TIME SERIES ANALYSIS OF RICE AND CORN PRODUCTION AND ITS IMPLICATION TO FOOD SECURITY IN THE PHILIPPINES

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ABSTRACT

This study attempts to analyze the economic dimension of supply and demand for rice and corn in the Philippines, particularly when the rice and corn shortages may be experienced in the country. The study utilized the descriptive design of research. Data on the rice and corn production and consumption were gathered from the Philippine Statistics Authority from 1960 until 2008 only due to unavailability of the data in the succeeding years. The time series data for rice and corn were analyzed using symbolic regression in order to ascertain the non-linear components of the trend. Findings revealed that production and consumption of rice have upward trends. However, rice production fluctuates more frequently than consumption. Similarly, the corn production and consumption also revealed upward trends. Yet, corn consumption does not display a smoother upward movement as anticipated. It is then concluded that precise estimates about shortages and surpluses can be made for the corn commodity, but the same estimates cannot be made with precision for rice production and consumption figures. Thus, food security measures must address rice production more intensely due to its inherent market volatility.

Keywords: *Food shortage, supply and demand, sustainability of food production*

1.0 Introduction

Food security is a global issue and one that every nation must confront. There are various facets to the issue of food security including but not limited to the technical aspects of food production, the social aspect of making food equitably accessible to all, and the political forces that control the flow of supply of and demand for food. The complex interaction of these forces made it extremely difficult to ensure food security (UN-Food and Agriculture Organization, 2013). However, what

appears to be more practical is to analyze these factors separately in order to isolate the full influence of such factors on a one-on-one basis. This study focuses only on the economic aspect of supply and demand for rice and corn in the Philippines. More specifically, the study assesses when rice and corn shortages may be experienced in the country.

At present, the United Nations Food and Agriculture Organization (UNFAO, 2013) claims that there are thirty six (36) countries experiencing rice shortage excluding the Philippines. Nonetheless, hugging the headlines of many news reports of late is the disturbing reality of lack of NFA rice (National Food Authority, 2018) in the local markets. This government-subsidized rice is intentionally distributed by the national government to ensure that the economically-deprived sectors of Philippine society provide access to this basic commodity. Meanwhile, rice and corn farmers claimed sufficient harvests, which they purportedly sell to private rice merchants. The situation is such that the government procures rice and corn from local farmers at a very low price while the private merchants buy them at significantly higher prices. The State, therefore, experiences "artificial rice shortage".

The Philippines is not threatened by rice shortage (Bureau of Agricultural Statistics, 2016). However, artificial rice shortages may actually occur due to hoarding and predatory business practices. State and private sector competition for rice may cause artificial rice shortages. There are other ways in which artificial rice shortage may occur. Hoarding of rice is another way to induce artificial rice shortage. Head (2008) described this scenario clearly: "Producers hoard their supply, causing artificial shortages in the market. Hoarding, in effect, is a price manipulation strategy. With a limited supply, prices go up, and the consumers resort to panic buying in an effort to catch commodity prices at lower levels."

There is yet another way to create artificial shortages. In the case of corn, for instance, the Bureau of Agricultural Statistics (2017) claimed that more than half of the Philippine population consume rice while the rest consume corn. In the case of corn, artificial food shortage can be induced because of the competing uses of corn in the market viz. animal feeds, oil (cooking oil, margarine), bioethanol for fuel and other industrial products (Gerbacio,et al.,2004). Hence, it would appear that there may not be enough corn for food but, in reality, supplies of corn may be more than sufficient for the population food requirements.

While this paper acknowledges the realities in the Philippine economic market, its main concern is on the mundane issue of rice and corn shortages. Artificial shortages can be remedied through economic policies while real shortages will have to be addressed by fundamental changes in the rice/corn production systems. This

makes actual shortage in rice and corn more important since its solution deal with modernizing agricultural production practices. Hence, this study is realized to determine whether our country really experience rice and corn shortages.

2.0 Conceptual Framework

This study is anchored on the basic economic Law of Supply and Demand (*Sali, G. et al. ,2014)*). In this economic theory, when supply exceeds demand, there are economic surpluses; conversely, when supply is less than demand, there are economic shortages. Sustainable food supply sufficient to meet the requirements of the consumers at every point in time lies at the heart of food security. The Schematic diagram of the study is shown below;

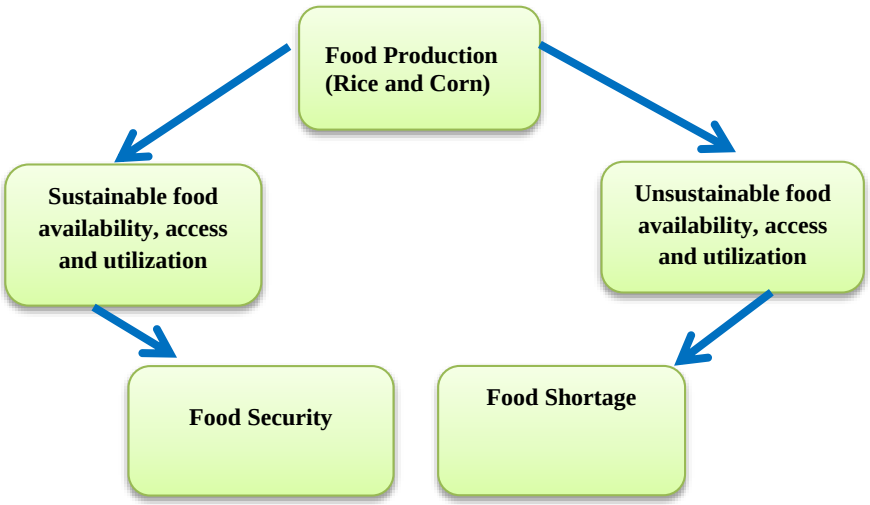

Figure 1. *Schematic diagram of the study*

Rice or Corn Production is the amount of yield produced in each calendar year in a given area. This production is dependent on the incidence of insect pest and disease infestation, soil infertility and acidity including the frequencies of drought and flood and even climate change occur in the specified area. Rate of Consumption is the quantity of items or goods being consumed by individuals. This rate of consumption is dependent on the total population of the country.

Food Security is related to sustainable food availability, food access, and food utilization. This can be achieved when sufficient quantities of food are consistently available to all individuals. Food Shortage is a serious problem of food scarcity which is caused by several factors, including war, environmental and social factors such as crop failure, overpopulation, and poor government policies.

3.0 Research Methods and Design

The study utilized the descriptive design of research. Data of rice, corn production and consumptions were gathered from Philippine Statistics Authority from 1960 to 2008. In accordance with the conceptual framework of the study, the surplus/shortage of rice or corn is obtained as:

$$\text{surplus or shortage} = \text{supply} - \text{consumption}, \quad \text{for each time t}$$

The difference between supply and consumption becomes a surplus if it is positive and becomes a shortage when it is negative.

The time series data for rice and corn were analyzed using symbolic regression in order to ascertain the non-linear components of the trend. Symbolic regression is a type of regression analysis where the functional form of the dependence on time is not specified. The building blocks of possible functions such as polynomials, trigonometric, and exponentials are inputted and genetic algorithm was used to execute symbolic regression.

In order to assess pattern shifts (if any) in the observed trends, the time series observations were sub-divided into decades e.g. 1960-1970, 1971-1980 etc., and symbolic regression was applied for each decade. This type of analysis will uncover persistent periods of surpluses or shortages in rice and corn in the Philippines.

This paper dwells on the technical dimension of rice and corn production and consumption. More specifically inferring the possibility of shortages in these two commodities through time series analysis.

4.0 Results and Discussion

Figure 2 shows the time series of rice production, including its rate of consumption over the period 1960 to 2008.

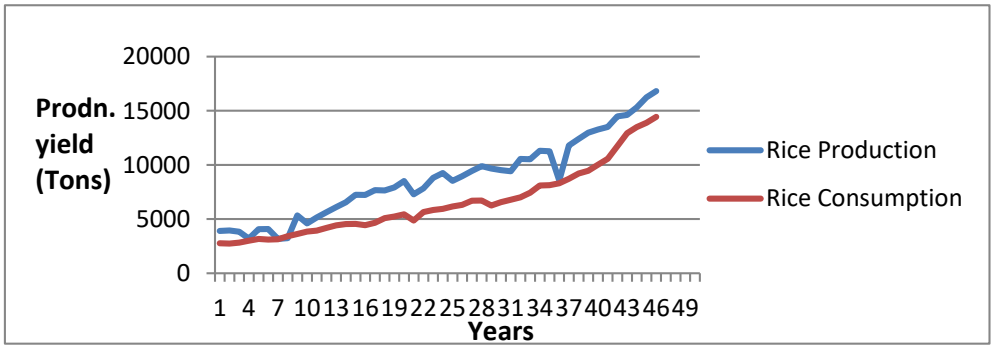

Figure 2. Time series of rice production, including its rate of consumption over the period 1960 to 2008.

As reflected in figure 2, both rice production and consumption have upward trends. However, rice production fluctuates occasionally. The said unusual fluctuation is due to a variety of factors that cannot be controlled such as climatic condition, temperature, rainfall pattern and other environmental factors that may influence. However, the consumption is solely dependent on the increase of population. The erratic and highly volatile rice production figures coupled with a smooth upward density dependent consumption figure makes the prediction of shortages or surpluses uncertain. For instance, unless one is able to precisely determine the exact time of "ups" and "downs" of rice production figures, shortages or surpluses cannot be calculated precisely.

Figure 3 shows the time series of corn production, including its rate of consumption over the period 1960 to 2008.

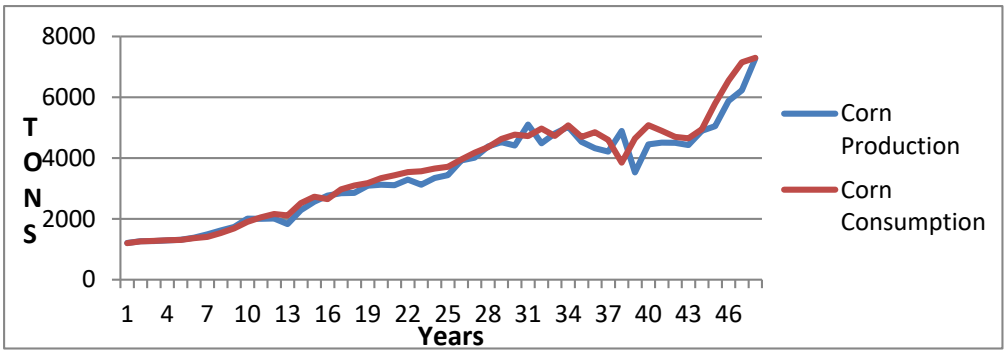

Figure 3. Time series of corn production, including its rate of consumption over the period 1960 to 2008

The value of corn production and consumption also reveals upward trends. The trend pattern of corn production is similar to the production of rice as observed (figure 2) where severe fluctuation occurs. Surprisingly, corn consumption does not display a smoother upward movement as anticipated. Instead, corn consumption figures revealed an inconsistent pattern / trend similar the production figures. The latter observation requires some explanation.

Corn consumption figures display erratic and volatile movements due to the different alternative uses of corn such as converting the corn products to the oil, bioethanol, and animal feeds apart from food consumption. If trends continue, then shortages of corn for food may be experienced in the future.

The Trend Curves Pattern

Analysis of the observed trends in the time series graph was done by breaking up the time periods through decades. Table 1 shows the trend lines of the rice production for five (5) decades in the Philippines. The computed trend lines for the first decade up to the last revealed an upward quadratic trend. This implies a faster growth rate for rice production from 1960 to 2000. This revealed that in that identified years, the utilization of high yielding varieties through the use of modern technologies primarily caused the production to increase.

Table 1. The trend lines in rice production

Decade	Trend Lines (x) Rice Production	Mean Absolute Prediction Error
1	Yt=4187.54-287.094*t+44.1877*t**2	5.0
2	Yt=4620.55+563.680*t-19.6074*t**2	1.6
3	Yt=6863.36+610.944*t-33.9140*t**2	2.9
4	Yt=12658.5+237.727*t+36.1412*t**2	.8
5	Yt=13103.5+496.817*t+20.9260*t**2	1.0

Apparently, table 2 displays a similar trend analysis for rice consumption for the five (5) decades in the Philippines. As reflected in the table, it also shows a quadratic trend from the first decade up to the last. This revealed a rapid growth rate in population from 1960 to 2008. It further implies that the population over the years up to recent is rapidly increasing.

Table 2. The trend lines in rice consumption

Decade	Trend Lines (y) Rice Consumption	Mean Absolute Prediction Error
1	Yt=2741.93+7.56114*t+9.84239*t**2	1.83
2	Yt=3998.60+64.7383*t+7.56057*t**2	2.3
3	Yt=4563.80+488.615*t-29.9623*t**2	2.4
4	Yt=6044.80+130.390*t+8.5275*t**2	2.9
5	Yt=9383.31+881.577*t-43.1311*t**2	0.9

Meanwhile, the table 3 shows the trend of the corn production in the Philippines for five (5) decades. As reflected in the table, the computed trend lines for the first decade up to the last revealed an upward quadratic trend. This implies a faster growth rate for corn production from 1960 to 2008 which also revealed that the used of improved varieties primarily caused the production to increase through the years.

Table 3. The trend lines of corn production

Decade	Trend Lines (t) Corn Production	Mean Absolute Prediction Error
1	Yt=1304.95-59.3962*t+12.4735*t**2	1.93
2	Yt=1681.82+167.577*t-1.69318*t**2	4.5
3	Yt=2929.57+104.605*t+6.53788*t**2	3.6
4	Yt=5071.72-109.601&t+1.78409*t**2	7
5	Yt=4725.27-284.530*t+74.6369*t**2	1.9

Further, table 4 displays a similar trend analysis for corn consumption in the Philippines from 1960 up to 2008. It also shows a quadratic trend from the first decade up to the last. This revealed a rapid growth rate in population from 1960 to 2008 and subsequently, it surpasses the rate of corn production.

Table 4. The trend lines of corn consumption

Decade	Trend Lines (z) Corn Consumption	Mean Absolute Prediction Error
1	Yt=1307.88-55.3417*t+11.0492*t**2	2.21
2	Yt=1834.78+158.817*t-0.700758*t**2	2.78
3	Yt=3423+9.05455*T+13.1818+t**2	.86
4	Yt=5071.9-123.644*t+8.59848*t**2	6
5	Yt=4726.79-106.548*t+58.9286*t**2	4.2

Overall Trend Curves

Table 5 presents the trend curve of rice, corn production and consumption from 1960 to 2008. The overall trends for the four - time series observations were obtained through symbolic regression. Some notable observations that can be made about the trend curves include: (a) Rice production figures have fluctuations due to the presence of a sine term; (b) Rice consumption figures are smoother because they are contained in a polynomial model; (c) Corn production and consumption figures are fluctuating because of trigometric terms. Corn production and consumption figures are "out -of - sync" because of angular phase displacement.

Table 5 Trend curve of rice, corn production, and consumption.

Trends	Solution	Mean Absolute Error	R squared
Rice Production	$x = 4.3e3+70.5t^2+0.00127t^5+\sin(t)-392t-1.51e-5t^6-2.45t^3$	358.95015	0.97337056
Rice Consumption	$y = 2.56e3+68.8t+9.5t^2+0.00645t^4-0.424t^3$	141.43769	0.99480842
Corn Production	$w = 1.26e3+6.57t^2-0.11t^3-14t \sin(5.58-0.424t)$	147.01958	0.96842309
Corn Consumption	$z = 1.9e3+21.1t^2+0.000323t^5-222t-0.0216t^4-311\cos(6.55t)$	126.26924	0.98242621

Table 6 shows the forecast values for these parameters. The mean absolute prediction error obtained are generally higher than the corresponding mean absolute prediction error for the trends. The least precise forecasted values are for the rice production figures while more precise prediction can be made for both corn production and consumption periods.

Table 6 Predicted (Forecasted) trend patterns of rice and corn production and consumption

Trends	Solution	Mean Absolute Error	R squared
Rice Production	$x=3.21e6+2.29e3t^2+\frac{2.09e-10t^7}{\sin(3.13+0.107t)}-1.61e5t-0.138t^4$	4461.79	0.99965834
Rice Consumption	$y=0.00279t^4$	3318.6729	0.99213216
Corn Production	$w=1.62e3t-3.47e4-463\sin(t)-16.9t^2$	549.32933	0.99155317
Corn Consumption	$z = 1.9e3+21.1t^2+0.000323t^5-222t-0.0216t^4-311\cos(6.55t)$	1756.0795	0.99971516

5.0 Conclusion

In the light of these findings, precise estimates about shortages and surpluses can be made for the corn commodity, but the same estimates cannot be made with precision for rice production and consumption figures. Thus, food security measures must address rice production more intensely due to its inherent market volatility.

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