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Application of Forecasting Methods on Prices of Local and Imported Rice in Ghana

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ABSTRACT

The field of forecasting is concerned with approaches to determining what the future holds. It is also concerned with the proper presentation and use of forecasts. Fluctuations in the prices of commodities are a phenomenon that is of statistical significance. In modern mathematical and social sciences it is important that the field of forecasting is developed and designed as a tool to help decision making and planning. This project discusses how we can use simple objective methods of forecasting on price data to forecast to a relatively high degree of accuracy, the prices of commodities. The study highlighted on the adequacy of the quadratic method of curve fitting for forecasting the prices of local rice based on a 5-year data set. It shows that, though most models can predict the prices reasonably, by considering the R^2 values and the Root Mean Squared residual values, the quadratic models are better than the other models such as linear, lognormal, logistics and the simple exponential. The project also depicts very similar trend characteristics between prices of imported and local rice in Ghana. It discusses how the use of forecasting methods on prices of commodities need to be developed to empower people because their use implies that, we can modify variables now to alter (or be prepared for) the future. Successful application of forecasting methods on prices of commodities especially a stable food like rice can improve the income of farmers and bring efficiency into the commodity market.

Keywords: Forecasting, Price, Response, Predictor, Regression. RMS, Residuals.

Introduction

The price of a good or an input shows what has to be given up in order to obtain the good or the service. It is usually denoted in monetary terms although payment need not be in monetary form. Prices of commodities in open markets are subjected to frequent fluctuations often of considerable amplitude. The basic reason for these fluctuations is due to the fact that producers are unable to control supply. The situation in agricultural products is often made worse by the inability to control processes of nature. If the demand is price-inelastic as is often the case of foodstuffs, we reach the paradoxical situation where bigger harvests due to favourable weather can mean lower profits for the farmers. All the cereals belong to the grass family called *Gramineae*. They have long, narrow leaves and seed producing grains that are rich in starch. Maize, wheat and rice are the most important cereals in terms of world food production while Guinea corn (sorghum) and millet provide a staple food in dry regions. Cereal crops suffer price fluctuations. They form the staple diet of a large percentage of Ghana's population in particular and that of the world as a whole. Per capita consumption of rice in Ghana increased from 17.5 kg per annum between 1999 and 2001 to 22.6 kg per annum between 2002 and 2004. By 2011, it had reached 38 kg per annum and projected to reach 63 kg per annum by 2015. This increase had transformed rice into Ghana's most important cereal food crop after maize. The evolution of rice prices, thus, has implications for national food security. Prices of these food commodities go through frequent price fluctuation. Frequent price fluctuations are often considered undesirable from the view point of both producers and consumers. However it becomes an area of great statistical interest.There are essentially two rice markets in Ghana- local and imported rice markets and about 70% of rice consumed in Ghana is imported. Various studies show that Ghanaian consumers have a higher preference for imported rice because of its perceived higher cooking and sensory characteristics and quality (Diako et al., 2011; Tomlins et al., 2005). Ghana has been importing significantly larger quantities of rice to address quality and quantity differences between local and import rice. The leading price exporting countries to Ghana are U.S., Thailand, Vietnam, China, Pakistan, India and Korea.

The equation $P_F = P_C + T_E + F + T_I + \pi$ describes the price of imported rice (P_F) as technically determined by purchase price plus freight and insurance to transport it to a Ghanaian port (P_C), excise, custom

and other government-mandated fees (T_E), internal transportation and distribution (F) and other transaction cost (T_I) and importers' margin (π).

Forecasting techniques is an answer to the study of variability in a data of this nature. Forecasting is the process of predicting future events based on foreknowledge acquired through a systematic process or intuition. The primary function of any forecasting technique is to predict the future using data we have in hand. It requires data, information and advanced knowledge. The proof of any forecasting model is its predictive capacity, not its conformance to a particular theory. This means, it is not too important to identify causal factors, and the approach is usually data driven. Data driven approaches have sometimes created disagreements between causal modelers and forecast modelers. In the areas of empirical forecasting and data mining, data-driven approaches are generally regarded as superior for the purposes of forecasting and of sample prediction. (Breimen, 2001). Aggregated forecasts are usually more accurate and the accuracy erodes as we go further into the future. Forecasts should not be used to the exclusion of known information. A good forecast should be timely, reliable and accurate as possible and should be easy to use and understand in most cases.

Forecasting techniques have wide applications in practice. A major challenge however is the type of technique to be used in a field at any point in time. For example, Bretschneider et al. (1989) compare the forecasting accuracy of different forecasting methods. On the basis of their results, they favour a combination of judgement and simple econometric equations, against time series and complex models. They suggest that the main reason for this is the knowledge of special events events state revenue forecasters might have. Grizzle and Klay (1994) also show evidence for combining judgement and simple methods against more complicated or automated techniques. In the same vein, Lawrence et al. (1998) back simple regression methods on the basis of transparency. Baguestani and McNown (1992) and Nazmi and Leuthold (1988), still ascertain time series techniques as viable for tax receipts forecasting.

The major question to ask is whether there are visible regular trends in the prices of both imported and local rice. Would the historical data alone be adequate for forecasting the prices of rice in Ghana? A large body of research confirms that combining forecasts from different methods and from independent experts improves accuracy. Should the forecasting of price of rice depend on only one model? Theory is helpful. For example, in many situations it is useful to know the economic theory that an increase in the price of a thing will tend to lead to a decrease in demand for it, and vice versa. Experts will tend to know about evidence from prior research, such as which causal (explanatory) variables are important, and the direction and magnitude of relationships. Should the future prices of rice be based on only the relevant economic theories of demand and supply or only statistical theories or a combination of statistical methods and economic theories? The major objectives of this project work on a broad base are to apply forecasting methods on prices of imported and local rice consumed in Ghana. Specifically, the work will aim at analyzing the trends in the prices of the local and imported rice in Ghana; obtaining a relevant forecasting equation to describe and predict the prices of local and imported rice consumed in Ghana.

Methodology

The field of forecasting is concerned with approaches to determining what the future holds. It is also concerned with the proper presentation and use of forecasts. In 1971, Cetron and Ralph developed one of the earliest classifications of forecasting methods and approaches. This classification consisted of five categories namely: intuitive methods, trend extrapolation, trend correlation, analogy and dynamic predictive models. This has been criticized for not being exhaustive enough. In 1985 Armstrong published his first "forecasting methodology tree" which was based on three assumptions of being firstly judgemental or statistical. Secondly if statistical it must be causal or non causal and thirdly if causal, it must be linear or non-linear. In 2001, Armstrong revised the classification of his earlier work and introduced a classification that introduces a distinction between methods that rely on judgement and those that estimate relationships using statistical approaches and quantitative data. In 2006 Gentry et al proposed an entirely new form of categorizing forecasting approaches and methods in the form of a grid. Forecasting is designed to help decision making and planning in the present. Forecasts empower people because their use implies that we can modify variables now to alter (or be prepared for) the future. A prediction is an invitation to introduce change into a system. The field of forecasting includes the study and application of judgment as well as of quantitative (statistical) methods. It is vogue today to diminish the value of mathematical extrapolation. Makridakis (1983), one of the gurus of quantitative forecasting, correctly points out that judgmental forecasting is superior to mathematical models; however, there are many forecasting applications where computer generated forecasts are more feasible The research mostly relied on regression curve fitting methods. Some of these methods are:

Linear Regression: This is a simple forecasting method that calculates a straight line. By its nature, the straight line it produces suggests that it is best suited to the data that is expected to change by the same absolute amount in each time period. The mathematical equation shows that the variable y_t varies by a constant a changes over time, t by factor b: $y_t = a + bt$. *Exponential Function*: This method uses an increasing or decreasing curve rather than the straight line of the Linear Regression method. An exponential method is useful when it is known that there is, or has been, increasing growth or decline in past periods. That is, $y = ab^t$. *Logarithmic Function*: This method is similar to Exponential Function, but uses an alternate logarithmic model: $y = a + b\log(t)$.

Logistic Function. This method attempts to fit a 'Logistic' (Pearl-Reed) curve $\frac{1}{y_t} = c + ab^t$.

*Parabolic Function***.** This method attempts to fit a 'Parabolic' (second order polynomial) curve: $y_t = a + bt + ct^2$.

Let $D_1, D_2 \ldots\ldots Dn$ be the past values of the series to be predicted. If we are making a forecast during period t , assume we have observed D_t , D_{t-1} etc.

Let $F_{t,t-1}$ be forecast made in period t for the demand in period $t+\tau$ where $\tau = 1,2,3\ldots\ldots$

Then $F_{t,t+\tau}$ is the forecast made in $t-1$ for t and $F_{t,t+1}$ is the forecast made in t for $t+1$

The research relied on a five year secondary data set collected by the Statistical Service of Ghana on the average price per kilogram of imported and local rice in Ghana. Various trend equations were fitted unto the analysis data. The data from 2008 to 2012 was used for the analysis whilst that of 2013 was used to validate the forecasting models developed.

Findings

Various trend line equations were fitted on the price data. The *SPSS* results for curve fitting for various models using the monthly prices as the response variables and the months as the independent time variables gives the result as shown in Table 1 below.

Table 1 : Trend Equations for Imported Rice

Model	R^2	Sigf.	b0	b1	b2
Linear	0.2450	0.000	0.5451	3.2083	
Log Parabola	0.1600	0.002	0.5391	0.00502	
Quadratic	0.2480	0.000	0.5467	1.7064	0.0246
Exponential	0.2510	0.000	0.5449	0.0006	
Logistics	0.0510	0.000	0.0002	0.9994	

The SPSS result above shows that generally, the R^2 values for all the models are low. This means the percentage of variation in the prices of imported rice explained by the time independent variable is low. The lowest being the logistics. The rest of the models have almost the same R^2 values and 0 significant F values. This means no single model can be relied on as the most appropriate model for predicting the monthly price of imported price.

Table 2: Trend Equations for Local Rice

Model	R^2	Sigf.	b0	b1	b2
Linear	0.938	0.000	0.2631	0.01764	
Log Parabola	0.793	0.000	0.2181	0.0314	
Quadratic	0.938	0.000	0,2635	0.01727	0.0061
Exponential	0.922	0.000	0.2657	0.0056	
Logistics	0.922	0.000	0.0004	0.9944	

The SPSS result in table 2 above shows that generally, the R^2 values for all the models are very high. This means unlike in the case of the imported rice, the percentage of variation in the prices of local rice explained by the time predictor variable is high. The lowest being the logarithmic parabola. The rest of the models have almost the same R^2 values and 0 significant F values. The highest R^2 values are given by the linear and the quadratic models. Since the F values are significant, the most reliable forecasting equations at 5% significant level are:

1. Linear: $y = 0.263198 + 0.01764t$
2. Quadratic: $y = 0.263581 + 0.01727t + 0.0061t^2$

Root Mean Square (RMS) of Estimates

Forecasts are subject to errors. The magnitudes of these errors are determined by the differences between actual and predicted values. These differences are known as residuals. These differences between predicted values and actual observation can generally be attributed to short term or random fluctuations within the system being studied. It is generally not possible to predict the direction of any particular random fluctuation, although one can estimate with reasonable accuracy the likely magnitude of the fluctuation. The average magnitude of the residuals provides a basis for such an estimate. The Root mean squared residual is a good measure for determining the model that predicts the actual values best. It is a 'standard deviation' which provides an estimate of the average difference between trend values and actual observations. The model with the least root squared residual is the most reliable model. The RMS of the models are calculated using the equation: Root Mean Squared Residual = $\sqrt{\frac{\Sigma(f-o)^2}{n}}$,

where n = number of observations f = forecast values o = observed values.

Table 3: Root Mean Squared Residuals

Model	RMS
Linear	78.56
Quadratic	78.54

From the Table 3 above the Quadratic Model have slightly lower Root Mean Squared residual values than the linear model. For the prices of local rice, the linear model and the quadratic model give Root Mean Squared residual values of 78.56 and 78.54 respectively. The difference between the two values is only 0.02. Quadratic Model with its least Root Mean Squared residuals is slightly better than the Linear Model in predicting the prices of the local rice.

Conclusion

The results above shows that by using the objective method of forecasting, the variation in the prices of imported rice as a response variable is not explained much with time as a predictor variable. However, in the case of the prices of local rice, time is a more reliable predictor variable. After the analysis and validation, it is seen that the quadratic model of $y = 0.263581 + 0.01727t + 0.0061t^2$ get predict to a high degree of accuracy the prices of local rice per kilogram on the Ghanaian market. However, in the case of the prices of imported rice, other forecasting methods could be relied on since the data based objective model fails to provide a reasonably robust model.

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