TIME SERIES ANALYSIS FOR THE PREDICTION OF RC MATERIAL COMPONENTS PRICES IN EGYPT

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Reinforced concrete (RC) as a construction material is widely used in the Middle East and particularly Egypt. Prices of the RC material components usually comprise an important portion of construction project costs. Prices of RC materials have witnessed significant changes and fluctuations over the past 15 years in Egypt, leading to severe impacts on the running projects' costs and to the failure of various projects as well as legal consequences on contracting companies. Factors affecting steel and cement prices (the major cost contributors to RC) have been related in previous literatures to cost of the production process, raw material prices, energy prices, macroeconomic variables, and industry related factors. Time Series Analysis involves the use of historical data to predict the future outcomes and the associated risks. Thus, the objective of this paper is to apply Time Series Analysis to better predict the prices of RC material components in Egypt. Prices of steel, cement, sand and crushed stones were collected for the period from 1997 to 2010. The collected data was divided into two sections based on the economic growth within the studied periods. A computer-based analysis was conducted using ForecastX and SPSS software to apply the Time Series analyses and detect trends, stationarity, and seasonality. Results indicate that the outputs on applying the Time Series models in both programs were nearly identical. Furthermore, the predictions for the last quarter of 2009 and the first two quarters of 2010 were compared to actual past prices as a way to validate the analyses. A reasonable degree of prediction accuracy was concluded for all materials, and in particular cement, although the global financial crisis in 2008 was found to negatively affect the predictive capability of the model. Time Series Analysis in general, although being a good prediction technique in stable economic and industry conditions, cannot predict sudden macroeconomic or other events, and therefore, future research is required to tie in input variables of material costs based on leading cost indicators and to explore how the effects of sudden events can be realized and hopefully predicted, if possible.

Keywords: reinforced concrete, time-series analysis, material prices, Egypt.

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INTRODUCTION

Construction projects sometimes fail to achieve their time, quality, and budget goals, partially due to the failure of the contractors to analyze and assess unanticipated dangers (Ghosh and Jintanapakanont 2004). Material prices in developing countries comprise the majority of construction costs and are also known to have high variability, as opposed to developed countries. Reinforced Concrete (RC) as a material is very popular worldwide and especially in the Middle East and comprises a large portion of material costs. Forecasting of material costs, and in particular RC, is an important function for effectively managing projects in terms of more accurately estimating, tracking and controlling projects. Time series analysis is a well-established technique that has been utilized successfully in many domains for forecasting processes (Hwang and Liu 2009). The objective of this paper is to apply Time Series Analysis, as a prediction technique, to the prices of RC materials. The analysis introduced herein is limited to the prices in the period from 1997 to 2009 which can be divided into a stable economic period from 1997 to 2002 and a growth economic period from 2006 to 2009. The analysis was differentiated by the status of the economy as it is believed that the Time Series model can perform differently in each period. The following sections discuss international prediction of material prices, forecasting with Time Series Analysis, data collection and analyses, validation of results and finally conclusion and recommendations.

INTERNATIONAL PREDICTION OF MATERIAL PRICES

Considerable amount of research has been conducted worldwide to identify the explanatory variables of building price indices such as Tender Price Index (TPI) in the UK, Hong Kong and Singapore, and in less cases the Construction Cost Index (CCI) in the USA (Ashuri *et al.* 2012). Unemployment level, construction output, industrial production, and the ratio of price to cost indices in manufacturing were used by Akintoye *et al.* (1998) as leading indicators for the TPI. In addition, time series historical data on economic, energy and construction market variables was used to explain variations in the CCI, using the parameters of gross domestic product, crude oil price, housing starts and employment level (Ashuri 2012).

In more specific terms of predicting RC prices, Walker (2006) pointed out that time-series analysis of cement prices should be performed on a month to month basis rather than day to day. The direct factors affecting cement prices in Europe were found to be: kiln fuel; electricity for materials handling and grinding; EU allowances for carbon emissions; cost of limestone; variable labour costs. Indirect factors were found to be: capacity utilisation; management of supply; impact of sea-freight cargo rates; locational variations in the intensity of competition. Hagimura *et al.* (1998) applied time series analysis to the process of cement production using modern control theory. Padhan (2012) fitted a Seasonal Autoregressive Integrated Moving Average (SARIMA) model to the production of cement in India. Pereira (2011) examined the time series of rebar prices in Brazil and concluded the existence of a long-run relation between prices of raw materials, international prices and domestic prices, and thus assist in predicting future prices of domestic rebars. Chou and Huang (2010) analysed the relationship between forward freight agreements and steel price index using the Vector Autoregressive Moving Average Model (VARMA).

FORECASTING WITH TIME SERIES ANALYSIS

Forecasting techniques range from simple to complex, and include the use of executive judgment, surveys, time-series analysis, correlation methods, market tests and simulation (Smith III *et al.* 1996). Wilson and Keating (2007) defined time series forecasting as the use of a technique to forecast future events based on known past events. Time Series Analysis explicitly recognizes the order in which experimental data are observed, as well as the statistical dependence of observed data (Abdelhamid and Everett 1999). The advantage of the time series method compared to other predictive methods, such as regression and neural networks, is that the other methods require future values of input variables that are not readily available, whereas, univariate time series analysis has been identified as the most effective way of carrying out work to develop predictive models for construction costs (Ahsuri and Lu 2010a). Therefore, univariate time series analysis was chosen in this paper as the research methodology due to its requirement of just one input variable for creating and calibrating models. Brockwell and Davis (2002) pointed out that time series analysis follows a standard procedure in sequence: examine the main features of data series; check dependency in data; choose a model to fit the series; diagnose the constructed model; and forecast and update data. Four major factors affect time series analysis: trend; seasonality; cycles; and irregular movements, whereas, seasonal component is concerned with the periodic fluctuation in the series within each year (Farnum and Stanton 1989). Simple Moving-Average (SMA), Holt Exponential Smoothing (Holt ES), Holt-Winters Exponential Smoothing (Holt-Winters ES), Auto-Regressive Integrated Moving-Average (ARIMA), and Seasonal ARIMA are some of the well-known time series approaches (Ashuri and Lu 2010b). The SMA is properly employed when there is no trend or seasonality present in the data (Wilson and Keating 2007). The Holt ES method is recommended to handle time series data that display trends (Brockwell and Davis 2002). Winters (1960) generalized the Holt ES method and developed the Holt-Winters Exponential Smoothing. A third-factor called seasonal smoothing is presented into time series analysis and is an estimated value of seasonal growth rate reflecting the seasonal pattern of time series data (Wilson and Keating 2007). ARIMA is built upon Auto-Regressive (AR) and Moving-Average (MA) approaches. ARIMA is recommended to model time series data displaying nonstationary behaviours (Box and Jenkins 1970).

DATA COLLECTION AND ANALYSIS

All the prices of concrete components (which are steel, sand, crushed stone – mostly used in Egypt - and cement) were obtained from the Central Agency for Public Mobilization and Statistics (CAPMAS 2010). Data was obtained in quarterly periods from 1997 till 2009. Raw materials are heavily used in the construction industry and their costs greatly affect the construction sector, which in turn both affects and is affected by the economy in terms of its indicators such as Gross Domestic Product (GDP). For example, the prices for Portland cement (50 kg package) from 1997 till 2008 for each quarter time series are shown in Figure 1. Prices of sand were also collected for the same period in terms of cubic meters, crushed stone in terms of cubic meters and 16 mm and 10 mm steel reinforcing bars (rebars) in tons.

Furthermore, experiences in developed countries have shown that construction investments and activities increase with the state of economic development of the country (Ali 2005). To assess the effect of economic activity or status on prices, the Gross Domestic Product (GDP) in Egypt was considered. GDP is the market value of all final goods and services produced within a country in a given period of time (Edgmand *et al.* 2001). Real GDP shows how the economy's overall production of goods and services changes over time, which is taking into consideration inflation (Colander C. 2006). Bade and Parkin (2007) explained that real GDP has been considered as the primary measurement of growth. Figure 2 shows the nominal and real GDP for Egypt in the period from 1996 to 2008.

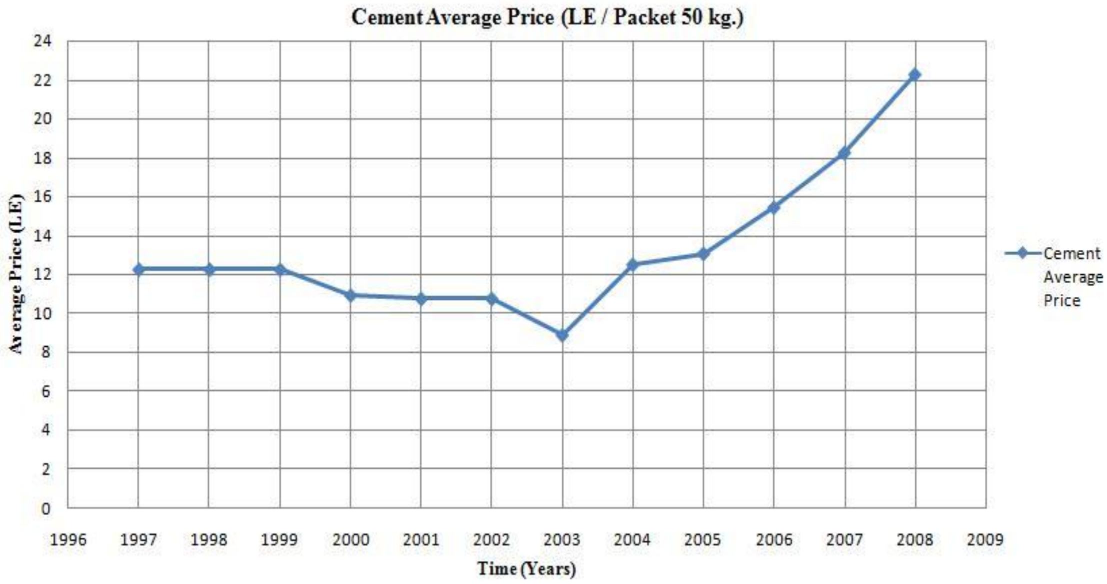

Figure 4: Cement Average Annual Price in Egypt 1997 - 2008 (Source CAPMAS 2009)

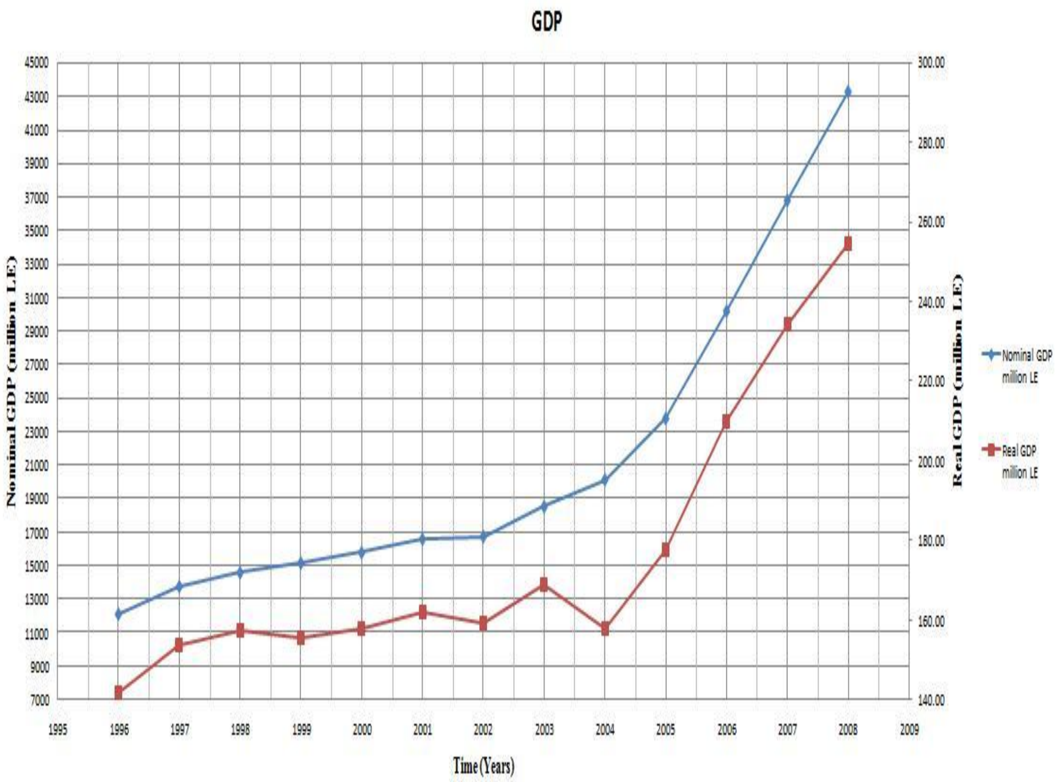

Figure 5: Nominal and Real GDP in Egypt 1996 - 2008 (Source CAPMAS 2009)

The period from 1997 to 2002 showed relative economic stability. A small downturn in 2004, probably due to inflation from the floating of the Egyptian currency (ECISC

2009), was succeeded by economic growth through the period from 2004 to 2008. Therefore, the analysis was conducted in two discrete periods; the first was an economic stable period from 1997 to 2002, and the second, an economic growth period from 2006 to 2009. The interim period was excluded due to abnormal economic situations that could distort the analysis. Two different kinds of programs, namely, SPSS (Statistical Package for Social Science) program and ForecastX program are used to apply time series in order to find out materials' trends.

Cement prices analysis

The cement price data was entered into SPSS software and the results of the time series analysis for the economic stability period (1997-2002) are shown in Figure 3. Different sets of data are used in the software to follow specific patterns relying on their behaviour. Upon testing the pattern that guide the data of this case, ARIMA model was the closest pattern that could give an interpretation for the set of data used. The model type was ARIMA(0,1,0). ARIMA stands for "Auto-Regressive Integrated Moving Average." A nonseasonal ARIMA model is classified as an "ARIMA (p,d,q)" model, where: p is the number of autoregressive terms; d is the number of nonseasonal differences; and q is the number of lagged forecast errors in the prediction equation (ARIMA 2010). The fit statistics produced an R2 – coefficient of determination 0.861, an estimate of the proportion of the total variation in the series that is explained by the model (Farnum and Stanton 1989). The value of MAPE – Mean Absolute Percent Error, an expression of percentage of relative error in order to introduce a unit free scale of evaluation (Farnum and Stanton 1989), was 3.047% which is considered a good fit as it is below 10% (Ashuri and Lu 2010a). The ForecastX software fitted a Holt-Winters model with an alpha of 0.95, beta 0.45 and gamma of 0.02, where alpha is the level of smoothing, beta the seasonal parameter, and gamma the trend parameter and the three factors are the smoothing constants factors (Wilson and Keating 2007).

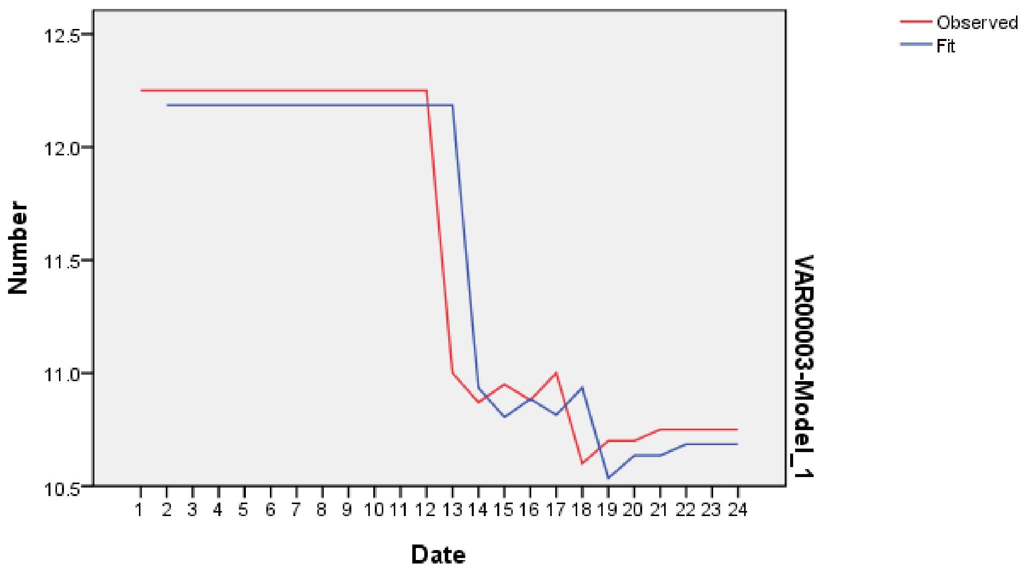

Figure 6: SPSS Observed and fit values for cement prices for economic stability period

The analysis was also conducted on ForecastX software, and results shown in Figure 4. The fitted model was Holt-Winters with an alpha value of 0.13, a beta value of 0.61 and gamma of 0.81. The fit statistics produced an R^2 of 0.9514, and a MAPE of 2.76%, which show good fitness of the model. The software produces lower and upper 95% confidence limits (Wilson and Keating 2007). SPSS analysis of the same period fitted a Holt model with an R^2 of 0.949 and MAPE of 3.047%. The Holt model is quite robust and has an easy to use projection procedure. The method allows data to be modelled by a local mean, a local trend and a local seasonal factor which are all updated by exponential smoothing. Seasonal effect may be additive or multiplicative, while a non-seasonal version is also available. The model is usually suitable for a series with a linear trend and no seasonality (Chatfield and Yar (1988). Holt's exponential smoothing is most similar to an ARIMA model with zero orders of auto regression, two orders of differencing, and two orders of moving average (Farnum and Stanton 1989).

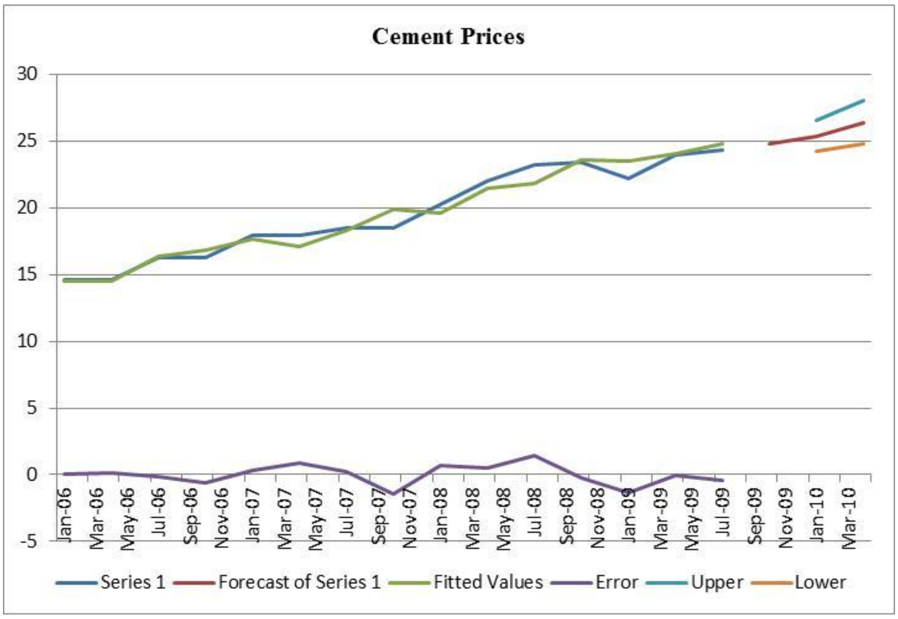

Figure 4: ForecastX observed and fit values for cement prices in economic growth period

Crushed stone and sand prices analysis

For the economic stability period, the crushed stone analysis on SPSS revealed a simple model, which is a model with a constant percentage rate for growth or decline that can be exponential in nature and has neither trend nor other pattern except random movement in the graph with its only smoothing parameter being level (Sorensen 2006). The ForecastX software detected a Holt-Winters model for both the stable and growth economic periods. The model detected for the economic growth period by SPSS was a Holt model, whereas the model detected by ForecastX was Holt-Winters.

A simple model was detected for sand prices in the economic stable period. ForecastX results for the same periods fitted a Holt-Winters model. As for the economic growth period, the fitted model for sand prices was the Brown model. Brown and Forsythe (1974) defined Brown's linear trend as the model that is appropriate for series in which there is a linear trend and no seasonality. Its smoothing parameters are level and trend, which are assumed to be equal. Brown's model is therefore a special case of Holt's model. Brown's exponential smoothing is most similar to an ARIMA model with zero orders of autoregression, two orders of differencing, and two orders of moving average, with the coefficient for the second order of moving average equal to the square of one-half of the coefficient for the first order. The model fitted by ForecastX for the same period was Holt-Winters.

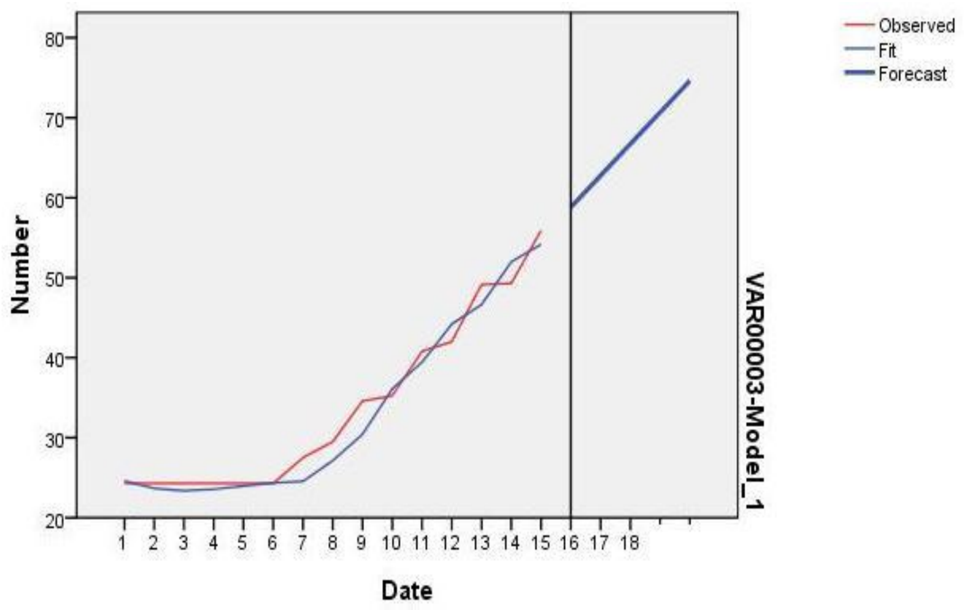

Figure 5: SPSS observed and fit values for crushed stone prices 2006-2009

Steel prices analysis

The fitted model for steel prices by SPSS in both the stable and growth economic periods was the simple model. The trend of the model in the growth economic period was horizontal, as shown in Figure 6, which although reports a simple model, shows inability to predict price values. This can be contributed to the unexplained variability in steel prices in Egypt in that period and the general public conception of price fixing, although no formal charges had been proven. ForecastX, on the other hand, fitted the stable economic period to the Holt-Winters model and the growth economic period to an exponential smoothing model. However, the plot shows inability to predict price values.

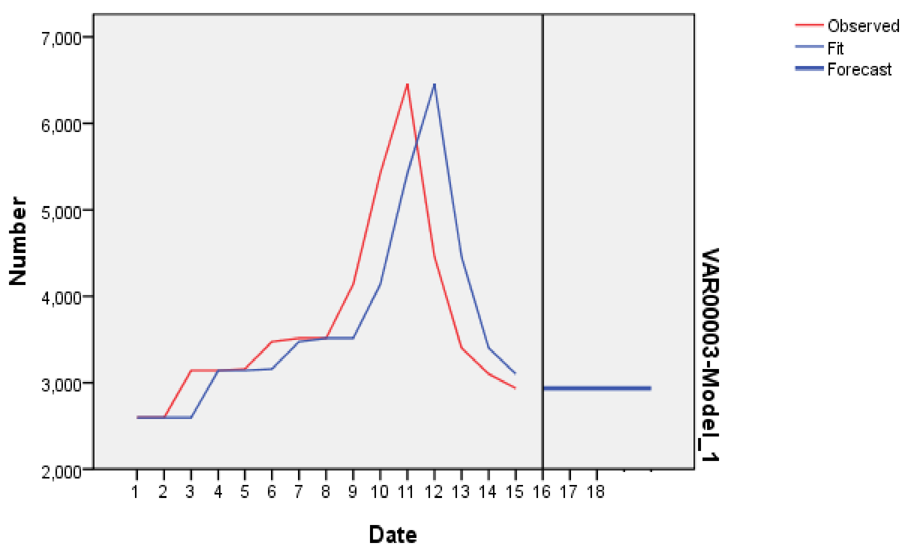

Figure 6: SPSS observed and fit values for steel prices in economic growth period

VALIDATION AND RESULTS COMPARISON

Validation is the process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation. To validate the results of this research, a comparison between the two methods results and the actual data, which was published by CAPMAS (2010). CAPMAS substituted wholesale prices reporting with retail prices reporting from 2007. Thus the actual wholesale prices for 2010 were calculated from retail prices with a correction factor. Table 1 shows the predicted values by both software and comparison with the actual prices. The difference between the results of the software are negligible and in the range of 1%. In light of the high variations of material prices in Egypt, the time-series average predictions were mostly in a range of 10% of the actual prices. The percent deviation for quarterly prices was the least for cement, and showed considerable variability.

A factor that might have impacted the average percent deviation is the global financial crisis in the second half of 2008. The crisis sparked off in the United States and spread to Europe and the rest of the world including Egypt, although not with the full effect as that in USA and Europe. Building and construction growth dropped from 15.4% before the crisis to 9.3% after the crisis (Abu Hatab 2009). A drop in growth can cause surplus in supply versus demand, and thus lower prices. This can explain the negative % differences in predicted vs. actual prices in Table 1. The unpredictability of the steel Time Series model can be attributed the positive % deviation in the validation. It can be concluded that, albeit Time Series Analysis is a good prediction technique, as shown in the high fit values in the analysis, it cannot accurately predict sudden events (wild cards) such as macroeconomic changes.

Table 1: Validation of RC Material Prices' Prediction in EGP

Material	Period	Predicted SPSS	Predicted ForecastX	Actual	% Dev. SPSS	% Dev. ForecastX	Avg. % Dev. SPSS	Avg % Dev. ForecastX
Cement	Oct. 2009	25.53	25.4	24.9	-2.53	-2.01	-5.13	-4.23
	Jan. 2010	26.27	26.43	25.24	-4.08	-4.71		
	Apr. 2010	27.02	26.32	24.84	-8.78	-5.96		
Crushed Stone	Oct. 2009	58.81	57.26	56.3	-4.46	-1.71	-13.98	-9.73
	Jan. 2010	62.76	63.94	53.19	-17.99	-20.21		
	Apr. 2010	66.72	59.9	55.84	-19.48	-7.27		
Sand	Oct. 2009	28.23	28.45	27.68	-1.99	-2.78	-8.51	-8.18
	Jan. 2010	29.58	30.58	26.65	-10.99	-14.75		
	Apr. 2010	30.94	29.42	27.49	-12.55	-7.02		
Steel	Oct. 2009	2933.61	2949.53	2935	0.05	-0.50	8.37	7.36
	Jan. 2010	2933.61	2976.31	3085.4	4.92	3.54		
	Apr. 2010	2933.61	3010.49	3672.9	20.13	18.04		

CONCLUSION AND RECOMMENDATIONS

The accurate estimation of concrete material prices is an essential practice, especially in developing countries where high price fluctuations can negatively affect projects' success and even viability. Factors affecting steel and cement prices (the major cost contributors to RC) have been related in previous literatures to cost of the production process, raw material prices, energy prices, macroeconomic variables, and industry related factors. A Time Series Analysis was conducted on the material components of RC in Egypt in the period from 1997 to 2009, in a univariate manner because other predictive techniques require future input variables that are not readily available to estimators. The analysis was differentiated for a stable economic period and a growth economic period. The outcomes of the Time Series model can be different in both periods and thus caution should be taken in the times of economic change or status switching. The results were verified using two distinct software: SPSS and ForecastX for the Time Series Analysis. The fitted Time Series models where used to predict the prices along 3 quarters and compared to actual prices to validate the models. A reasonable degree of prediction accuracy was concluded for all materials, and in particular cement, although the global financial crisis in 2008 was found to negatively affect the predictive capability of the model. Time Series Analysis in general, although being a good prediction technique in stable economic and industry conditions, cannot predict sudden macroeconomic or other events. High variability in construction material prices, and in particular RC, in developing countries poses high risks to domestic and international developers and contractors, thus making it increasingly important to utilize prediction tools, such as of this paper, in cost estimating and bidding. Further research is required to tie in input variables of material costs based on leading cost indicators and to explore how the effects of sudden events can be realized and hopefully predicted, if possible.

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