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Development of a Forecasting Model for the Assessment of Milled rice consumption in Sri Lanka

Marasinghe MMIK[11], Fernando APS[1], Dissanayaka SP[1]

Department of Agricultural Systems, Faculty of Agriculture, Rajarata University of Sri Lanka

ABSTRACT

Even though Sri Lanka has already achieved self sufficiency in rice, maintaining it over time is a question. This study examined the trend of the rice consumption and forecasts the consumption requirement of rice in 2030 using rice consumption data from 1960 to 2014. Development of a forecasting model was conducted by estimating four different regression equations using least square regression for four different time periods; 1960 – 2014, 1970 – 2014, 1980 – 2014 and 1990 – 2014. Of the four regression equations estimated, log-linear regression equation best explained the trend in all four periods (R^2>0.8)but the equation estimated for the period 1980 to 2014 was chosen for the prediction since it had the least Theil's Inequality Coefficient (0.0051). Accordingly by the year 2030, 3,155,005 metric tons of rice which is equivalent to 4,853,854 metric tons of paddy will be required for consumption in 2030 if the current trends continue. This is an increase of 13.86 percent demand for rice and to meet this future demand, productivity enhancement programs are recommended since extension of cultivable extents of paddy lands are limited.

Keywords: *Forecasting, Rice Consumption, Self Sufficiency, Trend Analysis*

1. Introduction

Rice (*Oryza sativa*) is the major staple crop of nearly half of the world's population, and is particularly important in Asia, where approximately 90% of world's rice is produced and consumed (Zeigler and Barclay, 2008). China, India, Vietnam, Nepal, Thailand, Indonesia, Bangladesh, and Sri Lanka are themajor rice producing countries in Asia (FAO, 2015). Sri Lankan contribution to the world rice production was 0.53 percent in 2012 (Central Bank, 2014).

Rice is the preferred staple food in Sri Lanka.From major food items, rice incurred the highest average monthly household expenditure which was Rs. 2,097.00 in 2013 (Department of census and statistics, 2013). The agricultural contribution to SriLankan economy was nearly 10.8% of GDP and 1.6% contribution was from rice production in 2013. About 29.7% Sri Lankan work force has beeninvolved in agricultural sector and nearly 18.6% of agricultural land used for rice cultivation (Department of census and statistics, 2013).This implies that Sri Lankan agriculture sector is dominated by rice cultivation and a large number of farm families directly or indirectly depends on rice cultivation. Therefore studying about the rice sector plays crucial role in the Sri Lankan economy.

Varying growth rates of rice production and consumption have been recorded over time in Sri Lanka. The highest growth rate in rice production and consumption was recordedin 1984 and 1964 respectively.Rice production grew modestly at an average of 3.80 percent perannum even though the year-to-year growth was very erraticranging from 0.16 percent in 1961 to 6.17 percent in 2013. Rice consumption also grew with the average growth rate of 2.08 percent per annum ranging from -5.10 percent in 1961 to 1.59 percent in 2013.The rice production has increased more than four times from 610,000 metric tons in 1960 to 2,850,000 metric tonsin 2014 and rice consumption has more than doubled from 1,138,000 metric tons in 1960 to 2,950,000 metric tonsin 2014.Therefore assessment of the future rice consumption and production requirements is important to take decisions on production improvement programs.

Just after the independence in 1948, the country produced only 36 percent of the total rice requirement. In the mid 1990, the rate of self sufficiency was more than 90 percent and rice was even exported in some years (Kikuchi *et al.*, 2002). Then Sri Lanka has already reached self sufficiency level in rice in last few years.Self sufficiencyrates of 2008, 2009, 2010, 2011, 2012, 2013, 2014 and 2015 were 100.1, 93.2, 106.1, 92.9, 96.1, 113.4, 84.8 and 106.8 respectively (Hector Kobbekaduwa Agrarian Research and Training Institute, Sri Lanka, 2015). But, fluctuation nature of the rate of self sufficiency in Sri Lanka with time raised a question, "is rice self-sufficiency possiblewithin the next several years?" Answer can be derived through, the trends in rice production and consumption in the Sri Lanka in the past as well as the future few years.

Although several literatures concerned issues on growth trends in agricultural production (Sivapathasundaram and Bogahawatte, 2012;Siriwardana and Jayawardena, 2014), literature on trend in rice consumption pattern in Sri Lanka is scarce. Since production and consumption trends in rice have important implications for poverty, food security, and economic development, this paper provides information on consumption pattern of rice in Sri Lanka. This information will be useful for resource allocation by producers, governments and aid agencies, and is at the core of food security issues.Hence, the main objective of the study was to develop a forecasting model to estimate the future rice consumption and production requirements by year 2030 and to assess the past trends of rice consumption in Sri Lanka.

2. Methodology

Rice consumption data taken from the United States Department of Agriculture, 2015for the time period of 1960 to 2014 were utilized for the study. Consumption pattern of the milled rice was analyzed using two techniques.

1. Tabular Analysis
2. Regression Analysis

Regression analysis was carried out using SPSS statistical software. Time series regression model with multi-period trend approach was used to analyze the rice consumption data. The quantity of rice consumed was made as a function of time trend as employed by Thanh and Singh 2006;Abdullahi, *et al.*, 2013 and Nmadu, *et al.*, 2013. The following equations given in the table 2 were estimated using ordinary least square regression technique:

Table 1: Regression equations

No	Descriptive title	Model
01	Simple linear	$Q = b_1 + b_2 T + e$
02	Double-log/Logarithmic	$\ln Q = b_1 + b_2 \ln T + e$
03	Semi-log (Right side)	$Q = b_1 + b_2 \ln T + e$
04	Semi-log (Left side)	$\ln Q = b_1 + b_2 T + e$

Where;

Q = Quantity of rice consumed in each year(Metric tons)
T = time variable (1, 2... n) for each year
b_1 = Intercept
b_2 = Regression coefficient
e= Error term
ln = Natural log (Log to the base)
The data on period of 55 years from 1960 to 2014 were divided into four periods as 1960 – 2014, 1970 – 2014, 1980 – 2014 and 1990 – 2014 and four equations were estimated for each period. Based on the results, best equation for each period was selected using respective R^2 and adjusted R^2 values of four equations. The selected four functional equations were subjected to the Theil Inequality coefficient analysis to determine theadequacy and appropriateness of chosen equation for explaining the trend and predicting future rice consumption.Theil inequality coefficient is a systematic measure of the accuracy of the forecasts obtained from an econometric model and has been suggested by H. Theil.This measure computed as:

$$U = \left[\sum (Q_t - q_t)^2 / \sum (Q_t - q_{t-1})^2\right]^{1/2} \quad (1)$$

Where;
U = Theil's inequality coefficient
Q_t = Actual observation of the year t
q_t = Predicted value of the year t
q_{t-1} = One year lag value of the actual observation
The values of the inequality coefficient can take zero as it is the lower limit but there is no an upper limit. The smaller the value of the inequality coefficient implies the betterthe forecasting performance of the model. If $Q_t = q_t$ then the coefficient value is zero and it is a perfect forecast (actual observation equals its predicted value). If U=1, it implies that $q_t = q_{t-1}$ means thatthe predictedvalue for a particular year approximately equals to the one year lag value of the actual observation for the year. Predictive power of the model is worse than the zero change prediction when U becomes greater than 1 (Koutsoyiannis, 1977).

3. Results and Discussion

3.1 Trend of rice consumption

Both milled rice production and consumption show increasing trend with time in the majority of the periods. The average growth rate of Sri Lankan population is 1.0 percent per year. Growth in population means an increase on demand for rice. This will lead toward the maintain increasing the rice consumption over a period of 55 years (from 1960 to 2014). Increase in income, increasing availability

of rice, increase in price of the alternative foods and the favorable government policies also caused to increase the rice consumption over time. There is a decreasing trend of the annual rice consumption from 1960 to 1963, and then shows an increasing trend with fluctuations for the period of 1964 to 1985, and then consumption tends to decreased for few years and again rice consumption is gradually increased from 1987 to 2006, and finally rose sharply from 2006 to 2014. The reason behind the increasing trend in the rice consumption after 1970 may be the increases in rice productivity because of the green revolution occurred in 1970 (Kikuchi *et al.*, 2002).There is an increasing growth of milled rice consumption after 1977 with the initiating adoption of open economic policies. The changes occurred in life style, increased participation of women in economic activities, increase in household income resulted to declining consumption of root and tuber crops while increasing growth of rice consumption (Jayawardena, 2000). There is an important change occurred after 1985 and that was the consumers have been reducing their per capita consumption of rice. The reason for this change was that rice was tended to be replaced by wheat in food consumption (Kikuchi *et al.*, 2002). Then it shows a gradual increasing consumption pattern which could be related to the increase of population growth.

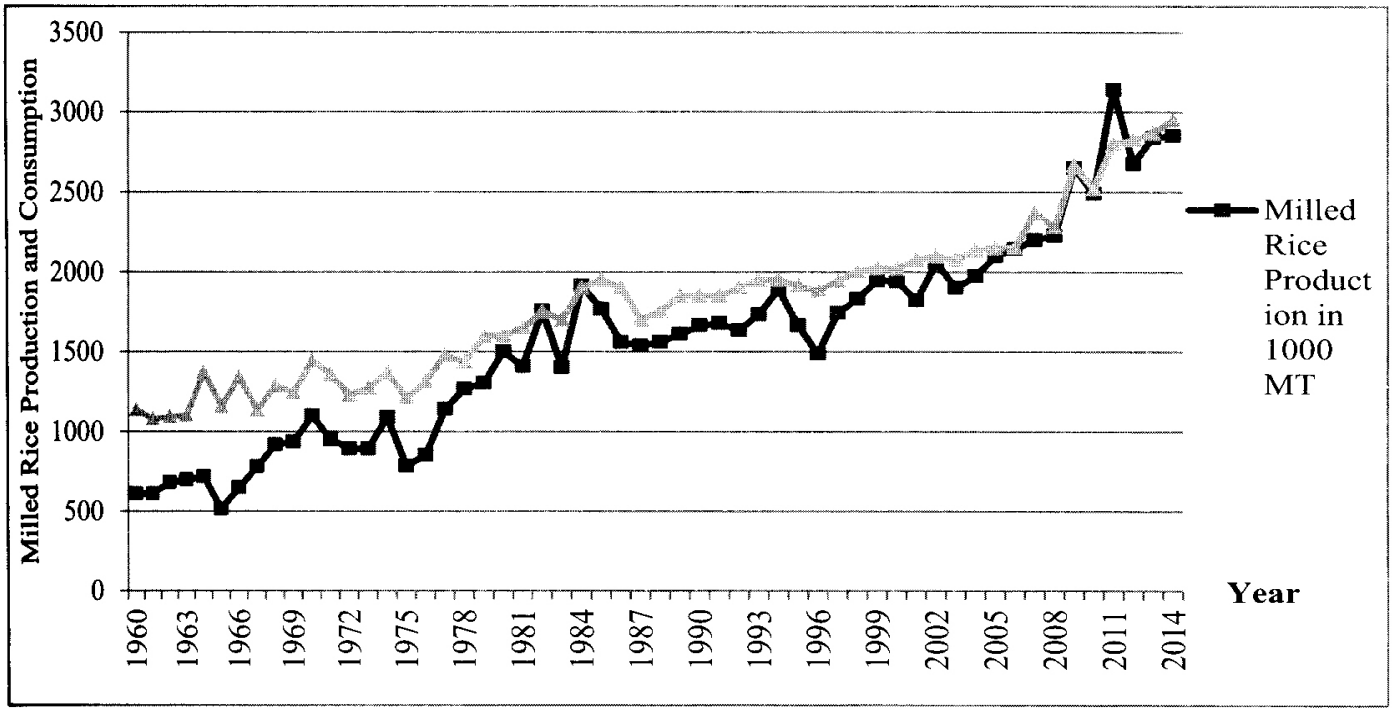

Figure 1: Trend of rice production and consumption(Source: United States Department of Agriculture, 2015)

3.2Regression analysis

Table 2 below presents the analytical comparison of the functional equations when they are fittedby the Ordinary Least Square method. The results of the coefficients of the trend models together with their corresponding standard errors are presented in this table, which also presents the values of R^2, adjusted R^2, t values and F ratio. The results showed that estimated coefficients of all functional equations are significant in explaining the variation in rice consumption over time. The adjusted R^2values varied from 67.8 percent to 93.2 percent. According to the results, left sided semi log functional forms were the best among other functional forms estimated for four periods from 1960 to 2014, 1970 to 2014,1980 to 2014 and 1990 to 2014 as it possess the highest R^2andadjusted R^2values among the each four trend models. Therefore it was selected as the best fit equation in explaining the trend for all the periods.

Table 2: Results of the Ordinary Least Square Regression equations for rice consumption

Period	Functional forms	Intercept	Coefficient	R^2	Adj-R^2	t-stat	F-ratio
1960 – 2014	$Q = b_1 + b_2 T + e$	973.655** (40.501)	29.294** (1.258)	0.911	0.91	23.28	541.98
	$\ln Q = b_1 + b_2 \ln T + e$	2.881** (.028)	0.269** (0.20)	0.77	0.77	13.37	178.76
	$Q = b_1 + b_2 \ln T + e$	403.725** (135.106)	1045.900** 97.629)	0.68	0.68	10.71	114.77
	$\underline{\ln Q = b_1 + b_2 T + e}$	3.037** (0.008)	0.007** (0.000)	0.93	0.93	27.21	740.48
1970 - 2014	$Q = b_1 + b_2 T + e$	884.53** (61.870)	31.589** (1.745)	0.884	0.881	18.107	327.856
	$\ln Q = b_1 + b_2 \ln T + e$	2.584** (0.41)	0.467** (0.27)	0.871	0.868	17.032	290.075
	$Q = b_1 + b_2 \ln T + e$	-1049.35** (221.731)	2012.731** (148.315)	0.811	0.806	13.571	184.161
	$\underline{\ln Q = b_1 + b_2 T + e}$	3.038** (0.013)	0.007** (0.000)	0.903	0.901	20.035	401.393
1980 - 2014	$Q = b_1 + b_2 T + e$	883.277** (107.447)	31.650** (2.733)	0.803	0.797	11.582	134.142
	$Q = b_1 + b_2 T + e$	2.527** (0.074)	0.503** (0.047)	0.775	0.768	10.666	113.758
	$Q = b_1 + b_2 \ln T + e$	-1808.82** (420.900)	2491.299** (268.415)	0.723	0.715	9.282	86.146
	$\underline{\ln Q = b_1 + b_2 T + e}$	3.073** (0.019)	0.006** (0.000)	0.843	0.839	13.329	177.664
1990 - 2014	$Q = b_1 + b_2 T + e$	328.448** (175.736)	43.765** (4.031)	0.837	0.830	10.858	117.903
	$\ln Q = b_1 + b_2 \ln T + e$	2.069** (0.123)	0.781** (0.076)	0.823	0.815	10.334	106.796
	$Q = b_1 + b_2 \ln T + e$	-4483.95** (730.361)	4114.007** (448.378)	0.785	0.776	9.175	84.186
	$\underline{\ln Q = b_1 + b_2 T + e}$	2.984** (.029)	0.008** (0.001)	0.869	0.864	12.374	153.110

**- Statistically significant at 5 percent probability.

Values in parenthesis are standard errors. The best fit equations are underlined.

The Theil's inequality co-efficient was calculated to find the equations with greatest predictive power from the left sided semi-log models of which the variation is best explained. The results of the Theil inequality coefficient analysis are shown in table 3. They indicate that all the chosen equations have good predictive power while the left sided semi log equation for the period of 1980-2014 has the highest predictive power as it possess least Theil inequality coefficient which was approximate to zero.

Table 3: Results of the Theil Inequality Coefficient Analysis

Period	Theil Inequality Coefficient
1960 – 2014	0.0706
1970 – 2014	0.0715
1980 – 2014	0.0051
1990 – 2014	0.0702

Therefore left sided semi log equation for the period of 1980 to 2014 was selected for the prediction of future rice consumption in 2030. The equation is as fallows.

$$\ln Q = 3.073 + 0.006T \quad (2)$$

It was estimated that 3,155,005metric tons of rice are required for consumption in 2030. This value is considerably higher than the current level of milled rice consumption which was 2,950,000 metric tons in 2014. Moving average valuesof milled rice consumption and paddy production wereused for further explanations due to fluctuation nature of the consumption and production data.Accordingly, estimated milled rice consumption is13.86 percent higher in 2030 than the average milled rice consumption of 2,771,000 metric tons. According to the Department of Agriculture, average milling recovery ratio is around 65 percent.Therefore 4,853,854 metric tons of paddy will be required to produce 3,155,005 metric tons of milled rice. Estimated paddy production is 25.2 percent higher than the averagepaddy production of 3,877,000 metric tons. Therefore local production of paddy should be enhanced in order to meet the increasing demand of the rice as well as to maintain the self sufficiency of rice.

Consumption change of the milled rice for the past 16years from 1998 to 2014 was 950,000 metric tons while 205,000 metric tons of consumption change was estimated for the future 16 years from 2014 to 2030. Estimated consumption change for the future 16 years show significant difference than the value of past 16 years. The major reason behind that is the diversification of food basket from starchy grains to non grainsfood such as vegetables, fruits, fish and meat as a result of the increased income. As well as people have changed their consumption pattern from the rice consumption to instant foods and prepared foods consumption along with their increasing income as well as the busy life schedule, especially in the urban sector population.

4. Conclusions

Rice has been the single most important crop in many developing countries and it has long been an important to maintain the self sufficiency of rice over the time. Main effort of this study was to find out the suitable trend model for the prediction of rice consumption in Sri Lanka. Here compared the performances of different regression models to derive best model for forecasting the rice consumption in 2030. Left sided semi log equation for the period of 1980-2014 was identified as the best model for the predictions. Accordingly, estimated milled rice consumption in 2030 is 3,155,005 metric tons while 4,853,854 metric tons of paddy will be required to satisfy that quantity of demand. Both values are higher than the current consumption and production values. Therefore, in order to maintain the self sufficiency of rice in Sri Lanka rice production should be increased over the years. It can be recommended that, policy implication that satisfies paddy farmers' needs, seed and fertilizer subsidies which can ensure the continuous production process, credit facilities to farmers to bare production expenses, storage facilities, infrastructure development and technology support need to be enhanced to increase the production and to motivate paddy farmers towards increasing local paddy production, because it is difficult to increase in the area of paddy cultivation due to limitation of this factor, implementation of above recommendations will maintain the self sufficiency of rice with time.

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