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Economic Variables as an Early Warning Sign for Monitoring Construction Cost Indices – "An Empirical Study on Egypt"

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ABSTRACT

The construction industry plays a crucial role in any nation's economic growth and prosperity through the implementation of the SDGs. Researchers reveal that the 17 SDGs are directly dependent by 17% and indirectly reliant by 27% on the construction industry's activities. In addition, the construction projects, whatever their type or components, continue for several years, during which many price changes and sharp economic fluctuations occur, whether at the local or international level, reflected in overall economic performance and the construction industry's health, leading to the project's cost changes and a shortage in the allocated budgets. Due to the difficulties this industry faces in reaching these goals, including the Egypt Vision 2030, we chose to look into these effects by using the ENR methodology to develop an explanatory construction cost indices model in Egypt similar to models used in other countries while making appropriate changes for the Egyptian markets. To illustrate the relationship between these selected economic variables and construction costs in Egypt and to act as an early warning sign to quantify, track, and predict the construction cost movements and trends in Egypt's construction sectors through a reliable model. A mixed research methodology consisted of semi-structured interviews with 15 industry experts and an empirical study covering 1990 through 2020 for selected local and international economic variables. We concluded that national and international economic variables significantly impacted as explanatory and predictive variables in Egypt's construction industry's cost indices; these variables are as follows: gross domestic product (GDP), consumer price index (CPI), USD to EGP exchange rate ($), inflation rate, lending rate, money supply, and unemployment rate, as well as international crude oil prices, gold prices, and copper prices. Nevertheless, further investigation

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	is required with more economic variables across various construction industry sectors over various time intervals and different time series statistical and econometric modeling techniques.

1. Introduction

1.1. General

In 2016, Egypt announced its Sustainable Development Strategy, Vision 2030, aiming to achieve UN Sustainable Development Goals (SDGs) for a better standard of living with a dependence on science, knowledge, and innovation. Launching the Egyptian government's vision for Egypt 2030 was accompanied by several bold, giant national plans and projects of a unique and developmental nature that had not been seen during the previous decades in the MENA region to comply with the UN's Sustainable Development Goals, leading to many booms in several development sectors, especially the building and construction industry in all its sectors, like infrastructure, transportation, power generation, water desalination, wastewater treatment, residential buildings, and the health facility, which is also expected to continue to develop and require additional massive funding for redeveloping impoverished communities. Accordingly, the Egyptian government, along with international and local parties, bodies, and banks that work as lenders or donors to finance these sustainable plans and related projects, and specialized global companies that provide "technology and special engineering services," as well as real estate developers, industrial developers, and contractors, face many challenges and difficulties in estimating the costs to be financed, loaned, and contracted for these mega-development plans and projects. Also, the unexpected and exceptional events that occurred worldwide over the past years and the subsequent sharp economic changes and pressure, especially on the economies of developing countries, led to critical situations like Egypt, where the currency devalued several times. Moreover, the subsequent significant challenges, especially in dynamic sectors like the building and construction industry, Due to the unique nature of the building and construction industries and the need for cost estimation and predictions of cost fluctuations, which are constantly in flux, with the price of materials rising and falling due to changes in local and international economic variables, as well as transport, handling, and labor costs varying from time to time, To overcome these problems, various project cost forecasting techniques are used, including indicators, which have been applied for many years in several countries in the developed world and are currently beginning to be applied in several developing countries as well as several countries in the Middle East. It has become essential, and the importance of issuing the building and construction sector cost indices lies in their ability to give a reasonably primary and accurate perception of the amount of price change and its development within the building and construction industry sectors over periods and during various economic conditions.

1.2. Literature Review

The building and construction industry and related sectors are the main contributors to the global economy and employment market. According to Behm (2008), the United Nations Sustainable Development Goals (SDGs) and the Egypt Vision 2030 Agenda offer opportunities for the building and construction industries to expand their focus and address several economic challenges. Accordingly, there is a vast opportunity for examining the large overlap between the construction industry on one side and economic growth challenges on the other. Goubran et al.'s (2023) research identified the UN SDG targets that are reliant (directly or indirectly) on

the building and construction industry. Goubran et al. (2023) interpreted that the various economic sectors' potential contributions to achieving the SDGs and their ambitions have yet to receive much attention. Additionally, Alawneh et al. (2019) stated that previous studies that examined the relationship between the construction industry and the UN SDGs 2030 Agenda took an insufficient approach to present the relationship between the construction industry and the SDG targets by emphasizing one of the subsectors, like buildings, rather than the entire industry when examining the contribution to the UN SDGs 2030 Agenda, or by focusing on one target UNSDG, like buildings, instead of the entire industry when examining the contribution to the UN SDGs 2030 Agenda, as stated by Alawneh et al. (2019), or by focusing on one target UNSDG, like SDG 11, as the key driver of the construction activities without reference to specific industry sectors, as interpreted by Metternicht et al. (2019) and Nilsson et al. (2018).

Also, Goubran et al. (2023) revealed that 17% of the UN SDG targets are directly dependent, and 27% are indirectly reliant on the building and construction industries' activities. Also, the research identified that targets are analysed and found to be related to all 17 UN SDG goals and defined that the most significant contributions of the construction industry to UN SDGs are SDG 11, 6, and 7 by illustrating the potential contribution from the construction activities through using a comprehensive definition of these sectors.

Building and construction is an economic activity involving the entire construction process, from producing raw and manufactured building materials and components to providing professional services such as design and project management to executing on-site physical work. Therefore, construction is an economic activity that crosses over all three economic sectors as follows (Gruneberg, 2000):

- The primary sector involves the extraction of natural resources;
- the secondary sector consists of the manufacture of building materials and components and the transformation of these materials into finished buildings; and
- The tertiary sector consists of the provision of consultancy services such as project management, design, and structural engineering.

From this particular standpoint, the construction process starts much before the commencement of physical work on the designated site. During this phase, materials and design transform, culminating in fully realized buildings, structures, and facilities. Due to the diverse array of business operations included in the construction industry, there is a need for reliable indices that can efficiently monitor, evaluate, and ensure the stability of this sector, also known as the construction industry's health.

Generally, the indices are tools commonly used in decision-making settings that require comparing firms, sectors, industries, or geographical divisions. Besides, indices are practical instruments to monitor the long-term fluctuations of any given phenomenon (Velenturf et al., 2021). Furthermore, Diewert (2007) explained that the past quarter century has seen remarkable progress in the theory and practice of index number theory and the closely related problems associated with measuring output, input, and productivity. Also, Diewert (2007) concluded that another positive development has been the production of the new ILO (2004) and IMF (2004). These manuals fill a gap in that until these manuals were produced, there was no comprehensive source of materials on index number theory and the measurement problems associated with having a CPI and a PPI.

So, construction indices are paramount as statistical indices within cost planning, managerial practices, and research about construction economics. The term construction covers various activities, including constructing dwellings, non-residential buildings, and civil engineering

works such as roads, bridges, dams, etc. Repairing, renovating, rehabilitating, and maintaining existing structures are also considered construction activities. Kncannon & Franchet (2008) interpreted that, given the wide range of construction activities, the classification of the building and construction industry indices also varies depending on the items that make up an index and their relative weights, with significant variation in the inclusion or exclusion of items like transport costs, consumption taxes, fittings, etc. that apply to each local and international institution and organization. Accordingly, many researchers worldwide have spent much effort in developed and developing countries to study the influential factors affecting the building and construction industry "market" and have tried to create many indices to monitor and assess the building and construction industry's performance "Industry Health" to ensure that the industry and related business activities are sustained growth. Therefore, they considered the indices representing the project's costs in different phases and disciplines within the industry to be very important, like those defined in the publication. This publication documents the collection and calculation methods of the construction price indices in several European countries. These findings provide significant perspectives on the price patterns seen across many fields within the building and construction industry. Multiple indices related to the construction industry have been developed for various purposes and viewpoints (Kncannon & Franchet, 2008).

The construction cost indices (CCI) have garnered considerable recognition and widespread use due to their capacity to forecast project expenses (Elfahham, 2019). Furthermore, Hassanein & Khalil (2006b) indicates the potential to introduce and implement construction cost indices. This should provide contractors and other construction parties operating in Egypt with an adequate tool for pricing and estimating projects. From the cost estimator and commercial proposal specialist's point of view, the project's feasibility studies, budgeting, and bidding stages generally include the three major items for any construction project: "material, labor, and equipment plus bidder markup." Materials prices are subject to the construction economy's situation.

Atabeylia et al. (2018) explained that the construction industry or construction economy is exceptionally dynamic. As a result, it is frequently difficult for the parties involved in construction projects to predict the market's future prices for materials, particularly in times of economic instability. This can often discourage developers from investing, diminish contractors' profitability, and delay payments by owners (Shiha, 2020).

The construction industry's ability to accurately forecast future trends is the main advantage of the Construction Cost Index (CCI). Cao et al (2015) mentioned that the Construction Cost Index (CCI) is critical for construction cost managers to prepare accurate budgets for owners and proper contractor bids. It is worth noting that positive feedback has been received after establishing the Construction Cost Index (CCI) in several countries worldwide, even if imperfect. Kim (2015) clearly shows that the introduction of the Construction Cost Index (CCI) in 2003 in Malaysia has reasonably improved construction cost estimation in the industry. On the other hand, this inability to accurately predict material price fluctuations often leads to overestimating or underestimating such prices. Inadequate cost estimation and inaccurate forecasting of construction material prices may lead to project delays, cost overruns, and adversarial relationships between parties, undermining the whole construction industry's reputation (Shiha, 2020).

Accordingly, Identifying and assessing early warning signals of potential issues in the future by the construction cost index facilitates proactive management to a great extent to detect cost volatility and subsequent challenges and, as a result, prevent adverse outcomes that conventional cost estimation practices may not observe. Ansoff defined a weak signal as

“imprecise early indications about impending impactful events... All that is known is that some threats and opportunities will undoubtedly arise, but their shape, nature, and source are not yet known” Nain, (2017). Weak signals indicate significant changes or trends and are often found in market research, industry news, and economic data. These signals can be used as an early warning system to anticipate and prepare for potential market changes, supplementing trend analysis and potentially altering the future. Dufva (2022) explained that weak signals are simply data points that indicate the probability of significant change or potentially emerging issues that could be underway. They represent emerging issues that may become significant and affect the business model, operations, or industry environment. Weak signals supplement trend analysis and can be used to expand on alternate futures. A weak signal is an existing thing or phenomenon that can be interpreted as an indicator of potential, more significant change.

Accordingly, to avoid this problem and to implement the best strategic technique possible, the contractor should have a tool or method capable of predicting future material prices. It is essential to predict the material price variations during the implementation of the project as well as prepare the tenders. Several prediction methods and models have been developed to predict the CCI accurately (Jesna & Dilip, 2022).

To predict the construction cost index until 2025, Elfahham (2019) stated that neural networks, linear regression, and autoregressive time series methods were used. It was found that the prediction using the autoregressive time series was the most accurate method. Many researchers have widely examined the best-fitted model to determine the construction cost indices. In contrast, other researchers have examined and explained the causality and relationship between macroeconomic variables and construction cost indices. However, only a few studies have looked at macroeconomic variables as an explanatory power for construction cost indices on a local level. This is the core of this research to fill the gap, and the application will take place in the Egyptian construction industry market.

Previous research (Shiha ,2020) has shown that the identified macroeconomic indicators used as predictors were GDP, unemployment rate, consumer price index, producer price index, foreign reserves, US dollar to Egyptian pound exchange rate, and lending rate. Macroeconomic indicators are one such factor that influences the prices of materials as they reflect a country's economic status (Jesna & Dilip, 2022).

While Atabeylia et al. (2018) explains that the construction economy is exceptionally dynamic, he studies this rationale based on the selected macroeconomic variables, namely the following three factors: the domestic producer price index, the consumer price index, and the construction labor input index. In addition, Ernest et al (2017) noted that the environmental characteristics of any economy influence the building industry. These can be defined by the typically used indicators from previous scholars' efforts to fully acknowledge, assess, and work out the critical relationship between construction, economics, and development. He used the consumer price index, producer price index, currency exchange rate, gross domestic product, and interest rate in his study. Several macroeconomic variables were present, like GDP, exchange rate, inflation, interest rate, consumer price index, unemployment, employment, crude oil price, producer price index, money supply, population, real house prices, labor costs, and monetary policy, which were the most prevalent. According to Asamoah et al (2019b), several factors, such as frequent changes in macroeconomic variables and the relative importance index, typically affect the cost of a building. Professionals considered the prime rate, interest rate, and inflation as macroeconomic components that impacted costs.

In conclusion, there is some positive feedback from local researchers, like Elfahham's (2019) explanation, that estimating construction costs and predicting price escalation are significant steps for project owners, estimators, and contractors. Also, Hassanein & Khalil (2006a)

explained that Egypt needs such an index within the Egyptian construction market. The presence of a cost index to help reflect price movement is an important element for the construction industry or international researchers. Asamoah et al (2019b) explained the key benefits of developing the construction cost indices: a) It enables contractors to carry out projects with extreme professionalism to prevent contractual conflicts and instead be able to pay for any claims. B) It also informs policymakers on external economic issues that should be considered when organizing, allocating funds, and carrying out project lifecycles. C) Information on economic issues that should be considered during project estimation and tendering is also given to consultants and contractors, who then work to design strategies to lessen the effects of these elements.

2. Materials and Methods

2.1. Materials

Research variables are defined as follows:

2.1.1. Dependent Variable

Construction cost indices were developed and utilized based on several methodologies and models, among them the Engineering News-Record (ENR) methodology and formula, considered the most famous worldwide. The dependent variable will be calculated based on the ENR calculation methodologies and procedures because it includes the necessary items for building and construction industry supplies that are frequently used in North America; nevertheless, some changes have been made to match the nature of Egypt's building and construction industry and the materials available, as interpreted by Elfahham (2019). The dependent variable formula is based on the Egypt 1 indices, developed by Hassanein & Khalil (2006a), and derivatives from the ENR methodology: average sale price of steel reinforcement, average sale price of ordinary Portland cement, average sale price for common brick unit price, and common labor hourly rate.

2.1.2. Independent Variables

The proposed independent variables were selected from the economic variables in Egypt as well as international variables, as shown in the Table 1.

Table 1.
Economic Variables Identified in Literature

Indicator	Paper	Region of Application
GDP Growth Rate	Shiha, (2020)	Egypt
	Jiang et al., (2013)	China
	Olatunji, (2010)	Nigeria
	Ng et al., (2004)	Hong Kong
Consumer Price Index	Ernest et al., (2017)	Ghana
	Cao et al., (2015),	Taiwan
	Ashuri et al., (2012),	United States
	Ng et al. (2004)	China
Foreign Exchange Rate	Shiha, (2020)	Egypt
	Ernest et al., (2017)	Ghana
	Cao et al., (2015),	Taiwan
	Olatunji, (2010)	Nigeria
Foreign reserves	Shiha, (2020)	Egypt
Inflation Rate	Elfahham, (2019)	Egypt
	Olatunji, (2010)	Egypt

Indicator	Paper	Region of Application
	Olatunji, (2010)	Nigeria
	Akintoye et al., (1998),	United Kingdom
Lending Rate	Shiha, (2020)	Egypt
	Cao et al., (2015),	Taiwan
	Olatunji, (2010)	Nigeria
	Ng et al., (2004)	Hong Kong
Money Supply	Ng et al., (2004)	Hong Kong
	Ashuri et al., (2012),	United States
	Akintoye et al., (1998),	United Kingdom
Unemployment Rate	Shiha, (2020)	Egypt
	Jiang et al. (2013)	China
	Ng et al., (2004)	Hong Kong
	Akintoye et al., (1998),	United Kingdom
Crude Oil Prices	Asamoah et al, (2019a)	Ghana
	Cao et al., (2015),	Taiwan
	Ashuri et al., (2012),	United States
	Olatunji, (2010)	Nigeria

2.1.3. Conceptual Framework and Hypotheses

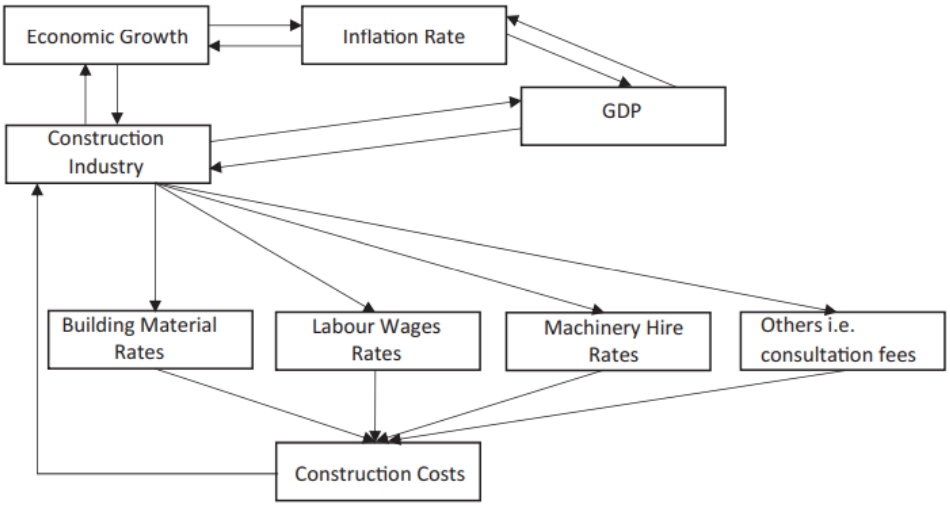

Figure 1. Relation between economic growth and the Construction industry (Musarat et al., 2021)

The following Figure 2. demonstrates the conceptual framework for this research and proposes the relationships and hypotheses that will be investigated within this research. This conceptual framework is mainly developed for establishing the construction industry's cost indices model, which directly relates to Egypt's macroeconomic and other international variables.

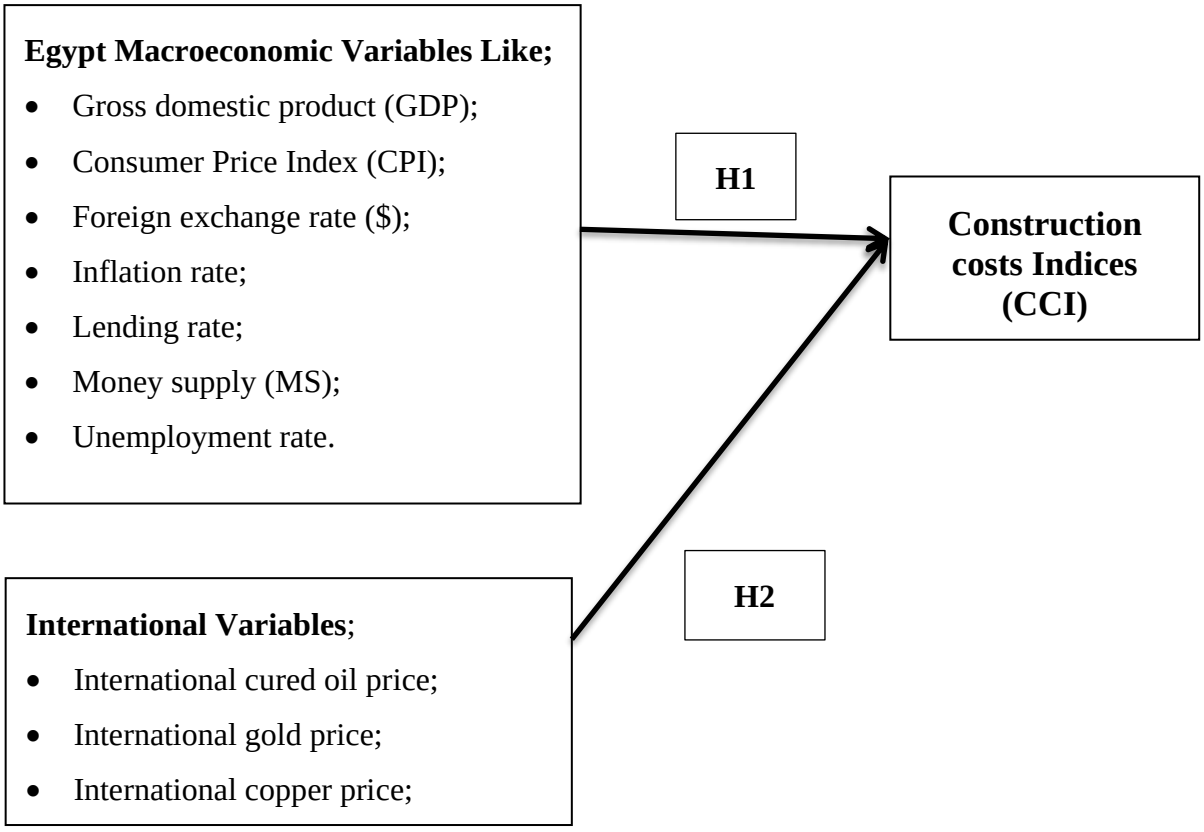

Figure 2. The Conceptual Framework

2.1.4. Models

Proposed Model:

$$CCI = ai + bi\ (\text{Egypt Macroeconomic Variables}) + ci\ (\text{International variables}) \quad (1)$$

2.1.5. Hypotheses

The study sought to test the hypothesis that Egypt's macroeconomic variables and international variables were significant explanatory and predictive variables of construction cost indices.

- H1: Egypt's macroeconomic variables are explanatory and predictive variables significantly impacting the proposed construction industry's cost indices.
- H2: International economic variables are explanatory and predictive variables significantly impacting the proposed construction industry's cost indices.

2.2. Methods

This study's exploratory mixed method included qualitative and quantitative methods. It started with a systematic literature review to examine the previous studies that looked at the economic variables related to construction cost indices, either locally or internationally. Then, it followed a qualitative approach using semi-structured interview questions to determine the current situation of Egypt's building and construction industry and conclude the most important influences and factors that must be considered in the quantitative study. Finally, we conduct a quantitative approach to assess and develop the proposed model using secondary historical time series data for independent variables (related to Egypt's macroeconomic and international variables) and dependent variables (related to construction costs, CCI). EViews version 12 was

used to analyze the statistical data from the autoregressive integrated moving average (ARIMA) prediction model.

Table 2.
Methods Used for Research Objectives

Objective	Method
I am reviewing the previous studies of the macroeconomic indicators and their relation with construction cost indices, locally and internationally.	Literature Review
Examining the current situation of the Construction industry in the Egypt market	Semi-Structured interview
Establishing the Construction cost indices using secondary panel data for macroeconomics as "independent variables" and ENR formula as "dependent variables."	Egypt case study

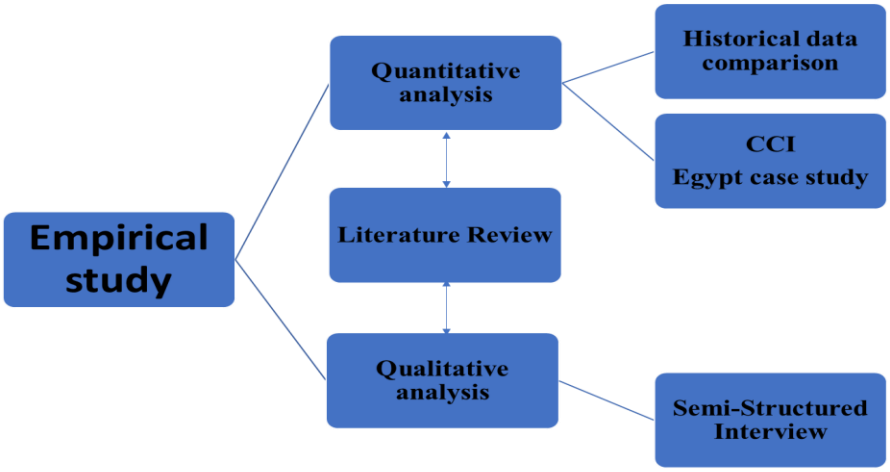

Figure 3. Empirical Study Framework

3. Results

As stated in the method, the research methodology used is an exploratory mixed-method study. It started with a systematic literature review to examine the previous studies of the relationships between construction cost indices and economic variables. This two-stage study, beginning with a Qualitative study, uses semi-structured interview questions with 15 selected industry experts to explore the current situation of the construction industry in the Egyptian market. Then, a quantitative study from the secondary panel historical time series data for independent (Egypt macroeconomic and international variables) and dependent (construction cost indicators, CCI) based on the ENR methodology.

3.1. A qualitative Study

The qualitative data analysis was conducted using data-gathering techniques from semi-structured interviews with 15 academic professors, professional engineers, and construction industry experts. Several opinions were obtained during this in-depth discussion, helping to access valuable information provided to help examine and explore the current situation and systemic analysis of the building and construction industry in the Egyptian market. Furthermore, this expert diversity enriched the outputs and covered most aspects and professional backgrounds, allowing us to get the best feedback possible. Also, the results obtained from these interviews helped bridge the uncertainty gap arising from the current Egyptian economic conditions and provided further suggestions and future recommendations.

The average interview time was 90 minutes. The classifications of the interviewers are as follows:

- In terms of academic background, all interviewees are BSc holders or above, including one interviewee professor in construction management, one interviewee doctor in business administration, and three interviewees holding a Master of Business Administration.
- In terms of professional background, ten interviewees were from international contracting companies, two were from consultant offices, one was from a professional expert “academic professor”, one freelancer engineer with more than forty years of experience, and one was in procurement and an expert in supply chain management.
- In terms of years of experience, four interviewees have thirty years or more of experience, seven interviewees have twenty years or more of experience, and four interviewees have ten years or more of experience.

We concluded that 100% of interviewees agreed with the following response: "from 1 to 8," and 93% up to 47% agreed as stated in "9 to 15.", Furthermore, responses that ranked less than 47% were ignored:

1. The government’s plan to achieve the Egypt Vision 2030, emerging from the SDGs 2030, is one of the vital drivers of Egypt's economy, especially the building and construction industry.
2. They continuously follow the Egyptian economy's changes, including macroeconomic variables, mainly due to the exceptional global and local circumstances affecting each other. "It affects the building and construction industries and the whole lifestyle."
3. Agreed that the construction industry in Egypt is affected by global and local economic conditions and related national economic reform plans.
4. Agreed that they reviewed and assessed the macroeconomic variables "indicators" trends in the project’s cost management processes and contract management with suppliers and contractors.
5. It is stated that a direct positive and simultaneous relationship exists between Egypt's economic performance, macroeconomic indicators, and construction industry development.
6. Agreed that implanting the early warning signs "concept" as a leading indicator, especially in turbulent circumstances and the current periods of economic instability,
7. Construction cost indices are essential in Egypt's market; currently, there are no similar indicators in Egypt, and it is necessary to establish different construction cost indices for various construction activities.
8. Parallel market foreign currency exchange rate influences as a critical barrier
9. Foreign exchange rate, interest rate, and inflation are the most influential, effective, and famous macroeconomic variables.
10. Foreign exchange rates, interest rates, and inflation influence determining and building the "construction cost indices."
11. It is required to determine the influence of copper and gold prices on the construction cost indices.
12. The government's limited financial resources and plans for economic reform to deal with economic fluctuations could represent the difficulties Egypt's building and construction industry faces.

13. Implementing the risk management methodology becomes essential for avoiding unforeseen issues and defining reserve margins and hedging strategies.
14. The critical barriers to determining and establishing the "construction cost indices" were over-prices of construction materials such as reinforcing steel and cement and the emergence as a norm;
15. There is a constant change in fuel prices locally "due to changing subsidies provided by the state and internationally due to "changing global crude oil prices." Competition within the building and construction industry market, the type of contract used between the contractor and the clients, and the contractual terms, a mechanism for disbursing dues to contractors and providing budgets for projects; the government applying for different deductions, levies, and royalties; construction technology used; and Increasing awareness and education about the importance of economic studies and indicators.

3.2. A Quantitative Study

Data collection techniques for quantitative analysis to achieve the research aim and objectives, as the part of the research follows a quantitative approach to measure the research variables: secondary panel data gathering from different robustness sources like the World Bank, CAPMAS, and Macrotrands website to collect the required time series data: gross domestic product (GDP), consumer price index (CPI), foreign exchange rate: "US dollar/Euro," inflation rate, lending rate, unemployment rate, international cured oil prices, gold prices, and copper prices.

E-views 12 software was used to analyze variables time series; the Autoregressive Integrated Moving Average (ARIMA) Prediction Model was used as a forecasting technique.

3.2.1. Descriptive Statistics of the Variables

The following table summarizes the descriptive analysis of this dissertation's four variables. The descriptive analysis includes the following measurements: mean, median, maximum value, minimum value, standard deviation, skewness, and Kurtosis.

The descriptive statistics in Table 3 present an overall frequency distribution of the variables under study. The average gross domestic product (GDP) is observed to be around 5.69%, ranging from a minimum of about 1.125% to a maximum of approximately 44.72%. The average CPI rate is 95.31990, while the average foreign exchange rate is 6.489%, the inflation rate is 6.48%, the lending rate is 14.28%, the money supply is 83.51, and the average unemployment rate is just 10.08%. The small positive skewness values of all the variables show that mean values are clustered to the left at very low values, indicating the data are fairly symmetrical; regarding GDP and unemployment rate, negative values show that mean values are clustered to the right at very low values, indicating the data are fairly symmetrical—however, Kurtosis is below 3. The probability of Jarque-Bera coefficients suggests no violation of the normality assumptions of the data.

Table 3.
Descriptive Statistics of the Variables

Variables	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Mean	223.8645	5.694932	95.31990	6.489516	10.01742	14.28432	83.51986	10.08929	47.52290	773.7761	1.976452
Median	154.7000	4.471700	57.75700	5.622000	9.470000	13.29200	82.37828	9.855000	41.51000	444.9900	1.630000
Maximum	545.4000	44.72900	303.1310	17.78300	29.51000	20.32800	98.13613	13.15400	99.67000	1773.730	4.000000
Minimum	81.70000	1.125400	19.14700	1.550000	2.270000	11.00800	69.71546	7.851000	14.42000	271.1900	0.720000
Std. Dev.	149.8907	7.412293	80.83595	4.468003	5.971128	2.762907	8.208646	1.685820	28.19181	501.3626	1.088294
Skewness	0.861358	0.917689	1.368459	1.652070	1.135746	0.846139	0.474502	0.430856	0.583603	0.555912	0.254026

Variables	**Y**	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**
Kurtosis	2.390782	2.50536	2.773794	2.561212	2.831719	2.429093	2.124399	1.959582	1.991963	1.753627	1.488127
Jarque-Bera	4.312739	838.5974	10.44891	17.24985	10.99837	4.120085	2.153577	2.357311	3.072242	3.603230	3.285843
Probability	0.115745	0.120000	0.755383	0.91180	0.644090	0.127449	0.340688	0.307692	0.215214	0.165032	0.193414
Sum	0.312739	0.5974	0.44891	0.24985	0.99837	0.120085	0.153577	0.357311	0.072242	0.603230	0.285843
Sum Sq. Dev	0.115745	0.120000	0.755383	0.91180	0.644090	0.127449	0.340688	0.307692	0.215214	0.165032	0.193414
Observations	31	31	31	31	31	31	31	31	31	31	31

Where: LX1Annual (GDP), LX2 Annual (CPI), LX3 Annual (Foreign exchange rate), LX4 Annual (Inflation Rate), LX5 Annual (Lending Rate), LX6 Annual (Money Supply), LX7 (Unemployment rate), LX8 Annual (international crude oil price), LX9 Annual (International gold price) & LX10 Annual (international Copper price).

3.2.2. Multicollinearity Test

Variance inflation factor (VIF) was used to assess the multicollinearity of independent variables. A VIF value of 10 or more was considered a cut point for the elimination variable from the model, as mentioned in Table 4, and a collinearity problem was detected as variables (X2) CPI, (X3) foreign exchange rate have great values.

Table 4.
Variance Inflation Factors for IV (VIF)

	Coefficient	**Uncentered**	**Centered**
Variable	Variance	VIF	VIF
C	5624.476	384.2126	NA
X1	0.36687	2.145287	1.332497
X2	0.135177	142.2922	58.39288
X3	25.45491	106.8224	33.59291
X4	1.274929	11.74454	3.005023
X5	8.323037	120.2089	4.200137
X6	0.408645	196.5422	1.820279
X7	8.813025	62.93816	1.655756
X8	0.172391	35.65324	9.057553
X9	0.001447	83.19798	24.03652
X10	218.6559	75.46759	17.11996

After taking the first differences for the independent variables, Table 5 presents VIF results for the variables mentioned, the VIF values for all variables within the accepted range.

Table 5.
Variance Inflation Factors for IV (VIF) with first differences

	Coefficient	**Uncentered**	**Centered**
Variable	Variance	VIF	VIF
C	52.46681	2.572635	NA
D(X1)	0.239629	1.455595	1.455538
D(X2)	0.535008	5.548612	3.197902
D(X3)	54.92498	6.654411	6.050257
D(X4)	1.19487	1.904229	1.895288
D(X5)	36.52036	4.079177	3.963252
D(X6)	0.739241	1.279374	1.27785
D(X7)	28.79864	1.686579	1.6862
D(X8)	0.199752	1.998877	1.996379
D(X9)	0.002189	1.970735	1.740348
D(X10)	235.3921	2.297612	2.262697

3.2.3. Unit Root Test (UR Test) for Model Identification

It is customary to look at the order of integration or do a unit-root test of the series before implementing any econometric evaluation of a time series or panel dataset. This is beneficial in preventing any erroneous estimation. To determine if the variables in question are stationary at levels I(0) or non-stationary at levels and become stationary after taking their first differences I(1), as well as to demonstrate that none of them are stationary at the second difference I(2) and above, the unit-root test is used. In each of these tests, the null hypothesis—that a series has a unit root—is compared against its stationary alternative. The results of unit-root tests of the variables' natural logarithms at levels and their first difference are summarized in Table 5. According to the output of the unit-root test findings, not all variables are stationary at their level forms. Nevertheless, when taking their initial differences I(1), they could all accomplish stationery, suggesting that none of the variables was I(2) or higher.

3.2.4. Model Identification

The augmented Dickey-Fuller (ADF) test was used to determine whether the variables were stationary. Table 6 (Appendix) demonstrates that all of the variables have unit roots in levels and are stationary in first differences because all ADF test values are significant at the 1% level in both the trend and intercept case and the only intercept case, which causes the mean series to become stationary.

3.2.5. Model Estimation

ARIMA is an acronym that combines two terms: AR and MA. ARIMA is the name for the generic model (p, d, q). The number of autoregressive terms (p) is the number of terms in the model. q is the number of moving average terms, and d is the number of differences. The AR phrase refers to a present value of a time series that may be calculated using prior values from the same series. The AR order is represented by p, which is the lag value after which the PACF plot crosses the upper confidence interval for the first time, and the MA term is a present value of series, which is defined as a linear combination of past errors; assume the errors are distributed independently with a normal distribution. The MA order is represented by the number q, which can be found on the ACF plot; this is the time lag after which the ACF passes the upper confidence interval for the first time. The correlogram was measured to identify the best-fit values.

3.2.6. Model Diagnostics

We estimated various models to determine the correct specification from adjusted R2, AIC, SC point of view, Table 7 (Appendix) reveals that ARIMA(1,1,11), ARIMA(1,1,1), ARIMA(1,1,10) ARIMA(1,1,2), ARIMA(1,1,3), ARIMA(2,1,9), ARIMA(1,1,1), ARIMA(1,1,8), ARIMA(1,1,4), ARIMA(1,1,9), ARIMA(1,1,3) and ARIMA(1,1,8) models are the most adequate fitted models to evaluate the forecasting values of CCI and Macroeconomic Variables.

The forecasted value for macroeconomic variables is given in Table 8 (Appendix). As seen from the table, all values will still increase in the forecasted period from 2021 to 2022.

The forecasted value for construction cost indices (CCI) will increase from 491.985.0 in 2021 to 541.184 in 2022; the forecasted value for GDP growth ratio will increase from 3.384.969% in 2021 to 3.723.466 in 2022; the forecasted value for CPI will increase from 4.417% in 2021–4.859% in 2022; forecasted value for foreign exchange rate will increase from 3.55% in 2022–3.911% in 2022; predicted value for inflation rate and other variable will also increase as explain in Table 8 (Appendix).

3.2.7. Testing the impact of Macroeconomic Variables on Construction Cost Indices (CCI)

As mentioned in Table 9 (Appendix), Macroeconomic Variables have a direct positive significant impact on Construction Cost indices(CCI) (B=1.095***, p-value<0.05); on the other hand, the R square is 98.4%, which means that Macroeconomic Variables explain 98.4%of the variation in construction cost indices.

The following equation could represent this impact, Estimation Equation:

LY = C(1) + C(2)*LX1 + C(3)*LX2 + C(4)*LX3 + C(5)*LX4 + C(6)*LX5 + C(7)*LX6 + C(8)*LX7 + C(9)*LX8 + C(10)*LX9 + C(11)*LX10 (2)

4. Discussion

4.1. A Qualitative Study

Based on in-depth discussions, interviews with building and construction industry experts, and systemic analysis, we found that the international crude oil price, the gold price, and the copper price got the most answers, the highest scores, and the most important. So, we can include these variables in the econometric model to gauge how they affect the construction cost indices. These variables data were gathered from the global database websites, furthermore, in future researchers, other variables, like iron ore, can be considered in future studies.

4.2. A Quantitative Study

The study results revealed a significant impact of economic variables on construction cost indices (CCI). The macroeconomic model predicts a change in CCI by 97.4%, which means the change of 1 unit in economic variables leads to a change in construction cost indices by 97.1%.

4.2.1. The Proposed Model

The proposed model is as follows:

LY = -1.81650232456 + 0.00486954649802*LX1 + 0.932485248351*LX2 + 0.329026776287*LX3 + 0.0725029341608*LX4 + 0.20422410394*LX5 + 0.435983519781*LX6 - 0.0201731831736*LX7 + 0.0712655930809*LX8 + 0.118211181679*LX9 + 0.00975652736729*LX10

Where:

LX1Annual (GDP), LX2 Annual (CPI), LX3 Annual (Foreign exchange rate), LX4 Annual (Inflation Rate), LX5 Annual (Lending Rate), LX6 Annual (Money Supply), LX7 (Unemployment rate), LX8 Annual (international crude oil price), LX9 Annual (International gold price) & LX10 Annual (international Copper price).

5. Conclusion

This part will cover the research conclusion, Limitations, suggestions, and Future Recommendations.

This research proposes a prediction model of construction cost indices in the Egyptian building and construction industry guided by economic variables identified in the previous literature and specified from semi-structured interviewees' recommendations. The study results revealed

a significant impact of economic variables on construction cost indices (CCI). Egypt's economic variables were collected from 1990 to June 2020 to cover several economic cycles, including booms and reactions.

This study has established significant economic variables affecting Egypt's construction cost indices. Furthermore, this is the first time it has been used to determine the critical barriers to construction cost index development based on the economic variables in Egypt. Also, the recent study addressed the obstacles that have been identified; practitioners should increase their ability to assist and share additional data and opinions for creating construction cost indices.

The study's findings offer valuable lessons for project stakeholders, policymakers, and practitioners in identifying macroeconomic variables that tend to influence prices in the building and construction industry.

Finally, establishing construction cost indices will critically contribute to effective cost planning and serve as the basis for effective and efficient pricing regimes among stakeholders to ensure value for money. Accordingly, further work is required to determine the effects of the other economic variables across various construction industry sectors over various time intervals and other econometric models to ensure the validity of the suggested model and its regular adoption by governmental bodies.

5.1. Research Limitations

Research Limitations are as follows:

1. Firstly, the rarity of data availability for some macroeconomic indicators is one of the main challenges in developing the Construction cost indices during the study period covered in this research, which is from 1990 to 2020.
2. Secondly, although this study period covered many events that reflected economic and political instabilities, we highly recommend extending the study period until the end of 2023. Extending the study period will allow us to learn more trends and produce more robust and reliable predictions covering the economic situation and subsequent fluctuations.
3. Third, the qualitative study was constructed based on discussions with industry stakeholders and experts, including employers, consultants, contractors, and academics. The sample size is 15 interviewees with more than 15 years of experience; finding enough industry experts with 15+ years of experience took much time; therefore, more respondents are required to ensure that diverse outcomes and feedback were achieved.
4. Finally, we faced a rarity in the study data sources, which should been more extensive. Furthermore, each data source's assumptions will affect the model's predictions. For instance, the data collected from the CAPMAS indicates that it reflects the average prices of construction materials in all Egyptian governorates from the 15th to the 17th of each month.

5.2. Research Suggestions and Future Recommendations

Even though this research was able to answer the thesis questions and achieve the objective, several recommendations and future research paths still need to be continuously explored to improve it for future researchers. The following suggestions are proposed for future studies:

1. Establishing and developing the construction cost indices using other time intervals (monthly instead of annually) to obtain a monthly forecast model to be used by

those interested in project cost management in cost prediction and reduced hedging, eliminating uncertainty and unexpected risks.

2. Expanding the sample size "study period" to cover additional years and to include more economic cycles and sharp global and subsequent local economic changes that occurred during 2021–2023, such as the coronavirus epidemic, the Russian-Ukraine war, and the disruption of global supply chains, would improve such models' reliability and to include more economic trends.
3. Establishing the building and construction industry indices to match the Republic's 29 governorates, including the border governorates and their administrative divisions. This way, each governorate will have its indicator that reflects its situation regarding the availability of services, materials, and skilled labor needed for projects.
4. Further studies are recommended to establish different types of building and construction industry indices for various construction activities, disciplines, and sectors in Egypt as reliable indices to enrich knowledge and keep abreast of global developments; furthermore, new indices like tender price indices can be developed.
5. This research studies the building and construction industry in Egypt only, so establishing and developing the building and construction indices in different MENA region countries that do not have similar indices is highly recommended to keep pace with scientific development and avoid economic challenges.
6. Compare the Egyptian construction cost indices with similar indices in the MENA region ("UAE and Saudi Arabia) to measure and determine the indices trend in light of global economic conditions.
7. Such Indices should be published periodically and in a clear and easy-to-use format for all readers and knowledgeable people.
8. Applying the new worldwide trend and knowledge revolution in artificial intelligence and big data and investigating further methodology and techniques for modeling these indices will lead to developing more models, algorithms, statistical tools, and techniques to provide various and reliable results.
9. Finally, the most important suggestion is that one of the following governmental organizations, bodies, and institutions should be responsible for establishing and developing the building and construction industry indices: the Central Agency for Public Mobilization and Statistics, the Contractors Union, the Ministry of Housing and Urban Communities, the National Centre for Housing and Building Research, the General Authority for Urban Planning, the Engineers Syndicate, the Public Authority for Industrial Development, the Housing & Development Bank, and the Ministry of Administrative Development. These indices will encourage the building and construction industry stakeholders to use and apply them to avoid cost uncertainty issues and minimize hedging and any price fluctuation risks in construction materials.

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Appendix

Table 6.
Augmented Dickey-Fuller Test Statistic

Variable	Level	Result	1st difference	Result
CCI(Y)	-1.237.774	Non-stationary	-3.584.264	stationary
GDP(x1)	-3.276.532	stationary		
CPI (x2)	1.431.714	Non-stationary	-6.064.166	stationary
Foreign Exchange Rate(x3)	-2.995.868	stationary		
Inflation Rate (x4)	-0.833325	Non-stationary	-4.406.253	stationary
Lending Rate(x5)	1.362.004	Non-stationary	-4.111.238	stationary
Money Supply(x6)	-3.966.819	stationary		
Unemployment Rate(x7)	1.865.741	Non-stationary	-7.069.366	stationary
Crude Oil(x8)	-3.230.169	Non-stationary	-2.880.664	stationary
Gold(x9)	1.165.730	Non-stationary	-7.633.008	stationary
Copper(x10)	-4.475.187	stationary		

Table 7.
Variables Fitted Model

Variable	ARIMA Model	Adjusted Square	AIC	SC	SE of Reg	Decision
CCI(Y)	(1,1,4)	.126.71	-1.948.008	-1.807.888	0.085327	Reject
	(1,1,11)*	.465.02	-1.718.515	-1.578.396	0.097298	Accept
GDP(x1)	(1,1,1)*	.564.97	2.136.264	2.276.384	0.63084	Accept
	(2,1,2)	.045.09	2.811.995	2.952.115	2.358.540	Reject
CPI (x2)	(1,1,1)	.048.28	-2.953.133	-2.813.013	0.051271	Reject
	(1,1,10)*	.134.19	-3.001.937	-2.861.817	0.048902	Accept
Foreign Exchange Rate(x3)	(1,1,1)	.093.28	-.476.56	-.336.44	0.180911	Reject
	(1,1,3)*	.097.73	-.472.69	-.332.57	0.18128	accept
Inflation Rate (x4)	(1,1,3)	.048.24	1.460.428	1.600.548	0.478589	Reject
	(2,1,9)*	.136.37	0.434406	1.353.900	1.494.020	Accept
Lending Rate(x5)	(1,1,1)*	.273.66	-1.913.175	-1.773.055	0.087585	Accept
	(1,1,2)	0.229063	-1.858.431	-1.718.311	0.090234	Reject
Money Supply(x6)	(1,1,8)*	.442.64	-2.530.351	-2.390.231	0.052931	Accept
	(1,1,5)	.001.13	-2.345.112	-2.204.993	0.07094	Reject
Unemployment Rate(x7)	(1,1,4)*	.112.03	-1.526.331	-1.386.211	0.105962	Accept
	(1,1,5)	.060.47	-1.479.503	-1.339.383	0.108996	Reject
Crude Oil(x8)	(1,1,1)	.040.88	.224.54	.364.66	0.257996	Reject
	(1,1,9)*	.016.18	0.188534	0.328654	0.250826	accept
Gold(x9)	(1,1,3)*	.308.62	-1.561.179	-1.421.059	0.104459	Accept
	(1,1,7)	0.413024	-1.680.335	-1.540.215	0.09625	Reject
Copper(x10)	(1,1,1)	.053.42	-0.052955	0.087164	0.224622	Reject
	(1,1,8)*	.030.50	-0.11968	0.02044	0.215489	Accept

Table 8.
Variables Forecast from 2021-2022

Variable	2021	2022
CCI(Y)	491.985.0	541.184
GDP(x1)	3.384.969	3.723.466
CPI (x2)	4.417.828	4.859.611
Foreign Exchange Rate(x3)	3.555.924	3.911.516
Inflation Rate (x4)	1.939.262	2.133.188
Lending Rate(x5)	2.060.856	2.266.942
Money Supply(x6)	8.682.426	9.550.669
Unemployment Rate(x7)	9.816.708	10.798.379
Crude Oil(x8)	9.816.708	10.798.379
Gold(x9)	3.343.369	3.677.706
Copper(x10)	1.052.775	1.158.053

Table 9.
Testing the Impact of Macroeconomic Variables on Construction Cost Indices (CCI)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1.816.502	1.587.016	-1.144.603	0.2659
LX1(GDP)	0.33487	0.02955	4.164.788	0.045
LX2(CPI)	0.932485	0.146604	6.360.584	0
LX3(Foreign exchange rate)	0.32903	0.144901	-2.270.706	0.0344
LX4(Inflation Rate)	0.72503	0.051221	2.415.498	0.0172
LX5(Lending Rate)	0.204224	0.180649	2.130.504	0.0271
LX6(Money Supply)	0.735984	0.240321	3.814.175	0.0447
LX7(Unemployment rate)	-0.52017	0.107798	-2.187.139	0.0434
LX8(international crude oil price)	0.271266	0.064702	1.101.446	0.0338
LX9(International gold price)	0.118211	0.119934	3.985.638	0.0361
LX10(international Copper price)	0.329757	0.113027	1.046.321	0.0321
R-squared	0.989971	Mean dependent var		5.204.085
Adjusted R-squared	0.984956	S.D. dependent var		0.645781
S.E. of regression	0.079207	Akaike info criterion		-1.962.080
Sum squared resid	0.125475	Schwarz criterion		-1.453.246
Log-likelihood	4.141.224	Hannan-Quinn criteria.		-1.796.213
F-statistic	1.974.181	Durbin-Watson stat		1.586.547
Prob(F-statistic)	0			