ASSESSING THE PRODUCTION VS. PRICE RELATIONSHIP OF BLACK TEA IN SRI LANKA: AN APPLICATION OF KOYCK'S GEOMETRIC-LAG MODEL

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Abstract

The potential relationship between production and prices of black tea in Sri Lanka was examined using time-series data (1991–2011) in Koyck's Geometric-lag models specified for three main elevations (High, Mid, and Low-grown). The results show that prices fetched at the Colombo auction impose a significant impact on production levels, and the time taken for an increase in price to have a complete effect on production was an average lag period of two and half months. Further, it shows that the actual and predicted levels of production were almost similar in most of the months during this period proving the validity and reliability of model.

Keywords: Agricultural price, Black tea, Distributed lag models, Time-series data

JEL Codes : C2, C22, Q1, Q16

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INTRODUCTION

Tea is of high importance to Sri Lankan economy in many different ways. For example, it is one of the main foreign exchange earners, and indeed, the highest out of the agricultural products (i.e. 199,440 Rs. Mn. In 2013 for nearly 320 Kg. Mn. Exported out of 340 Rs. Mn. Produced); generating income potential and livelihood for thousands of labor force involved with production, processing and marketing; creates a well-established marketplace as a popular domestic beverage across the nation (Ministry of Plantation Industries, 2013).

Broadly, Sri Lankan tea is divided into three groups, based on the geographical region where it is grown, such as High, Mid and Low-grown tea. In 2013, about 340 Mn. Kg. of tea production was recorded of which 208 Mn. Kg., i.e. about 61 percent, were recorded as Low-grown, while the production from the High and Mid elevations were limited to about 76 and 56 Mn. Kg. However, overtime, the increase of production has been marginal, for example, that in 2013 was just above 12 Mn. Kg. compared to 2012, and the same between 2011 and 2012 was just 1 Mn. Kg. During the 1990s, the national production of tea has increased by about 70 Mn. Kg., but it was increased only marginally during 2000 to 2010, i.e. about 25 Mn. Kg (Figure 1) (Ministry of Plantation Industries, 2013).

Figure 1: Total Black Tea Production in Sri Lanka (1991-2011)

Source: Statistical Information on Plantation Crops, Ministry of Plantation Industries

Tea is primarily sold in auctions where the prices are determined solely by the interplay between supply and demand, and therefore, the auction prices vary considerably with both quality and quantity of tea on offer, and the demand for tea at any given point of time.

Figure 2 illustrates the average black tea prices in Sri Lanka in real terms for the period of 1991 to 2011. For example, the average price for black tea through the Colombo Auction in 2012 was Rs. 391.64 per Kg indicating 9% increase compared to 2011. During the period 2000 to 2011, the annual average auction price for tea remained the highest for Low-grown followed by the High and Mid-grown tea. Further, the average price of Low and Mid-grown tea was always less than what was estimated for national tea production, or in other words, tea from High elevations always received a higher price given its high quality. The price fetched at the auction for a 1 Kg of black tea shows a decreasing trend, indicating differing prices over the two decades.

Figure 2: Average Black Tea Price in Sri Lanka (1991-2011)

Source: Statistical Information on Plantation Crops, Ministry of Plantation Industries

Reaction of production of a commodity to its price has been a key area of interest for economists for a long time, because it is customarily assumed that an improvement in prices received in the market would result an increased output. For agricultural commodities, this phenomenon has been investigated, both conceptually and empirically, in many different contexts (e.g. *spatial* – product-wise, geographical region; *temporal* – trends and fluctuations, panel data analysis etc.) which resulted in various theories (e.g. Cob-Web theorem), models and economic frameworks in order to make inferences about their status of production with the aid of estimates, forecasts and policy implications as well as recommendations.

Understandably a rational producer has the prime motive of maximizing the returns for her product/s by obtaining the best price/s in the auction. Inevitably, during the period of ‘high prices’, *ceteris paribus*, producers tend to ‘produce more’ and vise-versa.

However, the variable ‘time’ plays a greater role in this regard and prevalence of a lag between time taken to produce and price is determined is the key in decision making (Gujarati, 2004).

It was accepted for a long time that the current and recent past prices are expected to affect the current production more heavily than the production in the distant past (see, Bean, 1929). Moving beyond the ‘classical static models’ in economics explaining the production-price relationships, economists tend to examine such relationships for agricultural products by taking into consideration of the fact that its production process requires certain amount of ‘time’ in order to increase the production in response to the changes in prices (i.e. supply response), or in other words, one need to take into account of the ‘lag response’ of prices on the production decision.

Empirical studies on distributed lag models that specifically focus on plantation crop products are limited. Edirisinghe and Perera (2005), for example, evaluated the role played by the lagged price of rubber in replanting decision making using an Almon Lag model for data related to rubber prices from 1980 to 2004 and found that a ‘second degree polynomial’ was found to be best in describing data. The maximum time lag was found to be 8 years, but a lag of 4 years had the highest impact on the replanting decision.

However, several other studies provide an insight to application of lag variables, and in particular, Kyock transformations, which is of interest in this analysis. Erdalet *al.* (2009), for example, studied the relationship between prices and amount of potato produced and distributed under free market conditions in Turkey using Koyck model. The results show that production has been influenced by the lag value of average price formed in the market, and the time required for the changes in the prices to have an effect on production is about 12.3 years. Simialr specifications were applied in a number of others studies on agricultural commodities, for example Erdal and Erdal (2008) for dry onion; Erdal (2006) for tomato; Ozcelik and Ozer (2006) for wheat; Dikmen (2005) for tobacco, and Yurdakul (1998) for cotton.

However, to the best knowledge of the authors, an in-depth price analysis, which helps to understand the dynamics of price in relation to other important variables such as quantity of production, were not available in the context of tea sector in Sri Lanka. Therefore, in this shed of light, this study aims to fill that gap in literature by assessing the production versus price relationships for black tea in Sri Lanka. More specifically, it uses the Kyock model (1954) specified under the distributed lag models in this connection on the understanding that ‘time’ would play a major role in economic decision making with respect to prices and production, and especially to identify whether past prices affect production decision.

METHODOLOGY AND DATA

Theoretical Framework

Because of this structural feature, ‘distributed lag models’ in which the present values and delayed past values are taken into account for modelling can be used to investigate the potential relationships of production versus price, and for a product like Black tea it is more applicable. Perhaps, this phenomenon (i.e. time lag) has a special place in economics literature and econometric modelling in that it can allow the analyzing of the behavior of economic units based on appropriate dynamic models (Gujarati, 2004).

However, model specific estimates from distributed lag models have also shown certain drawbacks, including the lack of pre-information in the model about how long the lag period will be; increasingly lowered degrees-of-freedom as lag length increases, and the defining variables are in multiple linear relationships. In light of this, Koyck (1954) has suggested a method, based on the specific assumption that lags in the independent variable affect the dependent variable to some extent and the weight of the lags decrease geometrically, thus, made to estimate the Regression equation¹. While inviting the interested readers to follow Gujarati (2004) for an in-depth understanding about the theory and applications of distributed lag models, in general, and to the seminal article by Koyck (1954) for detail specification of the econometric model, below we define which for the purpose of this analysis:

Following Koutsoyiannis (1977), if Y_t and X_t denote the quantity of production and price of a particular commodity, respectively, and in this special case black tea, for a given period of time t and the terms α , β and λ stands for the parameters, and u_t is the error term, the original model that includes only the ‘exogenous lagged variables’ can be expressed as Equation 1:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \dots + u_t \dots\dots\dots (1)$$

Koyck’s geometric-lag scheme implies that ‘more recent values of X exert a greater influence on Y than remote values of X ’; thus, the lag coefficients of equation (1) decline in the form of a geometric progression.

$$\beta_k = \beta_0 \lambda^k, \text{ where } k = 0, 1, \dots \text{ and } 0 < \lambda < 1$$

¹The geometric distributed lag model is often used to investigate the current and carryover effect of advertising on sales. This model makes current sales a function of current and past advertising levels, where the lag coefficients have a geometrically decaying pattern. As this model involves an infinite number of lagged variables, one often considers the so-called Koyck transformation.

when λ values are closer to 1, it means that the values of defining variables in remote past have a significant effect on dependent variable Y and λ closer to 0 means that values of the defining variable in the remote past rapidly lose their effects on Y. Now we can adopt the 'Koyck's transformation' as shown in Equation (2) to (4), i.e.

Substituting the original model,

$$Y_t = \alpha + \beta_0 X_t + \beta_0 \lambda X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \dots + u_t \dots (2)$$

And lagged by one period,

$$Y_{t-1} = \alpha + \beta_0 X_{t-1} + \beta_0 \lambda X_{t-2} + \dots + u_{t-1} \dots (3)$$

And multiplying (3) by λ and subtracting from (2) one can specify the below,

$$\lambda Y_{t-1} = \lambda \alpha + \lambda \beta_0 X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \dots + \lambda u_{t-1} \dots (4)$$

The final expression for Koyck model is, therefore:

$$Y_t = \alpha (1-\lambda) + \beta_0 X_t + \lambda Y_{t-1} + (u_t - \lambda u_{t-1}) \dots (5)$$

The 'average lag length' proposed by the model is: $\lambda / (1-\lambda)$ which can be expressed as the time period required for a unit change in the defining variable to have a detectable effect on the dependent variable (Koutsoyiannis 1977). Once the model is specified, an analyst can use the Classical Least Square method to estimate the parameters of it. Further, the X variables that consist of lag values are not defined; hence, the issue of multicorrelation is solved.

DATA COLLECTION AND ANALYSIS

The secondary data required to investigate the relationship between production [i.e. High (HP); Mid (MP); Low (LP), and National tea production (NP) versus price (i.e. Colombo Auction Price) of black tea and Colombo Consumer Price Index (CCPI)] were obtained from the Annual Report of Central Bank of Sri Lanka and Sri Lankan Tea Board for the period of 20 years from 1991 to 2011 (i.e. 252 monthly observations). The respective prices offered to black tea from different elevations in the Colombo Auction were used with CCPI to develop estimable variables for the model explaining prices for 'High' (HRP), 'Mid' (MRP) and 'Low' (LRP) and an average price was calculated for the case of 'National' production (ARP).

The estimates of coefficients of the Koyck geometric-lag model were estimated using Stata (*version 11*) statistics software package. To verify the outcome of analysis further, serial impact of the autocorrelation was adjusted by applying the Paris-Wilson estimation. The results from transformed Durbin-Watson statistics indicated that all the values were approximated to value 2, proving that no serial-correlation is present.

RESULTS AND DISCUSSION

Table 1 reports the estimates from the Koyck's geometric-lag model with respect to all three elevations and the national production.

Table 1. Estimates of coefficients of Koyck's geometric-lag model

Variable	Parameter	Coefficient	Standard Error	P value
<i>High-grown Production</i>				
Constant	$\alpha (1-\lambda)$	5.5622	1.1012	0.0000*
HRP	$\phi\beta$	0.0005	0.0017	0.7760
HP lag 1 month	λ	0.1881	0.0695	0.0070*
	$R^2 = 3.3\%$	$P = 0.0055^*$	$DW = 1.94^a$	$Avgll = 0.23$
<i>Mid-grown Production</i>				
Constant	$\alpha (1-\lambda)$	0.8956	0.4268	0.0371**
MRP	$\phi\beta$	0.0027	0.0009	0.0042*
MP lag 1 month	λ	0.5461	0.05311	0.0000*
	$R^2 = 31.2\%$	$P = 0.0000^*$	$DW = 1.96^a$	$Avgll = 1.25$
<i>Low-grown Production</i>				
Constant	$\alpha (1-\lambda)$	0.7731	0.7731	0.5612
LRP	$\phi\beta$	0.0016	0.0016	0.0051*
LP lag 1 month	λ	0.0286	0.0286	0.0000*
	$R^2 = 79.8\%$	$P = 0.0000^*$	$DW = 2.12^a$	$Avgll = 7.77$

<i>National Production</i>				
Constant	$\alpha (1-\lambda)$	2.7101	2.0988	0.1984
ARP	$\phi\beta$	0.0101	0.0041	0.0140*
TP lag 1 month	λ	0.7206	0.0459	0.0000*
	$R^2 = 50\%$	$P = 0.0000^*$	$DW = 2.00^a$	$Avgll = 2.57$

*Note: P = P value, * and ** show significance at P = 0.01 and 0.05, respectively, a-Durbin Watson static, Avgll – Average lag length in months, HRP – High-grown tea price, MRP – Mid-grown tea price, LRP – Low -grown tea price.*

It highlights that all the models were highly significant indicating that there is a potential relationship between black tea production and the price it obtained at the Colombo Auction. The R^2 values, an indication of the overall measure of goodness-of-fit of the model specified, were relatively high in Low-grown production (79.8%) and above 50% in the case of National production. However, it was less than 50% for High and Mid-grown tea.

Given the fact that R^2 value falls below 50%, we may infer that other factors such as agronomic practices including fertilizer, adverse weather conditions, soil-plant-water relationships, and cost of essential inputs etc. can have a substantial impact on production in addition to the price as the major economic factor in deciding the production through expansion to area cultivation and increased productivity, i.e. yield per unit area.

The sign of the coefficient of constant terms was significant in all models except for the case; Low-grown and National production. Further, it was positive in the models specified for High, Mid and National production. The estimate of Price coefficient was positive and significant in all models except in the model specified for High-grown tea, which was non-significant and positive. This highlights that an increase of black tea price in real terms tend to increase black tea production.

Further, all the coefficients of variables showing ‘lagged production’ showed a positive impact on current production and were significant at the level of all three elevations as well as the national production. This is an indication that an increased production in a given year is stimulated by an increase in black tea production in the preceding period. We may, therefore judge that the price determined at the Colombo auction act as the major catalyst for decision makers in plantation industry to make decisions on the level of production. Moreover, a significant increase of price characterized by minimum fluctuations was seen to motivate individual plantations to adjust their resource-base aiming higher production in the future.

The ‘average lag length’ of 0.23 for the case of High-grown black tea production (HP) suggests that it takes less than half a month for High-grown black tea production to respond to corresponding High-grown tea price (HRP), i.e. production adjusted to respective price within a relatively short time. This value for Mid-grown black tea production (MP) was 1.25, i.e. it takes a little longer than a month to adjust to the Mid-grown tea price (MRP). This period for Low-grown production (LP) is nearly 8 months, while for the national production; it is about two and half months. The outcome of analysis, overall, proves that, except for the Low-grown production, black tea from other elevations respond relatively quickly to the price signals coming from the Colombo Auction, and even in the worst case, i.e. for Low-grown tea, such adjustments take place into two thirds of a year. The Koyck’s geometric-lag model estimated in this analysis for the cases of High, Mid, Low and National production can be specified as:

$$HP = 5.56 + 0.0005 HRP + 0.1881 HP_{lag\ 1}$$

$$MP = 0.89 + 0.0027 MRP + 0.546 MP_{lag\ 1}$$

$$LP = 0.77 + 0.0016 LRP + 0.0286 LP_{lag\ 1}$$

$$NP = 2.71 + 0.0101 ARP + 0.7206 NP_{lag\ 1}$$

Based on the above, the production estimates were made for each elevation covering the period of 1991 to 2011. The Residuals Plot to represent the error between ‘actual’ and ‘predicted’ production² was completed as depicted in Figure 3. The Residual Plot were significant at $p = 0.05$ indicating that the residuals were evenly distributed around the Mean, and more importantly, which were accounted in the Koyck geometric-lag model.

This proves the fact that the model specified above is a good-fit to demonstrate the relationship between productions versus price of black tea in Sri Lanka. This indicates that the price fetched at the Colombo Auction for the three different elevations were comparable with the quantity of tea produced in the respective elevations during the past two decades.

CONCLUSIONS

This study assessed the relationship of production versus prices of black tea in Sri Lanka during the period of 1991 to 2011. Overall, the results suggest that there is a lagged effect on production because of prices. In that, black tea prices have a significant

²Residuals are the elements of variation unexplained by the predicted model. The assumption was them to be normal and independently distributed with a Mean of zero and some constant Variance.

and a detectable effect on black tea production which is two and a half months on an average.

This indicates that, although tea is a perennial plantation crop, quantities supplied to the Colombo auction in response to the prices generated, there can be a change within a relatively shorter period of time, which is somewhat different from other major plantation crops like rubber and coconut for which it takes relatively long time to manufacture the intended output. So, it is inevitable that correct price signals are transferred through the marketing channel up to the point of processing in tea plantations so that they can manage the quantity of plucked leaves for black tea production. Also, we may infer that although the fluctuations to real prices of black tea is relatively low overtime, they did not increase sufficiently to generate higher revenues to cover the costs, for example, which in nominal terms increased from about 313 Rs./Kg. in 2010 to Rs. 422 Rs./Kg. in 2013. How this scenario affects replanting decision of tea is an interesting area for further investigation. Also, we shall not disregard the fact that variation of production, especially under different elevations, can be caused by several other factors exogenous to this model that were not considered in this analysis, including weather and other agronomic practices.

REFERENCES

- Bean, L. H. (1929). The farmers' response to price. *American Journal of Agricultural Economics*, 11, 368-385.
- Central Bank of Sri Lanka, Annual Reports (1991 – 2011), Colombo, Sri Lanka.
- Dikmen, N. (2005). The relationship tobacco and price with Koyck – Almon approach. *Proceedings of National Econometrics and Statistical Symposium*, Istanbul University. 26-27 May.
- Edirisinghe, J. and Perera, D. (2005). Role of price on replanting decisions of rubber: an application of Almon Lag Model. *Sri Lankan Journal of Agricultural Economics*, 7, 21-31.
- Erdal, H., Erdal, G. and Esengun, K. (2009). An analysis of production and price relationship for potato in Turkey: a distributed lag model application. *Bulg. J. Agric. Sci.*, 15, 243-250.
- Erdal, G. (2006). The analysis of the relation between production and price in agricultural products with Koyck model (tomato case). *Journal of Agric. Faculty of Gaziosmanpasa University*, 23, 17-24.

- Erdal, G. and Erdal, H. (2008). The interaction between production and prices for dry onion. *Journal of Agricultural Faculty of Gaziosmanpasa University*, 25, 33-39.
- Gujarati, D. N. (2004). *Basic Econometrics* 4thed. The McGraw-Hill Companies, 659-675.
- Koutsoyiannis, A. (1977). *Theory of Econometrics* 2nd ed. Mackays of Chatham PLC, Chatham, 304-310.
- Koyck, L. M. (1954). *Distributed Lags and Investment Analysis*. North Holland Publishing Company, Amsterdam, 21-50.
- Ministry of Plantation Industries. (2013). *Statistical Information on Plantation Crops*. Colombo, Sri Lanka.
- Ozcelik, A. and Ozer, O. O. (2006). Analysis of correlation of wheat production and prices with Koyck models in Turkey. *Journal of the Agriculture Sciences of Ankara University*, 12, 333-339.
- Sri Lanka Tea Board. (2012). *Statistical Bulletin*, Colombo, Sri Lanka.
- Yurdakul, F. (1998). The econometrics analysis of relationships between cotton production and prices: Koyck – Almon approach. *Journal of Faculty of Economics and Administrative Sciences of Cukurova University*, 8, 1-4.