Influence of Material and Labour on Construction Index Predictability

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Abstract: This study examines the long-run relationship between construction materials and labour with the construction cost index. The essence is also to investigate the efficiency of the variables that predict the construction index in Turkey. Monthly data from January 2015 to August 2023 was obtained for four Turkish indexes on construction, building, residential and non-residential as dependent variables. In contrast, the monthly material and labour cost indexes were obtained as explanatory variables. The study employed the fully-modified ordinary least square (FMOLS) technique. The findings revealed that the material cost index determines a substantial part of the construction index, followed by the labour cost index. However, those costs are less efficiently used. Therefore, the suggestion is that the construction industry should shift from the traditional approach and consider a more efficient approach through technological innovation. This finding supports the need for the construction industries to employ appropriate technology to enhance accurate construction index prediction that could prevent waste from labour slack time and procurement of costly materials. However, the limitation of the study is the data constraint in obtaining more variables for the prediction. Still, material and labour cost indexes used for the prediction are sufficient for making the conclusion of the finding valid.

Keywords: Turkey, Construction cost index, Cointegration regression, COVID-19, Labour and Material cost indexes

1. Introduction

Even though the construction industry is an essential sector that enhances economic development by providing employment opportunities, innovatively beautifying the country through a series of internationally attractive buildings, and promoting tourism, the sector's low productivity rate has raised concern, especially in the post-pandemic period. More importantly, emphasis has been placed on construction's contribution to economic development. This implies

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that the construction sector is the grassroots of every developed economy, and paying attention to the sector is crucial. With the continuous increase in urbanisation, the proposition is that by 2050, the population that would have urbanised would amount to 50% of the global population. However, studies are curious about low productivity if the construction continues with the traditional business framework [6]. The low productivity in construction industries was traced to components of construction indexes, mostly construction labour[2] cost across different countries [3; 6; 14] and the waste of construction materials[3]. Furthermore, construction labour has been referenced as the primary resource in the construction project, which immediately affects the cost and time of each construction activity [12]. Therefore, construction industries need to pay attention to attaining sustainable construction labour. This may increase construction productivity by directly or indirectly minimising material waste and eliminating construction labour slack time.

This further strengthens the cruciality of examining the long-run relationship between the construction industry's material and labour cost indexes and empirically contributing to the research gaps in the sector. The research gap was found in that several studies focus on either construction labour or construction materials with less attention to linking both factors together through their collective efficiency level. Note that the contribution of this study is very important as the sector has proven to propel the development of other industries significantly. In addition, both individuals and businesses are either directly or indirectly benefiting from construction industry products. This implies that the cost efficiency of the construction industry is essential for the betterment of the nation.

Brief findings from this study are that a significant relationship between construction materials, construction labour and the total construction cost indexes was established. However, the study emphasised the association between construction materials, construction labour, and the construction industry is inefficient. This indicates that Turkish construction cost indexes are not a pure reflection of the efficient construction market. The laps in the Turkish construction cost indexes are traced to material and labour cost indexes.

The rest of the study is structured as follows: section 2 focuses on the literature review. Section 3 discusses the data and methodology used in the study. Section 4 explains the findings, and section 5 concludes the study.

2. Literature Review

The previous studies were themed on the construction industry, construction materials and construction labour studies.

2.1 Construction Industry

The construction industry plays an essential role in economic development by creating business opportunities and employment, and it is one of the building blocks of any nation [3]. Still, low construction industry productivity remains challenging for this sector, and its effect on the national economy is a huge concern. Without readiness for significance in the construction industry by accelerating the rate of digitising the industry, the associated challenges could remain unaddressed [1]. The recent boom in the construction industry has resulted in a shortage of construction materials and labour. This eventually contributes to inadequate design and further hinders project management potential [3], especially in developing countries where the integration of the construction industry with technology is extremely low. The construction

[2] Construction labour denotes the labour cost of workers in either the projects of substantial construction or buildings or residential or non-residential projects.

[3] Construction material denotes materials used in either the projects of substantial construction or buildings or residential or non-residential projects

industry has the potential to benefit from advances in technologies such as the Internet of Things, Blockchain and Artificial intelligence [15].

The following hypothesis is developed:

H_1: There is a long-run relationship between Turkish construction cost indexes, construction material and construction labour.

2.2 Construction Materials and Construction Labour

The availability of construction equipment plays a significant role in predicting construction labour productivity [12]. This implies that essential construction equipment is essential to improve construction labour productivity. Efficient construction material is also required to make the dwelling affordable [20] and material provenance [22].

The need for construction labour advancement has been emphasised for over two decades and remains emphasised in the 21st century, which has trench down the productivity of the construction industry [3, 11]. Zhao et al. [23] emphasised that neither labour surplus nor deficit threatens the construction industry. Unfortunately, several studies reported that the construction industry employed low-skilled foreign staff to fill the construction work gap that native workers refused to do [3, 7]. This implies that the construction industry sometimes sorts for cheap labour that may have yet to require work experience and could eventually be at huge cost due to waste of construction materials and slack time.

Labour deficits make the construction industry employ inexperienced and unqualified labour at a cheaper wage. In contrast, labour surplus threatens qualified labour laid off. In addition, Ayodele et al. [5] reported an increase in the construction labour rate of turnover, which needs to be addressed by creating a sustainable workforce in the construction industry. Even though the construction industry is labour-intensive, the productivity of the construction labour remains a huge concern as they remain less productive [3], which is costly and time-consuming. Alaloul et al. [4] emphasise that ignoring the inflation rate while estimating the construction industry is estimating construction labour wages has resulted in cost overrun of construction projects. Productivity is a measure of construction industry efficiency as the construction labour constitutes about 30% of the whole construction project's emphasis on productivity is essential [12]. This emphasises that the construction labour issue is a huge construction industry matter.

The following hypothesis is developed:

H_2: There is a weak efficiency in the relationship between Turkish construction cost indexes, construction material and construction labour.

3. Data and Methodology

3.1 Data

This study's monthly frequency data from January 2015 to August 2023 was obtained from the Turkish Statistics Department (https://data.tuik.gov.tr/). The year 2015 construction cost index is the reference point. Construction material cost index, construction labour cost index, total cost index for Turkish construction index, Turkish Building index, Turkish residential index and Turkish non-residential index. Construction labour is a valuable asset in the construction industry [21] and construction materials [9]. It has been argued that proper workforce planning contributes significantly to construction economic recovery [23]. This indicates that construction material and construction labour are important variables for determining the wellness of Turkish construction cost indexes.

Furthermore, available data on the Turkish construction industry also supports the need to examine the efficiency of the construction sector. Based on the latest report of August 2023, an annual increase of 66.46% for the Turkish construction cost index was reported for the same month in the previous year and an increase of 4.62% compared to August in the previous month. Similarly, the material cost index increased by 1.92% relative to August in the previous year and about 113.27% compared with August in the previous year. In addition, the building

construction cost index experienced about a 4.09% increase on the monthly comparison basis and 65.48% on the annual comparison. The material index under the building cost index is increased by 1.83% and 113.11% on monthly and annual comparisons. Such slight changes under the construction cost index and building cost index are that each of them accounts for different types of construction.

Similarly, the Turkish construction turnover rate is essential to reveal the turnover rate of the Turkish construction industry. Although the report reflects an increase in the construction turnover compared to their respective basis of comparison, the cross-comparison reflects a significant reduction, especially on monthly comparison in August 2023 relative to July 2023.

Table 1: Turkish Construction Cost Index Changes

	Construction Cost Index		Building Construction Cost Index	
	Monthly changes	Annually Changes	Monthly changes	Annually Changes
August Data				
Total Construction Index	4.62%	66.46%	4.09%	65.48%
Material Index	5.82%	52.18%	5.15%	50.28%
Labour Index	1.92%	113.27%	1.83%	113.11%
Construction Turnover rate	2.6%		106.3%	
July Data				
Total Construction Index	15.67%	62.25%	14.68%	62.55%
Material Index	9.76%	47.01%	8.185	46.64%
Labour Index	31.66%	111.68%	31.62%	111.74%
Construction Turnover rate	11.3%		116.7%	

Authors' extraction from publicly available Turkish Government Statistics Database. Source (data.tuik.gov.tr)

In addition, the study controls for the COVID-19 pandemic by capturing the effect in the models. Control for the COVID-19 Pandemic is essential because the series used in this study would be small for the analysis if split. COVID-19 is an important crisis that should be considered due to its overall influence on the global and national economy. The COVID-19 pandemic caused a decline of 1.6% in Chinese construction jobs within a month in March 2020 and resulted in a cut of 1000 jobs within another month in May 2020 [13]. During the COVID-19 pandemic, delays in payment and increased construction material costs were documented [2]. All data was transformed into logarithm values for normalising the data [17], and cointegration regressions were employed.

3.2 Method

The present study employed the panel cointegration technique to examine the long-run relationship between the variables and the efficiency of the relationship. This study employed grouped FMOLS to establish a long-run relationship between construction materials and labour with Turkish total construction cost indexes. FMOLS is chosen because the technique provides robust results and addresses heterogeneity, endogeneity, and autocorrelation problems [16, 18]. Similarly, FMOLS is one of the panel cointegration techniques considering a small sample bias [19]. Therefore, the total construction cost index is expressed as a function of the materials used and labour employed as holding other variables constant as follows:

$$Total\ Construction\ Cost\ Index_{it} = \int (Construction\ Materials_{it}, Construction\ Labour_{it}) \quad (1)$$

The panel FMOLS model of this analysis approach was adopted and as expressed in the studies of Ruan and Yan [16] and Liu et al. [10] as follows:

$$\hat{\beta}_{GFM} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_{FM,i} \quad (2)$$

The cross-sectional dimension is denoted by N, and the estimator for FMOLS is denoted with $\hat{\beta}_{FM,i}$ in the i^{th} Turkish construction cost index.

The corresponding t-statistics is expressed as follows:

$$t\hat{\beta}_{GFM} = N^{-1/2} \sum_{i=1}^{N} \hat{\beta}_{FM,i} \quad (3)$$

Among the advantages of The FMOLS technique over Engle-Granger (EG) is that it introduced error terms that validate long-run estimation [8] and permit uneven serial correlation features for cross-section series.

A more specific model of equation 1 is expressed as follows:

$$lnTotal\ Const\_Cost_{it} = \alpha_0 + lnLabour_{it} + lnMaterial_{it} + COVID - 19_{it} + \varepsilon_{it} \quad (4)$$

where,

$lnTotal\ Const\_Cost$ represents the logarithm value of Turkish total cost indexes of construction, building, residential and non-residential.

$lnMaterial$ represents the logarithm value of Turkish construction material cost indexes.

$lnLabour$ represents the logarithm value of Turkish construction labour cost indexes.

$COVID - 19$ represents a dummy variable for control for the COVID-19 pandemic effect, and ε represents error terms.

4. Empirical Findings

The panel analysis regression starts with a preliminary analysis, including descriptive statistics and a stationarity test. Then, the study proceeds with modelling the Fully-modified ordinary least square (FMOLS) technique for the cointegration analysis and predictability of the efficiency of the relationship.

Preliminary Analysis

4.1 Panel Descriptive Statistics

Table 2 presents the descriptive summary of the study series. A wide spread between the minimum and maximum of all the series indicates that Turkish construction industry indexes have experienced substantial changes between January 2015 and August 2023. With a wider range between the minimum and maximum cost index of materials (Max = 1105.1900, Mini = 92.2100); labour (Max = 1155.3300, Mini = 96.9300); and total cost (Max = 1118.7400, Mini = 97.1300) revealed that construction industry index had experienced unprecedented change between January 2015 to August 2023. The coefficient of standard deviation, skewness and kurtosis showed that the series are not normally distributed. Therefore, using parametric analysis may result in a misleading conclusion. Furthermore, the construction labour series exercised catastrophe during the study period. This might be due to mobility restrictions during the COVID-19 pandemic, whereby the work-at-home policy was widely implemented in several countries, which was a complete restriction on field work such as construction projects. In contrast to the construction material and construction total costs, the needs of most individuals

have changed from property accumulation as there is no guarantee of survival during those periods.

Table 2: Descriptive Statistics of Construction Cost, Construction Materials and Construction Labour Costs

	TOTAL COST	MATERIAL	LABOUR
Mean	282.4179	287.5351	269.9713
lnMean	5.3741	5.3663	5.3819
Median	190.5150	184.8350	204.3750
lnMedian	5.2497	5.2194	5.3199
Maximum	1118.7400	1105.1900	1155.3300
lnMaximum	7.0199	7.0077	7.0521
Minimum	97.13000	97.21000	96.93000
lnMinimum	4.5760	4.5768	4.5739
Std. Dev.	243.5888	256.8503	217.4281
lnStd.Dev	0.6823	0.7147	0.6081
Skewness	1.712320	1.593172	2.181661
lnSkewness	0.8719	0.8701	0.9036
Kurtosis	4.872364	4.230402	7.496736
lnKurtosis	2.6486	2.5393	3.1839
Jarque-Bera	264.0543[a]	202.2223[a]	680.4929[a]
lnJarque-Bera	54.8513[a]	56.1662[a]	57.1924[a]
Observations	416	416	416

Note that ln represents the logarithm value. The table presents raw values and logarithm values of the series of the variables examined.

4.2 Panel stationarity test

Before estimation, the stationarity of the panel series was conducted. The panel stationarity test of cross-sectional and individual stationarity test results is presented in Table 3. ADF and PP stationary test techniques are used, and the result concluded that the series is not stationary at level, but the stationarity is significant at first difference. This indicates that the series is integrated in the order of 1, I~(1). The p-value of individual stationary test results is presented for construction, residential and non-residential buildings. According to several studies, if the time-series dimension is not stationary, the model based on the panel data could generate a spurious conclusion [16, 19].

Table 3: Stationary Test Result

	Trend and intercept			
	Level		1st Difference	
	ADF	PP	ADF	PP
ADF – Fisher Chi-Square	0.0246		40.5169	
	(1.0000)		(0.0000)	
PP – Fisher Chi-Square		0.00914		138.403
		(1.000)		(0.0000)

Individual P-Values				
Construction	0.9973	0.9991	0.0070	0.0000
Buildings	0.9973	0.9990	0.0057	0.0000
Residential	0.9978	0.9991	0.0051	0.0000
Non-residential	0.9953	0.9982	0.0079	0.0000

4.3 Regression Findings

This study presents a panel long-run relationship between material and labour cost indexes with Turkish cost indexes of construction, building, residential and non-residential buildings. It is obvious that the Turkish construction industry has been experiencing an exponential increase in cost, as predicted by materials and labour cost indexes, and urgent attention is required. Therefore, it is important to examine the changes in the construction index.

The finding revealed that the FMOLS model is consistently appropriate for the analysis without violating diagnostic tests. In a similar approach, Sharma and Bakshi [19] employed the FMOLS as an alternative model for establishing long-run association among the variables, which is reported to be valid for the analysis.

The finding revealed that the construction materials and labour lag significantly predicts the current construction cost index. The lag of the materials cost index and labour predicted a substantial increase in the current construction cost index. The construction materials cost index predicted above 70% of the current construction cost index changes, and the construction labour cost index predicted less than 30% of changes in the current construction cost index. However, inflation and tourist attractiveness may substantially increase the Turkish construction index. Continuous housing price increases have been reported in other countries where tourism and inflation may not be contributing factors. Construction materials more explain the changes in total construction cost than construction labour. The finding further explained the behaviour of construction materials in the Turkish construction industry.

4.3.1 Panel Long-run Relationship

Turkish Construction cost index:

$$Total\ Const\ Index = 1.4868 Const\ Material - 1.0893 Const\ Material + 0.3549 Const\ Material + 0.2097 Const\ Labour + 0.0653 Const\ Labour - 0.0272 Const\ Labour + 0.0017 COVID - 19$$

Table 4: Long-run relationship between construction materials, labour and total construction cost

Variable	β	Prob.
$lnMaterials_{-1}$	1.4868	0.0000
$lnMaterials_{-2}$	-1.0893	0.0000
$lnMaterials_{-3}$	0.3549	0.0000
$lnLabour_{-1}$	0.2097	0.0000
$lnLabour_{-2}$	0.0653	0.0002
$lnLabour_{-3}$	-0.0272	0.0549
COVID_19	0.0017	0.5648

Adj_R^2	0.9987	
Wald Test	9803.434	0.0000
$HQ_{(5)}$	-0.031	0.447

Adjusted R-square implied that the cost of construction materials and construction labour wages explain 99.87% of the Turkish total construction cost index changes.

Table 4 reveals that construction materials and labour cost indexes established a long-term relationship with the total construction cost index. However, construction materials and labour cost indexes in the total construction cost index predictability are significant until the third lag. This implies that the Turkish construction cost index could be more efficient. The finding revealed that a 1 unit change in the first construction material cost index lag predicts a 1.4868 unit increase in the total construction cost index. The finding revealed that a 1 unit change in the second construction material cost index lag predicts a decrease of about 1.0893 units in the total construction cost index. The finding revealed that a 1 unit change in the third construction material cost index lag predicts a 0.3549 unit increase in the total construction cost index.

Similarly, the finding revealed a 1 unit change in the first construction labour cost index lag predicts about 0.2097 units increase in the total construction cost index. The finding revealed a 1 unit change in the second construction labour cost index lag predicts about 0.0653 units increase in the total construction cost index. The finding revealed that a 1 unit change in the first construction labour cost index lag predicts a -0.0272 unit decrease in the total construction cost index. Even though the degree of predictability of the lags of construction materials and labour cost indexes in predicting the Turkish total construction cost index is decreasing as the lag length increases in absolute value, the Turkish construction cost index is still inefficient. This implies that market imperfection plays a significant role in the Turkish construction market. Such continuous increases in the construction industry could have been traced to substantial waste in the construction materials and unproductive time of construction labourers that tend to be inefficient accumulated costs on the total construction cost index.

Those costs could be classified as unsystematic and eliminated through the full technological integration of the construction industry process. Although the construction industry consumes a substantial quantity of raw materials, some of those material ends up in waste in construction waste [9]. Several countries experienced a shortage of construction labourers, which obstructed the construction work progress [13]. This could be traced to the nature of the tasks involved, and those who are ready to work may need more experience and are temporarily engaged in the construction labour force. Labour inexperience contributes to construction materials waste [9]. Either of the above may contribute to task delay, which may cost the construction industry. From the construction industry perspective, technological integration of the construction process is essential, with its own initial cost that may be realised over time. The ability to commit such initial costs may contribute to delays in technologically integrating the construction process. In addition, the COVID-19 pandemic exerts a positive but insignificant effect on the construction industry.

Studies have established that a substantial amount of construction materials end in waste, and construction labour slack time is a cost to the construction industry. If eliminated, it would reduce the total construction cost. In addition, experience gained over time through on-the-job training and adopting technological approaches in the construction industry process could increase industry efficiency. Idle working time on labour and waste on materials used may be eradicated if the construction process is fully technologically automated, and the efficiency of the industry could be elevated. For example, one-fifth ($\frac{1}{5}th$) of the labour costs are estimated to be unproductive, and above 50% of the material cost would have been avoided. Eventually, the construction cost index could be reduced. In support of this, Wong et al. [21] suggested the need for authority intervention in ensuring construction labourer acquires the required knowledge to make them relevant and appropriate and coupled with skills that the technological

integration of the construction industry would require. The findings passed the Wald diagnostic test that the serial is significantly different from zero, which implies the findings are valid.

5. Conclusion

The study examined the long-run association and efficiency of the predictability of the relationship between construction material index, labour index and total construction cost index. The finding revealed that the material index explains more changes in the total construction cost index relative to the labour index. The finding also revealed that the efficiency of the Turkish construction cost index is low as up to three layers of lagged material index and lagged labour index significantly explain the changes in the current total construction cost index. Studies from Hong Kong [21] and Sri Lanka [9] have also reported that construction materials and labour could be more efficient. Reference is made to construction material waste and inefficient use of construction labour, which contributed to the increase in the total construction cost index [9, 21]. As housing affordability is becoming a burden for individuals and the government, the authority needs to step into the policy of shaping the construction industry right, as all the costs involved in the construction process would either directly or indirectly pass on to the final retailers. Incorporating technology that could reduce waste in construction material and construction labour indices may also cut the long-term construction cost index. The limitation of this study is that the material index and labour index are used in predicting the changes, and the COVID-19 pandemic effect was controlled.

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