# The Housing Cost Predicting Model for Conventional Private sector Construction Projects in Iran

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**Abstract**

The housing market has a special place in Iran's economy, including the impact of building on fixed capital, the effect on other economic activities, household livelihood, and the association of housing boom and bust periods with macroeconomic indices. The housing market is considered an engine that drives economic activity. Recognizing market trends, entering and exiting markets at the correct times, and making the best use of investment opportunities are some of the goals of every economic activist. Conclusive predictions may not be attainable due to certain aspects of the housing market; however, it is possible to make probabilistic and acceptable predictions by evaluating prior behavioral tendencies. The research is functional regarding purpose, and it uses is analytical method. The purpose of this study is to present a model for predicting housing costs in Iranian traditional private sector construction projects using a multiple regression. This research was done with a firsthand data survey based on data type criteria and a questionnaire based on field research. Data analysis tools are SPSS and AMOS, and developed with Matlab. A questionnaire was used to acquire construction cost data from builders during 2015 to 2019. The results of the bootstrap test and the regression model demonstrated that the construction costs of 3–7 story buildings could be predicted based on a time factor (completion time).

**Keywords:** Construction Cost, Housing, Prediction, Private, Multiple Regression

**Tob Regul Sci. ™ 2022;8(1): 1830-1843**
**DOI: doi.org/10.18001/TRS.8.1.139**

## Introduction

The housing market plays an exceptional role in Iran's economies, such as the impact of construction on the formation of fixed capital, its effect on other economic activities, its place in the livelihood economy of households, and the relationship between housing market and bust periods with macroeconomic indices. But in the other perspective, the housing market is considered a driver of productive activities because changes in construction investment as a variable affected by housing price fluctuations, affect the variables of GDP and recruitment, therefore the housing sector plays an essential role in shaping the cycles of commercial activities (Maleki, 2016).

Early estimation of the project's final estimated cost is essential to the actual success of the project. Initial estimates are also uncertain feature and can incorrectly estimate and report the project's costs. These factors affect reliable cost estimates, display risk and uncertainty and can affect overall value-added delivery. Risks are unavoidable in construction projects and cannot be completely avoided. Contrary to developed project planning, incident events complicate or fundamentally change the initial project planning and prices (Hurst, 2019).

The initial cost estimate is exposed to the effects of vulnerable behaviors, while being aligned with the demands of key stakeholders to ensure that the financing proposal is consistent with the objectives (Mohammad Karimi et al., 2010).

Recognizing market trends, timely entry and exit, and optimal use of investment opportunities are some of the goals that every economic activist pursues. Accurate and definitive predictions in the housing market are possible due to some factors. Many activists and policymakers in this sector do not have the expected ability to make accurate predictions. However, through behavioral analysis of past periods, probabilistic predictions can be made, even appropriately. The supply of housing, in addition to its price, is influenced by various factors such as the price of production institutions (land, construction costs including human resources wages, construction materials, and equipment), fees, and charges of permits (design, supervision, implementation, and construction license, etc.), safety and stability of the excavation, civil liability insurance (damage to third parties), housing construction credits and financing, new construction technologies, construction completion time, scale, production, government policies (taxes, subsidies, regulations, supportive-social housing, etc.), and waiting time; Other factors such as housing stock and vacant houses affect the supply of housing (Maleki, 2016).

The main issue of this research is to predict the construction costs of 3-to-7-story buildings by time factor (completion time) using the multiple regression method.

## A review of the research literature

Prediction of the construction cost for any project is a very complex process. There are multiple variables to consider when estimating construction costs. Each variable must be correctly estimated based on the proper study, past experience, and research to calculate the total construction project's cost. Many factors affect the cost of construction and have a significant impact on the project's cost, as follows. 1) Similar construction projects, 2) Construction materials costs, 3) Manpower wage rates, 4) Construction site conditions, 5) Price inflation factor, 6) Project schedule, 7) Design quality and technical specifications, 8) Engineering validity, 9) Legal requirements, 10) Insurance requirements, 11) Size and type of construction project, 12) Location of construction, 13) Engineering review, and 14) Probability It is always advisable to add at least a possible 10% of the total project's cost for unforeseen costs and inflation (Hurst, 2019).

In recent decades, the leading indices of the Iranian housing market, such as the number of residential-commercial units, the worth of real estate, price index, and the number of residential units concerning the number of households, have had significant changes (Ravanshadnia, 2015). The following Ten quantitative and qualitative indices show the particular importance of the housing sector for the economy of the country and the Iranian household.

- Iranian households' share of the country's wealth (about 88%),
- The proportion of gross domestic fixed capital formed (The ratio has increased about 55% in the early 1980s to around 35% in the late 2000s),
- Share in the household expenditure basket (33% of the expenditure according to the statistics of year1991),
- The role of housing in GDP (about 5% of value-added directly related to the construction sector),
- The share of calculating the inflation index,
- No complete dependence on imports and the possibility of localization of equipment,
- Proportion of the required labor force with the structure of education and skills of the country's labor force in typical construction,
- The share of housing construction in labor employment (about 15.4% in 2012),
- Proportion of investment horizon with the expectations of Iranian investors (factor of attractiveness and promotion of exceptional value),
- The country's economy's most private sector (Ravanshadnia, 2015).

Each variable should be estimated correctly based on appropriate research, previous experience, and research to calculate the total project cost of construction. (Despite equivalent commodities such as gold, coins, currencies, and stock exchanges are not equivalent.). This factor has caused problems in the pricing of real estate compared to other goods; to some extent, it is a matter of taste and the flow of parties to the transaction. The involvement of intermediaries and brokers in determining and directing prices, especially during the real estate boom and an influx of demand, is greater than that of financial markets, especially in the absence of transparency and severe information asymmetry in this market.

Housing construction and supply is time-consuming (housing production is less-demanded in the face of price growth in the short term). On the other hand, the aggregation of financial resources by housing buyers, and the formation of actual purchase demand, requires time and planning. In the housing market, imbalances (risk-cost imbalances) are prevalent. The position of investment in the housing sector is based on two indices of risk and revenue, compared to other options (stock exchange, coins, gold, etc.). In the long-run, most countries' housing investments have returned average returns while offering medium risks. A study of the historical trend of Iran over the past 21 years also confirms this situation (1982-2013). In Iran, unsecured corporate bonds have not been issued, but the position of this option in most countries, in the long run,is between housing and bank deposits (Koozechi, 2013).

**Iran's Housing Market**

A housing market is considered to have formed when the current price of an item exceeds its intrinsic value, and this gap continues to grow over time (Koozechi, 2013). A housing market occurs when housing price increases are not justified by the basic concepts of macroeconomics and essential factors in the housing market. In this case, expectations of rising prices in the future are the most crucial reason for the current price rise. Continuation of low-interest rates, growth of high-risk mortgage loans and speculation in the housing market are the most important reasons for the bubble in this market (Derakhshan, Mojtahedzadeh, 2008).

Boom-bust periods have always been evident in this market; by examining the housing market developments in Iran; some of them are predictable (Ravanshadnia, 2015). It is essential to consider the following brief points in this field.

- Positive cash flow benefits and real estate equity proposition are effective in the wealth of real estate entrepreneurs.
- The rise in equity is strongly tied to current economic conditions and real estate prediction.
- Real estate is the only type of investment that rarely adapts to the general trends of other markets.
- There is no accurate prediction in the field of real estate; as a result, the real estate market is heterogeneous, and the market is moving slowly. Therefore, investors usually forget how important the market trend really is, but when the real estate market downturn comes, everyone wants to understand the movement!

In normal conditions, the ups and downs of the real estate market occur slowly over time, and predicting and measuring its trend is approximate and probabilistic. A historical background of Iran's housing market reveals that it follows a particular pattern that is influenced by the country's economic structure, and that this pattern has dominated fluctuations in housing supply and demand in recent decades (Ravanshadnia, 2015). According to this basis, and as a contrast to general inflation, housing prices do not have a linear trend, its curve has a gradual trend, and housing price growth fluctuates under general inflation (Maleki, 2016).

A look at the fluctuations in housing prices and general inflation in recent decades also shows that during this period, in some years, the growth rate of housing prices has been higher than general inflation and some rare cases, less than that. It intensifies, reduces, or accelerates the delay in the predicted periods of the market. In this way, factors such as population structure, economic growth, world oil prices, household incomes, the situation of parallel markets (stock exchange, coins, gold, currency), liquidity and inflation, housing construction and purchase facilities, housing production markets, government policies, urban planning laws, etc. all they leave undeniable effects on the housing market (Maleki, 2019).

## Research Methodology

The research is functional regarding its purpose, and it uses an analytical method based on a survey based on the time of data collection, a quantitative one based on the nature of data and the basis of research, a correlation one based on the research subject or problem, one with first-hand data based on the data type, and a field questionnaire based on the data collection method.

## Regression Analysis

The relationship between a dependent variable and several independent variables is expressed by regression analysis. Regression analysis is performed for two primary purposes:

1- Making a model establishes a quantitative relationship between a dependent variable and several independent variables.

2- In this case, several known factors, called "predictor variables," are predicted by a dependent variable called a "criterion variable."

These two objectives are inextricably linked. As a result, a model that predicts the values of the criterion variables should be built.

The difference between regression and goal-based correlation is that the goal of correlation models is to examine the extent of the relationship between two or more variables; Regression, on the other hand, seeks to predict one or more variables based on one or more other variables. Regression is based on past data, it is called regression. Therefore, from the point of view of purpose, we display the correlation between the importance and depth of the relationships among variables. The distinction between a regression and a record of correlation outcomes is that correlation measures the impact of a variable in pairs, even as the regression version assesses the impact of a variable at an identical time (Tavalaie, Mohammadzadeh Alamdari, 2017).

## Multiple Linear Regression

Researchers can use multivariate regression to study linear relationships between a set of independent factors and dependent variables, taking into account existing relationships between independent variables. The purpose of regression is to aid in the explanation of the dependent variable's variance. This is accomplished in part by determining the number of variables (two or more independent variables) that contribute to this variance. Multiple regression analysis is well suited for examining the effects of independent multivariate variables on the dependent variable (including experimental variables). Multiple regression is a statistical technique in which the values of one variable (y) are estimated using the values of two or more additional variables (independent variables x1,... K2). Because the variables in multiple regression are linear, the multiple regression equation is defined by three variables related to Equation 1:

$$y' = b_0 + b_1(x_1) + b_2(x_2) + \cdots + b_k(x_k) \quad (1)$$

(Vazan, 2022)

## Collection of Regression Input Data

The most important input for regression modelling to estimate the initial finances is data time series. The nature of the data collected, such as the content of data, the level of details, the number of samples, the effect on the selection of variables and the analysis method, other information, such as execution duration, the average height of floors, etc., can be extracted from this data.

## Variables Used in the Analysis

In each parametric model, the model's accuracy indicates the efficiency of the variables selected to make the model. The model with more minor error has used more effective variables (Huynh et al., 2020). The following project factors were utilized as independent variables in multiple linear regression to establish the association with the dependent variable (cost per $m^2$ of the building) through multiple linear regression are; height of floors (st)[1], number of floors (st), duration of the project (in months). Cost estimation was done using a questionnaire of 120 people by private housing developers. The variables provided to the respondents according to the characteristics of the project are: building area, residential use, reinforced or steel-concrete structure, quality of conventional construction (typical), construction area (medium urban level), regional adjustment (matching with Tehran), elimination of land prices and municipal tolls and the map is designed to increase the accuracy of the estimate. The number of input data is the construction cost of 1252 units, which is recorded in terms of million Toman's per square meter.

[1] St: storey

**Table 1. Dispersion statistics (Mean, Standard deviation, Minimum, and Maximum Construction Costs) from 2015 to 2019:**

| Construction cost | Fiscal year | mean | standard deviation | minimum cost | maximum cost |
|---|---|---|---|---|---|
| The total construction cost of 3-St | 2015 | 0.75 | 0.005 | 0.74 | 0.76 |
| | 2016 | 0.81 | 0.2 | 0.76 | 0.86 |
| | 2017 | 0.94 | 0.05 | 0.86 | 1.03 |
| | 2018 | 1.31 | 0.18 | 1.03 | 2 |
| | 2019 | 1.75 | 0.09 | 1.56 | 1.97 |
| The total construction cost of 4-St | 2015 | 0.78 | 0.005 | 0.77 | 0.80 |
| | 2016 | 0.85 | 0.03 | 0.80 | 0.90 |
| | 2017 | 0.98 | 0.06 | 0.90 | 1.08 |
| | 2018 | 1.37 | 0.16 | 1.09 | 1.66 |
| | 2019 | 1.84 | 0.10 | 1.64 | 2.07 |
| The total construction cost of 5-St | 2015 | 0.85 | 0.006 | 0.84 | 0.87 |
| | 2016 | 0.93 | 0.03 | 0.87 | 0.98 |
| | 2017 | 1.07 | 0.06 | 0.98 | 1.17 |
| | 2018 | 1.49 | 0.18 | 1.18 | 1.80 |
| | 2019 | 2.00 | 0.11 | 1.78 | 2.25 |
| The total construction cost of 6-St | 2015 | 0.90 | 0.006 | 0.89 | 0.92 |
| | 2016 | 0.98 | 0.03 | 0.92 | 1.03 |
| | 2017 | 1.13 | 0.06 | 1.04 | 1.24 |
| | 2018 | 1.58 | 0.20 | 1.25 | 1.92 |
| | 2019 | 2.15 | 0.11 | 1.91 | 2.40 |
| The total construction cost of 7-St | 2015 | 0.96 | 0.007 | 0.95 | 0.98 |
| | 2016 | 1.04 | 0.03 | 0.98 | 1.10 |
| | 2017 | 1.20 | 0.7 | 1.10 | 1.31 |
| | 2018 | 1.69 | 0.21 | 1.33 | 2.05 |
| | 2019 | 2.28 | 0.12 | 2.03 | 2.56 |

According to the table1, the average construction cost has significant fluctuations over time, then the time factor could affect the construction cost.


Fig.2 Trend of the mean construction cost from 2015 to 2019

**Table 2. Dispersion statistics (mean, standard deviation, minimum and maximum construction cost) over five years without year break:**

| Variable | Mean | Standard deviation | Minimum cost | Maximum cost |
|---|---|---|---|---|
| The total construction cost (3 St) | 1.09 | 0.37 | 0.74 | 2 |
| The total construction cost (4 St) | 1.14 | 0.38 | 0.77 | 2.07 |
| The total construction cost (5 St) | 1.24 | 0.42 | 0.84 | 2.25 |
| The total construction cost (6 St) | 1.31 | 0.45 | 0.89 | 2.40 |
| The total construction cost (6 St) | 1.40 | 0.48 | 0.95 | 2.56 |

*St: Number of floors.

According to the table2, means, the average construction cost fluctuates significantly over time, and then the time factor can affect the construction cost.

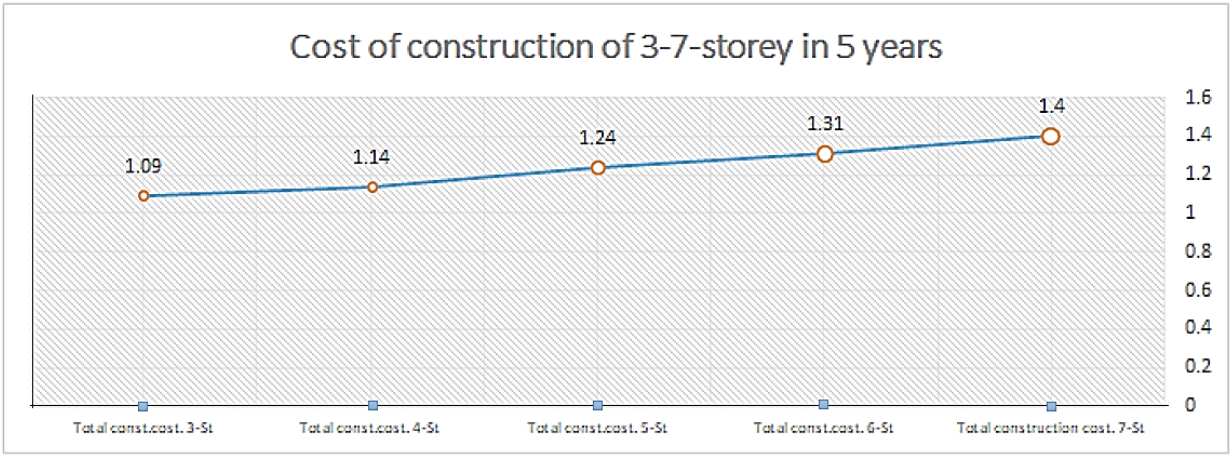


**Diagram 1. Cost of construction of 3-to-7-storey in 5 years without break years**

**Table 3. Dispersion statistics (Mean, Standard deviation, Minimum and Maximum construction time and construction cost of 3-to-7-storey) for total of five years**

| Variables | statistics | | | |
|---|---|---|---|---|
| | mean | Standard deviation | Minimum value | Maximum value |
| Completion time of 3 St | 10.80 | 3.14 | 6 | 20 |
| *The total cost of 3 St | 1.09 | 0.37 | 0.74 | 2 |
| Completion time of 4 St | 12.43 | 3.52 | 7 | 24 |
| *The total cost of 4 St | 1.14 | 0.38 | 0.77 | 2.07 |
| Completion time of 5 St | 13.15 | 3.75 | 7 | 24 |
| *The total cost of 5 St | 12.41 | 0.42 | 0.84 | 2.25 |
| Completion time of 6 St | 17.54 | 18.18 | 11 | 32 |
| *The total cost of 6 St | 1.31 | 0.45 | 0.89 | 2.40 |
| Completion time of 7 St | 18.32 | 3.44 | 13 | 33 |
| *The total cost of 7 St | 1.40 | 0.48 | 0.95 | 2.56 |

* Construction cost in terms of million Tomans per $m^2$.

* Multiple regression model of the effect of completion time over 2015 to 2019 on the total construction costs of 3-to7-storey buildings

It seems that the construction costs of 3 to 7 storey buildings are predicted by the time factor (completion period).

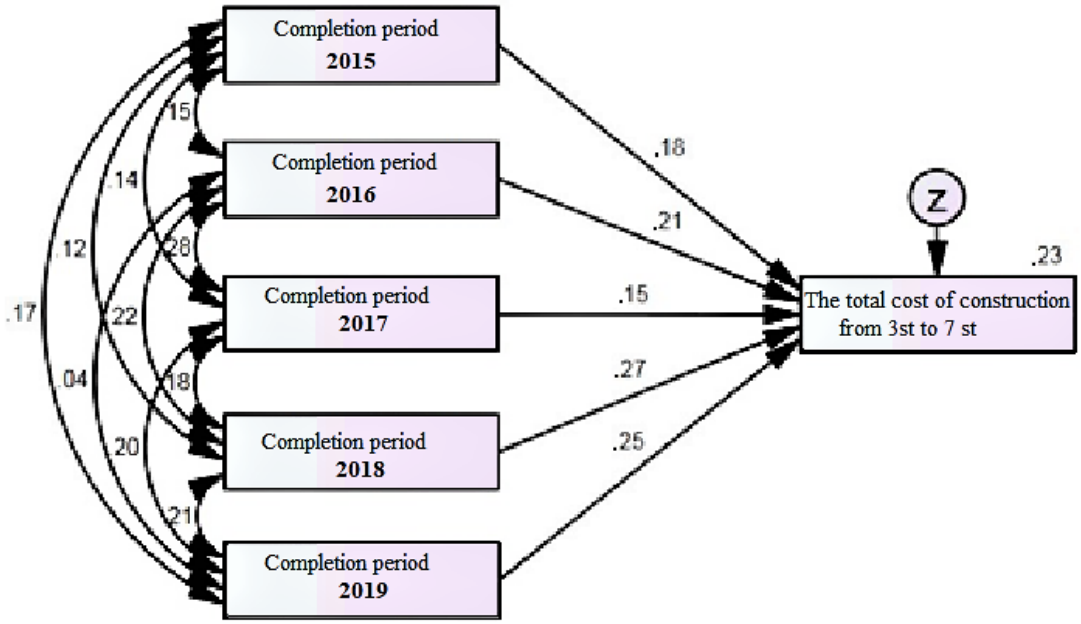


Diagram 2. SEM Model

Table 4. Output regression weights

| variables | Standardized values | Critical point | Significance level |
|---|---|---|---|
| The intensity of the effect of completion time in 2015 | 0.18 | 4.32 | 0.04 |
| The intensity of the effect of completion time in 2016 | 0.21 | 4.81 | 0.03 |
| The intensity of the effect of completion time in 2017 | 0.15 | 4.09 | 0.04 |
| The intensity of the effect of completion time in 2018 | 0.27 | 5.12 | 0.03 |
| The intensity of the effect of completion time in 2019 | 0.25 | 5.03 | 0.03 |

Table 5. The Bootstrap test output at $R^2$

| Standardized values | minimum | maximum | Significance level |
|---|---|---|---|
| 0.23 | 0.15 | 0.27 | 0.03 |

According to the multiple regression model and its standard output in Amos software, $R^2$ in this model is equal to 0.23 and indicates that 23% of the variance of the dependent variable (costs of construction of 3-to7-storey buildings) is explained by the independent variable (completion time of work from 2015 to 2019); that is, 23% of the change in construction costs of 3-to7-story

buildings is related to the time variable. The value of the significance level in this test is equal to 0.03 and is less than the standard error level of 0.05 which reports the significance of these effects statistically. These effects (effect of an independent variable on the dependent variable) are significant and the research hypothesis is confirmed. Therefore, the construction costs of 3-to7-storey buildings are predicted by the time factor (completion time).

**Discussion**

Despite confirming the accuracy of the analysis based on the bootstrap regression model (confirmatory), this study, similar to regression analysis research, is unfortunately less accurate due to its simplicity and ease of use ($R^2$ = 23%). Therefore, to increase the accuracy and validity of construction cost predictions, optimization algorithms and artificial intelligence methods should be used for model development. Therefore, in the research of model development, data optimization algorithms and artificial intelligence tools have been used to validate the data and measure the accuracy of the optimized initial data, which is briefly mentioned.

The number of initial input data to MATLAB software was 1252 construction cost based on time series. Particle swarm optimization (PSO) is a universal optimization method. In fact, the PSO algorithm is used to optimize neural network weights to minimize errors. The reason for choosing the PSO algorithm is that the studies have shown exemplary performance in financial management research. Therefore, this method was selected to discuss the optimization of housing cost data. The multilayer perceptron neural network with three Bayesian neural network algorithms, multilayer perceptron and intelligent PSO algorithm has been used to determine the weights of this approach. Finally, the results of these three algorithms based on MAPE, MSE and $R^2$ have been tested together for the whole data (data from 1 to 100 were used for training and data from 101 to 106 were used for testing). In fact, an algorithm has a better overall performance that can get the best results on test data. Based on all three criteria, the PSO algorithm performs better on the test data than the other two algorithms. The results are summarized in Table (6).

**Table 6. Algorithms with three standard errors in training and testing**

| Final results of basic algorithms | total MAPE | training MAPE | Test MAPE | total MS | training MSE | Test MSE | total $R^2$ | training $R^2$ | test $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Bayesian neural network | 2.957 | 2.9707 | 2.7265 | 0.002056 | 0.0020962 | 0.0013678 | 0.96055 | 0.95889 | 0.57642 |
| Artificial multilayer perceptron neural network | 2.3835 | 2.2779 | 4.1427 | 0.0016133 | 0.0015343 | 0.0029294 | 0.96906 | 0.96994 | 0.10576 |
| PSO particle swarm optimization | 2.9690 | 2.991 | 2.6179 | 0.0020777 | 0.0021213 | 0.0013516 | 0.96015 | 0.95044 | 0.5674 |

MAPE is the absolute value of the percentage of errors; the lowest value is related to the multilayer perceptron algorithm (backward-forward), and MSE is also related to the perceptron network. Regarding R2, the lowest value is associated with the PSO algorithm and the highest value corresponds to the neural perceptron network (backward-forward). Due to the proximity of the coefficient of detection values to 1, the analysis has high accuracy. Optimization and

prediction algorithms for the research data were evaluated based on three criteria: MAPE, MSE, and R2, which were highly accurate compared to previous research. (Karanci, 2010; Tavana & et al., 2018; Jiang & et al., 2022; Malekian et al., 2018, Stayesh, Ahadianpour Parvin, 2008' Rafiei, Nobakht, 2013; Huang & et al., 2008). The Bayesian artificial neural network algorithm had lower prediction accuracy than the multilayer perceptron neural network algorithm. In the analytical method (modeling), the validity and reliability of artificial intelligence development research, using retest and reproducibility, the results showed that the reliability was approved by the professor of civil engineering faculty and the accuracy of the analysis and findings were confirmed.

## Conclusion

According to the output of the Bootstrap test for detecting significance or non-significance, $R^2$ in this model is equal to 0.23, it indicates that 23% of the variance of the dependent variable (construction costs of 3- to 7-storey buildings) is expressed by the independent variable (completion time from 2015 to 2019). The value of significance level in this test was equal to 0.03, in software output and the regression weights, it was reported more minor than the standard error level of 0.05, and was not zero in the lower and upper limit intervals. In general, these effects (the effect of the independent variable on the dependent variable) are significant and the research hypothesis is confirmed; the construction costs of 3-to7-storey buildings can be predicted based on the time factor (completion period). The use of the bootstrap test in the regression model as a confirmatory factor was found according to the standard limits and resulted in the reliability of the research. The construction cost prediction model based on multiple regression compared to sophisticated and professional AI algorithms is less accurate because of the raw data input (Lowe & et.al., 2006). Ease of access and application of multiple regression is helpful for the first stage of prediction, and variables affecting estimation should be considered; it is challenging to use many input variables (Smith, Mason, 1997). Given the information obtained from the multiple regression method, it is possible to understand the normality of the data and the need for data mining and optimization, advanced artificial intelligence methods can be used to develop the model and increase the prediction accuracy.

## Acknowledgment

We would like to thank the honorable professors in the compilation of the Ph.D. dissertation, the employer of the dissertation research project, Juan beton gharb Company, as a financial sponsor, and Hooman Badieifar, the statistical consultant.

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