty, D., Elhegazy, H., Elzarka, H., & Gutierrez, L. A novel construction cost prediction model using hybrid natural and light gradient boosting. Advanced Engineering Informatics Vol. 46, No. 101201, 2020.

[11] Chen, C. Y., Liu, J. F., & Wang, L. C. Instability patterns of Ferro fluids immersed in a fluid layer. Magneto hydrodynamics Vol. 3, PP. 235-244, 2010.

[12] CII, Grau, D., & Back, W. E. Improving the predictability of project outcomes–Research report. Research Rep, PP. 291-11, 2013.

[13] Elhegazy, H., Ebid, A., Mahdi, I., Haggag, S., & Abdul-Rashied, I. Implementing QFD in decision making for selecting the optimal structural system for buildings. Construction Innovation Vol. 21, No. 2, PP. 345-360, 2021.

[14] Ernest, K., Theophilus, A. K., Amoah, P., & Emmanuel, B. B. Identifying key economic indicators influencing tender price index prediction in the building industry: a case study of Ghana. International Journal of Construction Management Vol. 19, No. 2, PP. 106-112, 2019.

[15] Faghih, S. A. M., & Kashani, H. Forecasting construction material prices using vector error correction model. Journal of construction engineering and management Vol. 144, No. 8, 2018.

[16] Fan, R. Y., Ng, S. T., & Wong, J. M. Reliability of the Box–Jenkins model for forecasting construction demand covering times of economic austerity. Construction Management and Economics Vol. 28, No. 3, PP. 241-254, 2010.

[17] Fellows, R. and Liu, A. Data collection, in Research Methods for Construction, 2nd edn, Blackwell, Oxford, PP. 137–60, 2003.

[18] Hwang, S., Park, M., Lee, H. S., & Kim, H. Automated time-series cost forecasting system for construction materials. Journal of Construction Engineering and Management Vol. 138, No.11, PP. 1259-1269, 2012.

[19] Jiang, H., Xu, Y., & Liu, C. Construction price prediction using vector error correction models. Journal of Construction Engineering and Management Vol. 139, No. 11, 2013.

[20] Taherdoost, H. Determining sample size; how to calculate survey sample size. International Journal of Economics and Management Systems Vol. 2, PP. 237-239, 2017.

[21] Kholif, W., Hosny, H., & Sanad, A. Analysis of time and cost overruns in educational building projects in Egypt. International Journal of Engineering and Technical Research Vol. 1, No. 10, PP. 1-8, 2013.

[22] Obeng-Ahenkora, N. K., & Danso, H. Principal component analysis of factors influencing pricing decisions of building

materials in Ghana. International Journal of Construction Management Vol. 20, No. 2, PP. 122-129, 2020.

[23] Oghenekevwe, O., Olusola, O., & Chukwudi, U. S. An assessment of the impact of inflation on construction material prices in Nigeria. PM World Journal Vol. 3, No. 4, PP. 1-22, 2014.

[24] Oladipo, F. O., & Oni, O. J. Review of selected macroeconomic factors impacting building material prices in developing countries–A case of Nigeria. Ethiopian Journal of Environmental Studies and Management Vol. 5, No. 2, PP. 131-137, 2012.

[25] Olatunji, O. A. The impact of oil price regimes on construction cost in Nigeria. Construction Management and Economics Vol. 28, No. 7, PP. 747-759, 2010.

[26] Rajaprabha, R., Velumani, P., & Jayanthi, B. Factors affecting the cost of building material in construction projects. International Journal of Science and Engineering Research Vol. 4, No. 4, PP. 1-6, 2016.

[27] Shahandashti, S. M., & Ashuri, B. Forecasting engineering news-record construction cost index using multivariate time series models. Journal of Construction Engineering and Management Vol. 139, No. 9, PP. 1237-1243, 2013.

[28] Shahandashti, S. M., & Ashuri, B. Highway construction cost forecasting using vector error correction models. Journal of management in engineering Vol. 32, No. 2, 2016.

[29] Shash, A. A. Factors considered in tendering decisions by top UK contractors. Construction management and economics Vol. 11, No. 2, PP. 111-118, 1993.

[30] Swei, O., Gregory, J., & Kirchain, R. Construction cost estimation: A parametric approach for better estimates of expected cost and variation. Transportation Research Part B: Methodological Vol. 101, PP. 295-305, 2017.

[31] The Construction Industry Institute (CII). Construction Industry Institute, https://www.construction-institute.org/scriptcontent/index.cfm (Accessed March 29, 2013).

[32] Thomas Ng, S., Cheung, S. O., Martin Skitmore, R., Lam, K. C., & Wong, L. Y. Prediction of tender price index directional changes. Construction Management and Economics Vol. 18, No. 7, PP. 843-852, 2000.

[33] Wang, W. C., Bilozerov, T., Dzeng, R. J., Hsiao, F. Y., & Wang, K. C. Conceptual cost estimations using neuro-fuzzy and multi-factor evaluation methods for building projects. Journal of Civil Engineering and Management Vol. 23, No. 1, PP. 1-14, 2017.

[34] Waris, M., Liew, M. S., Khamidi, M. F., & Idrus, A. Criteria for the selection of sustainable onsite construction equipment. International Journal of Sustainable Built Environment Vol. 3, No. 1, PP. 96-110, 2014.

[35] Windapo, A., & Cattell, K. Examining the trends in building material prices: built environment stakeholders' perspectives. Manage Construct Res Pract Vol. 1, PP. 187-201, 2012.

[36] Wong, J. M., & Ng, S. T. Forecasting construction tender price index in Hong Kong using vector error correction model. Construction management and Economics Vol. 28, No. 12, PP. 1255-1268, 2010.