Empirical Analysis of Rice Prices, Production, and Consumption in the Philippines: Implications for Self-Sufficiency Policy

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ABSTRACT

The Philippines' level of rice self-sufficiency remains an integral aspect of food security. To formulate self-sufficiency policy directions, this study empirically analyzed factors affecting rice production, consumption, and prices using fixed effects model estimation of an unbalanced panel data of fifteen rice-producing regions from 2003 to 2020. Further, this study utilized a vector autoregressive (VAR) approach on time series data of rice self-sufficiency, production, consumption, and prices from 1998 to 2020 to explore and understand the dynamics of the relationship between these variables. The research findings suggest that the area of production and cost of irrigation are significant factors affecting rice production volumes. Fertilizer costs, while statistically significant, exert virtually no impact on price levels of regularly milled rice. The Granger causality tests revealed that consumption Granger-cause rice self-sufficiency. Further, rice self-sufficiency, consumption, and prices were found to Granger-cause production. The researcher also performed forecast error variance decomposition through the impulse response function test to determine the impact of shocks among the study variables and derived implications for rice self-sufficiency policy in the Philippines.

Keywords: Food security, rice self-sufficiency, VAR, agricultural policy.

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1. INTRODUCTION

Rice security only emanates if a country is self-sufficient in producing rice which ultimately impacts food security (Siwar, Idris, Yasar, & Morshed, 2014). However, issues and challenges related to the growing population, natural calamities, and corruption incidence, achieving sustainable food security surfaces as a difficult plight (Onder, 2021; Prosekov & Ivanova, 2018). It is in this light that government interventions are deemed necessary to bolster production technology among farmers, provision of subsidies and financial assistance, and extension of programs to improve rice productivity (Aliyeva et al., 2019). Ultimately, these policies and programs have short-run and long-run impacts on resource allocations decision.

Rice is considered a political commodity because it is the staple food in the Philippines and a major source of agricultural employment for Filipinos (Intal & Garcia, 2005). Previous administrations aimed for the country to achieve self-sufficiency in rice but have yet to succeed and continue to depend on importation. This can be attributed to declining land devoted to rice farming and increasing demand due to the growing population (Davidson, 2016). The Philippine Rice Research Institute (PPRI) (2011) emphasized that self-sufficiency in rice means that a country must produce the national rice requirement

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while maintaining a buffer stock that can be tapped in times of need. Nevertheless, PPRI believed that the inability to produce enough rice would not risk the nation's food security.

From 1970 to 1980, rice production in the Philippines has been rapidly growing, resulting in a surplus (Tibao, 2009). However, the growing population and rapid urban development, agricultural areas were replaced by industrial, commercial, and residential projects (Cao, Chaiwan, & Chaiboonsri, 2023), leading to shortage of local rice supply. To fill in the gap, the government started importing rice from its neighboring countries and became one of the world's biggest rice importers at the start of the 21st century (Freedman, 2013). As the government aimed to promote rice self-sufficiency, they promoted the use of hybrid rice varieties and funded research to increase rice yield, reduce crop maturity, develop insects and diseases resistant varieties and increase the efficiency of farm inputs (Redoña et al., 2003). The efforts of the government to achieve rice self-sufficiency failed given that the country remained as a net importer of rice to fill in the shortage (Intal & Garcia, 2005; Cardona & Garcia, 2016).

Previous studies conducted in the Philippines regarding rice self-sufficiency investigated the factors that influenced rice productivity and its technical efficiency in selected provinces (Mariano, Villano, Fleming, 2011; Villano, Bravo-Ureta, Solís, & Fleming, 2015). Briones (2019) analyzed the competition in the rice industry by looking into the market structure of rice production, harvesting, milling, distribution, and trade. Cardona and Garcia (2016) identified the different factors affecting the production, consumption, and importation of rice. To support the extant literature, this study aimed to investigate determinants of rice-related variables, namely production, consumption, and prices from 2003 to 2020 utilizing panel data estimation of fifteen rice-producing regions in the Philippines. This research deviated from Cardona and Garcia (2016) by introducing the rice prices variable as rice given that changes and volatility of rice prices may undermine self-sufficiency (Li, Chavas, &Li, 2022). Furthermore, using a vector autoregressive approach of time series data from 1998 to 2020, the researcher analyzed the causality between rice self-sufficiency, production, consumption, and prices to ascertain the possible impact of government policies on these research variables. Based on the research findings, the study raised key implications for self-sufficiency policy directions to achieve food security in the country.

2. REVIEW OF RELATED LITERATURE

2.1 Land

The unequal distribution of agricultural land is regarded as the source of poverty and inefficiency in agriculture. The findings of Vixathep, Onphanhdala, and Phomvixa (2013) showed that land inequality is controlled, and access to agricultural infrastructure is measured by irrigated areas. Land policies such as allocation, utilization, and management of agricultural land could lead to food security and poverty alleviation. In Indonesia, the food self-sufficiency policy relies on the sustainability of productive land that meets the requirements for the carrying capacity of agricultural land. But the quantity and quality of land have degraded in some regions of the country.

2.2 Water

Abundant land and water resources can ensure abundant rice production (Tuong & Buoman, 2003; Piao et al., 2010). Ugalahi (2015) reviewed the impact of an intensive and consistent irrigated rice production scheme to hasten Nigeria's rice self-sufficiency. The findings concluded that the country has fragmented, inconsistent and unimplemented policies, multiple water regulatory institutions with overlapping and duplicating mandates, and a poor management system

Irrigated rice consumes a large amount of water which could threaten the water supply (Li, 2001; Buoman et al., 2007). On this note, Kenya developed alternative irrigation water technologies or the system of rice intensification (SRI) to avoid depletion of the water supply. The objective of SRI boiled down to achieving efficient use of water to improve rice yields. Kaloi et al. (2021) analyzed the factors affecting the adoption of SRI and found that age was significant but with a negative effect on the adoption of SRI. On the other hand, farm size, household size, distance from the canal, off-farm work, access to credit services, access to extension services, and years in rice farming were positively and significantly influencing factors in the adoption of SRI.

2.3 Farm Inputs and technical efficiency

Koirala et al. (2014) studied the way farmers make production decisions and the technical efficiency of rice production in the Philippines. Results of the study showed that land area, planting season, fuel cost, fertilizer cost, and land rent have a positive significant relationship with the value of rice production in the country. With regard to technical efficiency. Filipino farmers have lower technical efficiency in rice production due to the price of fuel, fertilizers, and land rent. In Nigeria, Omoare and Oyediran (2020) found that inadequate finance, pest, and diseases incidence, climate change, birds disturbance, land degradation, poor soil fertility, non-availability of quality seeds and agro-chemicals, lack of rural infrastructure, inadequate agricultural extension support on training and capacity-building, high cost of fertilizers and tenure problem impact rice production. In Indonesia, Purba et al. (2020) showed that the majority of rice farms in the tidal lowlands were inefficient under decreasing returns to scale with rice production positively affected by nitrogen, phosphorus, and potassium fertilizers, herbicides, insecticides, and fungicides.

Cañete and Temanel (2017) found that the factors that greatly affect rice yield were the cost of farming services, the quantity of seeds, the amount of fertilizers applied, and the cost of farm services in irrigated farms. For rainfed farms, rice yield was affected by the cost of farm services and quantity of seeds, farm services, land area, the quantity of fertilizer applied, and the cost of pesticides. Musaba and Mukwalikuli (2019) concluded that land size, seed quantity, agrochemicals, labor, gender, extension access, and line planting were significant and positively related to rice output. In the Philippines, Benabise et al. (2016) described that under an irrigated system, there was a positive output-input relationship in all variables such as seeds, labor, and nitrogen content of fertilizers, chemicals, and pesticides used in farming. On the contrary, age, educational attainment, the number of years in rice farming, and the number of training received tenure (owned) and topography (flat) were significant in lessening technical inefficiencies of farmers.

Alam and Effendy (2017) reported that urea fertilizer, organic fertilizer, and labor directly affect rice production. On the other hand, Rasyid et al. (2016) found that seed, fertilizer, pesticide, and labor significantly affect rice production positively while socioeconomic factors such as farmer age, education, experience, number of household members, and the frequency of visiting the field laboratory had significant positive effects on the level of technical efficiency.

Total rice area and production gradually decreased in the province of North Sumatra in Indonesia due to changes in land use and stagnant productivity. Siagian (2019) presented that the factors identified most affecting rice land change were the distance of rice land to the district capital, the distance of rice land to the provincial capital, population density, slope, and the distance of farmers' rice land to a road.

ADB (2014) reported that access to extension services had a negative correlation with production technical efficiency while investments in irrigation are significant. The legal environment and financing are found to be negatively related to cross-sectional technical efficiency but the regressions supported their importance in improving the reallocation of land and inputs in changes in land ownership. On the other hand, the land is found to be highly important to improve efficiency and total rice production. Thus, to improve the investment climate, significant investments in institutions, reforms, and public infrastructure are recommended.

2.4 Competitiveness and government policy

Using the value chain analysis (VCA) framework, Mataia et al. (2020) analyzed the rice value chain (RVC) in the Philippines, examined the value additions, and identified constraints. The study identified that the major constraints identified in the retail value chain include high production and marketing costs of paddy and rice attributed to low yield, high labor cost, and material inputs, and insufficient crucial infrastructure and market facilities (e.g., modern mills, dryers, cheap transport, and energy). These resulted in high domestic paddy and rice prices and low competitiveness of the entire rice value chain.

Briones (2019) presented an appraisal of the rice industry including production, harvesting, milling, distribution, and trade. Based on the findings, it was concluded that the market structure is highly competitive at all levels. Government intervention has a limited impact on the rice industry within the domestic market except for statutory restrictions on rice importation from the private sector. Market players confirmed that there are strong competitive pressures at every stage of the marketing chain. Increases in rice prices tend to be followed by a withdrawal from stocks which resulted in a subsequent decline in prices.

Based on the study conducted by Cardona and Garcia (2016), the Philippines is not rice self-sufficient due to the increasing gap between production and consumption, and the rising amount in the importation of rice. Their findings showed that rice production and importation affect rice self-sufficiency positively while rice consumption affects rice self-sufficiency negatively.

3. RESEARCH FRAMEWORK

Productive efficiency is a macroeconomics and microeconomics concept that explains how production inputs are utilized at optimum levels to produce maximum output. In macroeconomics, productive efficiency is when the market maximizes output at an optimum amount of fixed resources (Blanchard & Johnson, 2013).

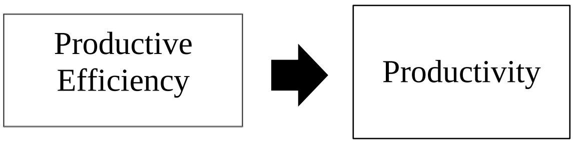

Figure 1. *Relationship between productive efficiency and productivity*

The productive efficiency concept is illustrated on a production possibility frontier (PPF), where all points on the curve are points of productive efficiency. An equilibrium may be productively efficient without being allocatively efficient, which may result in a distribution of goods where social welfare is not maximized. With the economy operating below its production possibilities frontier, productive inefficiency can occur because the productive inputs physical capital, and labor are underutilized. This means that some capital or labor is left idle or that these inputs are allocated in inappropriate combinations to the different industries that use them (Krugman, 1994).

Productivity measures how efficiently production inputs such as labor and capital are used in an economy to produce a given output level. As a key source of economic growth and competitiveness, productivity it is used to measure the performance of an economy. At the micro level, it is used to measure capacity utilization, the position of an industry in the business cycle, and production capacity to assess demand and forecast the industry's growth. It is measured in terms of the total inputs per unit of output. Labor input is measured in terms of hours worked, while capital inputs are measured in terms of the cumulative stock of fixed investments (Krugman, 1994).

Since improvements in productive efficiency take time to implement and economic growth happens slowly, the government needs to take action. They have to identify where the additional spending should be made to produce the largest quantity of goods and where they should reduce spending to do the least harm. At the firm level, the market economy organizes a process where firms try to produce goods and services the consumers want in quantity, quality, and price. In the short run, increasing the production of a good means decreasing another good in the economy while in the long, productive efficiency occurs at the point where the marginal cost equals the average total cost for each good.

4. CONCEPTUAL FRAMEWORK

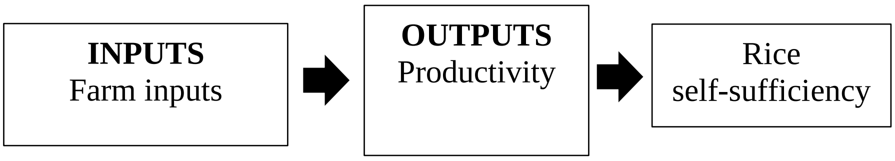

Figure 2. Relationship between farm inputs and outputs and rice self-sufficiency

Farm management comprises the farm, farmer, and resources used by the farmer. Farming needs an input-output relationship, which optimizes the use of inputs to maximize output. Deciding what to produce, how to produce, and how much to produce are influenced by factors such as farm inputs, extension services, policies, and programs. The productive capability of land should be sustained because it is the source of farmers' food and income. Knowledge and skills in cultural practices enhance the ability of farmers to perform farming activities effectively. Farm labor is usually performed by family members and financial capital are fund used by farmers in carrying out farming activities

Productivity is defined as the ratio between the output and inputs. It measures how efficiently production inputs are being used to produce a given level of output. Furthermore, it determines capacity utilization to ensure that demand could be met. Finally, productivity determines the production performance of farmers which improves the standard of living of farmers. Increasing national productivity can raise living standards because more real income improves people's ability to purchase goods and services, enjoy leisure, improve housing and education and contribute to social and environmental programs. Productivity growth can also help businesses to be more profitable.

5. METHODOLOGY

5.1 Data Collection

The researcher first investigated the factors that may influence the volume of production and consumption as well as the level of rice prices using panel estimation. This involved utilizing an unbalanced panel dataset from fifteen-rice producing regions in the country from 2003 to 2020. Aggregate data from these regions were sourced from the Philippine Statistics Authority (PSA) and the Philippine Rice Research Institute (PRRI), resulting in a total of 3,077 observations. On the other hand, the researcher also investigated the dynamic relationships between rice self-sufficiency, production, consumption, and prices through time series estimation, specifically through a vector autoregressive (VAR) approach. The time series data of the four variables spanned from 1998 to 2020 which are sourced from the PSA. The description of the variables was elaborated further in Appendix A. In operationalizing the methodology, the researcher performed the panel and time series estimation using STATA 14.

5.2 Rice Self-Sufficiency Measure

Consistent with the agricultural sufficiency measure of the Food and Agricultural Organization (FAO), the researcher utilized the self-sufficiency ratio of rice sourced from PSA. The self-sufficiency ratio is given by Equation 1:

$$SSR = \left(\frac{rice\ production}{rice\ production + rice\ imports - rice\ exports}\right) * 100 \tag{1}$$

The rice self-sufficiency ratio (SSR) shows the magnitude of the volume of rice production in relation to domestic utilization. It refers to the extent to which the supply of rice in the country is sourced from its domestic production or the extent to which a country relies on its production resources.

5.3 Model Estimation and Specification

5.3.1 Panel Estimation

To determine the factors influencing rice production, consumption, and prices, the researcher estimated the following models:

$$RP_{it} = \beta_0 + B_1 AR_{it} + \beta_2 IR_{it} + \beta_3 FE_{it} + \beta_4 PE_{it} + \varepsilon_{it} \tag{2}$$

In this model, RP_{it} represents the volume of rice production of region i at time t and constitutes the model's dependent variable. With regard to the independent variables, AR_{it} pertains to the area in rice production measured in hectares; IR_{it} represents the cost of irrigation measured in pesos per hectare; FE_{it} represents the estimated amount of inorganic fertilizer used in rice production; and lastly, PE_{it} pertains to the cash cost of pesticide rice farmers utilized in their production methods.

$$RC_{it} = \beta_0 + \beta_1 PCI_{it} + \beta_2 PR_{it} + \beta_3 PO_{it} + \varepsilon_{it} \tag{3}$$

The rice consumption model is represented by Equation 3. In this model, RC_{it} refers to the volume of rice consumption of region i at time t. The independent variables include PCI_{it} which is the per capita income represented by the gross regional domestic product income per capita, PR_{it} which pertains average annual price of ordinary or regularly milled rice and PO_{it} which represents the population of the rice-producing region.

$$PR_{it} = \alpha + \beta_1 CL_{it} + \beta_2 CF_{it} + \beta_3 PE_{it} + \beta_4 IR_{it} + \varepsilon_{it} \tag{4}$$

The third model in this study is represented by Equation 4. In line with investigating the determinants of rice prices, PR_{it} represents the price of rice in region i at time t. The research employed independent variables including CL_{it} or cost of labor measured by the average agricultural wage rates of farm workers, CF_{it} or the cash cost of fertilizer, PE_{it} or the cost of pesticide, and CI_{it} or the cash cost of irrigation paid by rice farmers.

The researcher estimated Equations 2, 3, and 4 using panel data analysis to control for unobserved heterogeneity in the sample and alleviate multicollinearity issues among the independent variables (Porter & Gujarati, 2009). The researcher utilized unbalanced panel data from fifteen rice-producing regions in the Philippines from 2003 to 2020. To associate cross-sectional with time series data and formulate the characteristics of the market, pooling methods were used for the panel data. Panel data models enable the researcher to account for any influence of the cross-sectional data and, finally, estimate the suitable empirical model. Porter and Gujarati (2009) underlined that the overall model for the panel data allows the researcher to assess empirically the link between the dependent and independent variables with more flexibility.

As panel data considered observations on similar cross-sectional units over numerous periods, there might be cross-sectional effects on each rice-producing region. On this note, the fixed and random effects model were employed to control for such effects. The fixed effects model considers the independence of each rice-producing (i.e. cross-sectional units) in the sample by allowing the intercept to vary for each region yet keeps the assumption that the slope coefficients are constant within the region. Meanwhile, the random effects model estimates the coefficients assuming that individual or group effects do not correlate with other independent variables and can be formulated. Finally, the researcher utilized the Breusch-Pagan Lagrange Multiplier Test, Wald's Test, and the Hausman Specification Test to determine which pooled OLS, fixed, and random effects model would be used for the empirical analysis.

5.3.2 Time Series Estimation

5.3.2.1 The Vector Autoregressive (VAR) Model

The researcher employed the vector autoregressive (VAR) model to explore the dynamic relationship between rice self-sufficiency, consumption, production, and prices. The VAR model is commonly utilized for forecasting systems of interrelated time series and for examining the dynamic effect of random disturbances (i.e., shocks) on the system of variables (Sims, 1980). In comparison to other time series econometric models, the VAR approach considers each endogenous variable in the system as a function of the lagged values of all the endogenous variables in the system. Given the uncertainty of a variable's actual exogeneity, variables can be treated systematically (Sims, 1980). In understanding the relationships between production, consumption, prices, and rice self-sufficiency in the Philippines, the following system of equations displays the four-variable case order of the VAR model:

$$\begin{aligned}
SSR_t &= \beta_{10} - \beta_{12}RP_t - \beta_{13}RC_t - \beta_{14}PR_t + \gamma_{11}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{12}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{13}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{14}\sum_{m=1}^{m=j} PR_{t-m} \\
&\quad + \varepsilon_{SSRt} \\
PR_t &= \beta_{20} - \beta_{21}SSR_t - \beta_{23}RC_t - \beta_{24}RP_t + \gamma_{21}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{22}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{23}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{24}\sum_{m=1}^{m=j} PR_{t-m} \\
&\quad + \varepsilon_{PRt} \\
RC_t &= \beta_{30} - \beta_{31}SSR_t - \beta_{32}RP_t - \beta_{34}PR_t + \gamma_{31}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{32}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{33}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{34}\sum_{m=1}^{m=j} PR_{t-m} \\
&\quad + \varepsilon_{RCt} \\
PR_t &= \beta_{40} - \beta_{41}SSR_t - \beta_{42}RP - \beta_{43}RC_t + \gamma_{41}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{42}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{43}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{44}\sum_{m=1}^{m=j} PR_{t-m} \\
&\quad + \varepsilon_{PRt}
\end{aligned} \tag{5}$$

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In Equations 5, SSR_t represents rice self-sufficiency, RP_t represents rice production, RC_t represents rice consumption, and PR_t represents the price of rice at year t. The ε_{SSRt}, ε_{PRt}, ε_{RCt}, ε_{PRt} are white noise disturbance terms with standard deviation σ_{SSR}, σ_{RP}, σ_{RC}, and σ_{PR} respectively and zero means. The contemporaneous effects are measured by the β parameters while the lag m effects are measured by the γ's. Moreover, note that the equations were not in reduced form because, for instance, SSR_t exhibit a contemporaneous effect on RP_t, RC_t, and PR_t. Henceforth, isolating time t variables in the left-hand side, Equations 5 would be:

$$\begin{aligned}
&SSR_t + \beta_{12}RP_t + \beta_{13}RC_t + \beta_{14}PR_t \\
&\qquad = \beta_{10} + \gamma_{11}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{12}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{13}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{14}\sum_{m=1}^{m=j} PR_{t-m} + \varepsilon_{SSRt} \\
&\beta_{21}SSR_t + PR_t + \beta_{23}RC_t + \beta_{24}RP_t \\
&\qquad = \beta_{20} + \gamma_{21}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{22}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{23}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{24}\sum_{m=1}^{m=j} RP_{t-m} + \varepsilon_{PRt} \\
&\beta_{31}SSR_t + \beta_{32}RP_t + RC_t + \beta_{34}PR_t \\
&\qquad = \beta_{30} + \gamma_{31}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{32}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{33}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{34}\sum_{m=1}^{m=j} PR_{t-m} + \varepsilon_{RCt} \\
&\beta_{41}SSR_t + \beta_{42}RP + \beta_{43}RC_t + PR_t \\
&\qquad = \beta_{40} + \gamma_{41}\sum_{m=1}^{m=j} SSR_{t-m} + \gamma_{42}\sum_{m=1}^{m=j} RP_{t-m} + \gamma_{43}\sum_{m=1}^{m=j} RC_{t-m} + \gamma_{44}\sum_{m=1}^{m=j} PR_{t-m} + \varepsilon_{PRt}
\end{aligned} \tag{6}$$

Transforming Equations 6 in matrix form,

$$\begin{bmatrix} 1 & \beta_{12} & \beta_{13} & \beta_{14} \\ \beta_{21} & 1 & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & 1 \end{bmatrix} \begin{bmatrix} SSR_t \\ RP_t \\ RC_t \\ PR_t \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \\ \beta_{30} \\ \beta_{40} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} \end{bmatrix} \begin{bmatrix} SSR_{t-m} \\ RP_{t-m} \\ RC_{t-m} \\ PR_{t-m} \end{bmatrix} + \begin{bmatrix} \varepsilon_{SSRt} \\ \varepsilon_{PRt} \\ \varepsilon_{RCt} \\ \varepsilon_{PRt} \end{bmatrix}$$

The matrix can then be simplified as:

$$\begin{gathered} BX_t = \Gamma_0 + \Gamma_1 X_{t-m} + \varepsilon_t \\ X_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-m} + B^{-1}\varepsilon_t \\ X_t = A_0 + A_m X_{t-m} + e_t \end{gathered} \tag{7}$$

where $X_t = \begin{bmatrix} SSR_t \\ RP_t \\ RC_t \\ PR_t \end{bmatrix}$, $B = \begin{bmatrix} 1 & \beta_{12} & \beta_{13} & \beta_{14} \\ \beta_{21} & 1 & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & 1 \end{bmatrix}$, $\Gamma_0 = \begin{bmatrix} \beta_{10} \\ \beta_{20} \\ \beta_{30} \\ \beta_{40} \end{bmatrix}$, $\Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} \end{bmatrix}$,$\varepsilon = \begin{bmatrix} \varepsilon_{SSRt} \\ \varepsilon_{PRt} \\ \varepsilon_{RCt} \\ \varepsilon_{PRt} \end{bmatrix}$

Equation 7 is the reduced-form representation of the four-case variables VAR model. X_t is a $(k\ x\ 1)$ vector of endogenous variables, A_m are matrices of coefficients to be estimated, and e_t is a $(k\ x\ 1)$ vector of serially uncorrelated white noise residuals.

5.4 Empirical Results

5.4.1 Descriptive Statistics and Correlation

Table 1 presents the descriptive statistics for all variables, such as response and explanatory variables. The descriptive statistics are based on fifteen rice-producing regions in the Philippines from 2003 to 2020 which summed up to 3,077 observations.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max

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PR	288	106.727	80.314	19.329	376.515
AR	288	280.868	184.055	79.898	730.784
IR	288	358.684	263.165	0	1124
FE	283	4.542	1.225	1.68	7.84
PE	288	1245.972	559.415	0	2874
RC	224	59.858	32.685	13.533	161.684
PCI	288	95609.111	34111.005	34848	180396
PO	288	51.828	30.013	14.516	160.573
PR	288	30.9	7.461	16.85	43.39
CL	272	174.173	60.555	87.71	356.95
CF	282	4186.039	1576.847	824	8738

Based on the descriptive statistics, the fifteen rice-producing regions in the Philippines had an average yield of 106,727 metric tons of ordinary rice from 2003 to 2020. Figure 3 illustrates that rice production in the fifteen regions exhibited a moderate upward trend. The production volume of the fifteen regions experienced notable fluctuations from 2008 to 2010 and 2013 to 2015. The drastic drop in rice supply in 2008 reflected the tightening of the global rice markets which resulted in a food crisis (Dawe, 2012). Similarly, the rice crisis was also captured in the decline in rice consumption from 2008 to 2010 as shown in Figure 4. During the 2008 food crisis, Regalado (2010) noted that people lined up early in the morning to buy a cheaper and limited amount of rice (i.e., two kilograms per individual) from government-allocated rice stores. Meanwhile, the decline from 2013 to 2015 mirrored the impact of super typhoon Haiyan in the Central Luzon region. Observably, the maximum area of rice production in the sample reached 730,784 hectares, which is located in the Central Luzon region – the rice granary of the Philippines (Palis, Morin, & Hossain, 2002). The United States Department of Agriculture (2013) performed a damage assessment in the central Philippines and reduced the production estimate in years 2013 and 2014 rice production by 60,000 tons or 0.5 percent.

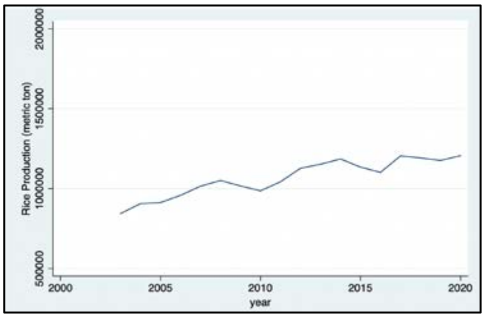

Figure 3. Volume of Rice Production in the Philippines, 2003 to 2020

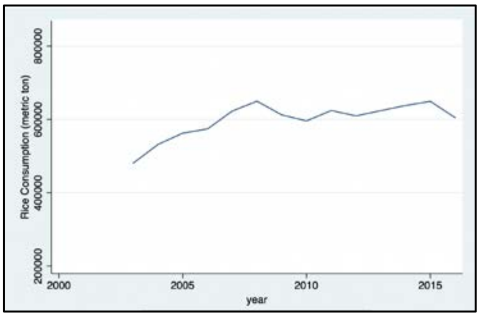

Figure 4. Volume of Rice Consumption in the Philippines, 2003 to 2016

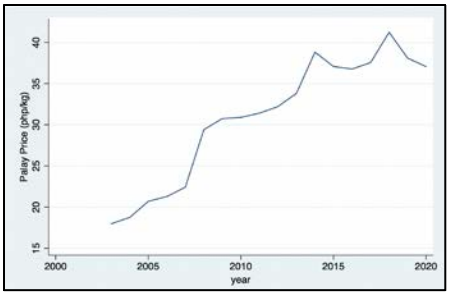

Figure 5. Per-kilogram Price of Rice, 2003 to 2020

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The average price per kilogram of rice in the sample was around PHP 30.9. However, the per-kilo price of ordinary rice had gotten as high as PHP 43.39. Figure 5 displays a rising trend in the per-kilo price of rice. The steepest price spike observably happened during the 2008 food crisis, followed by the impact of declining rice supply due to production losses brought about by super typhoon Haiyan, and the price increase in 2018. Such an increasing trend in prices could be especially damaging to low-income households. While the average income per capita in the sample was around PHP 95,609 annually in the sample, the descriptive statistics reveal that the lowest average income per capita was PHP 34,848 annually, which roughly averaged PHP 2,904 per month. Consequently, a rise in the per-kilo price of rice is tantamount to a drop in real income for net consumers of rice. This decrease in disposable income not only raises the number of poor people but also pushed them deeper into poverty and hunger. Given less money available, low-income households are forced to allocate less spending on essential needs such as health care and nutritious food (Dawe, 2012; Djulius, Lixian, Lestari, & Eryanto, 2022).

Examining the descriptive statistics of production input variables, farm workers were paid an average of PHP 174 daily. This level of agricultural wage rate was relatively lower compared to other costs of rice production. It can be observed that the average cost for irrigation was found to be PHP 358 per hectare, reaching as high as PHP 1,124 per hectare. The average expenditure on pesticides was PHP 1,245 and could get up to PHP 2,874. Moreover, fertilizer recorded the highest average cost in the sample, which was PHP 4,186 per hectare, and even hit PHP 8,738 per hectare.

5.4.2 Panel Estimation Analysis

5.4.2.1 Model Selection

Table 3 presents the results of the Hausman Specification test, Wald's test, and the Breusch Pagan Lagrange Multiplier (LM) test for the best model selection in the panel data analysis. The researcher employed Wald's test to determine which between the specification of the fixed effect model (i.e., least square dummy variable 1, 2, 3) and pooled OLS is better. Upon performing Wald's test, the LSDV3 specification of the fixed effect model emerged to be the better model than the pooled OLS and the other two specifications of the fixed effect model.

Table 3. Results of the Hausman Specification Test, Wald's Test, and the Breusch Pagan Lagrange Multiplier Test for Model Selection for the Pooled OLS, Fixed, and Random Effects

Model Number	Model Comparison	p −value	Remarks
Model 1A and 1B	Pooled OLS - Fixed	0.0016	Fixed effects model was selected.
Model 1A and 1C	Pooled OLS – Random	0.0000	Random effects model was selected.
Model 1B and 1C	Fixed – Random	0.0000	Fixed effects model was selected.
Model 2A and 2B	Pooled OLS – Fixed	0.0000	Fixed effect model was selected.
Model 2A and 2C	Pooled OLS – Random	0.0000	Random effects model was selected.
Model 2B and 2C	Fixed – Random	0.0039	Fixed effects model was selected.
Model 3A and 3B	Pooled OLS – Fixed	0.0000	Fixed effects model was selected.
Model 3A and 3C	Pooled OLS – Random	0.0000	Random effects model was selected.
Model 3B and 3C	Fixed – Random	0.0014	Fixed effects model was selected.

Notes. 1 = rice production, 2 = rice consumption, 3 = price of rice; A = Pooled OLS, B = Fixed effects, C = Random effects

Further, the Breusch-Pagan LM test for random effects indicates that zero variance across entities, meaning there is no significant difference across units (i.e. no panel effect). The LM test in the first, second, and third models was less than 0.05, indicating the presence of panel effects. This entailed that the random effect model was better than the pooled OLS in the rice production, consumption, and price model.

From Wald's test and the Breusch-Pagan LM test, both random effects and fixed effects are the preferred models compared to the pooled OLS. That said, the Hausman test was utilized to examine if the fixed effects model is more appropriate than the random effects. The Hausman test assesses the uniqueness of the error term and whether they are correlated with the response variable; and the null hypothesis is that they are not correlated (i.e., random effect exists) (Baltagi, 2008). In the three models, the researcher rejected the null hypothesis, meaning that the fixed effect model is more appropriate than the random effects model. On this note, the researcher employed the fixed effects model in analyzing the results of the panel estimation.

5.4.2.2 Results of Panel Model Estimation

Table 4 presents the estimates of the regression model on production, consumption, and rice price utilizing the pooled OLS, fixed effect, and random effects panel data estimation. The adjusted R-squared implied that the independent variables, namely area of production, irrigation, fertilizer, and pesticides, are significant in explaining 95.83% of the variability in rice production in the Philippines. Out of the four independent variables in the rice production model, the area of production and irrigation cost were significant at the 1% level in predicting production. The results suggest that an additional 1000 hectares allocated to rice plantations increase production volume by 5,963 metric tons. This makes economic sense as more land area used in growing rice contributes to increasing production volume. Interestingly, an increase in irrigation costs (measured in pesos per hectare) leads to a rise in production volume. Nonvide (2017) stated the participation of farmers in an irrigation system implies an additional cost which, in the context of this study, is the fee paid for the irrigation services. Numerous research also pointed out that the farmer's adoption of irrigation systems led to a rise in yield. Note that the irrigation fee is measured in pesos per hectare. Consequently, this means that as rice producers experience a rising share of irrigation fees in their production costs, more production areas would be included in the irrigation system. Given the positive association between land area and the volume of production, a larger area covered by irrigation thus implies higher yield levels.

Table 4. Regression Results of Pooled OLS, Fixed Effects, Random Effects Estimates

Variables	Pooled OLS	Fixed Effects	Random Effects
Model 1: Production (RP)			
AR	**0.4048*****	**0.5963*****	**0.5011*****
	(0.0051)	(0.0199)	(0.0141)
IR	**0.0357*****	**0.0127*****	**0.0158*****
	(0.0043)	(0.0035)	(0.0029)
FE	**5.4813*****	**0.9284**	**2.7313*****
	(0.9203)	(0.8353)	(0.7072)
PE	**-0.0048*****	**-0.0002**	**-0.0013**
	(0.0017)	(0.0018)	(0.0018)
Constant	**-38.483*****	**-70.8986*****	**-50.3525*****
	(3.8926)	(6.6333)	(6.1743)
Adjusted R^2 (overall)	0.9681	0.9527	0.9588
F-test	$p < 0.0001$	$p < 0.0001$	$-$

Wald's test	–	–	$p < 0.0001$
Model 2: Consumption (RC)			
PCI	**-10.2406*****	**2.9482**	**-9.7506****
	(2.2481)	(4.749)	(3.8795)
PO	**1.141*****	**0.893*****	**1.0013*****
	(0.0245)	(0.0716)	(0.0615)
PR	**0.0966**	**-0.2013**	**0.2063*****
	(0.1022)	(0.3048)	(0.0898)
Constant	**115.9688*****	**-20.4832**	**114.2555*****
	(23.8623)	(53.6291)	(41.2992)
Adjusted R^2 (overall)	0.9142	0.9104	0.9146
F-test	$p < 0.0001$	$p < 0.0001$	–
Wald's test	–	–	$p < 0.0001$
Model 3: Price of rice (PR)			
CL	**0.0715*****	**-0.0006**	**0.075*****
	(0.0063)	(0.0046)	(0.0061)
CF	**0**	**0**	**0.0003**
	(0.0003)	(0.0001)	(0.0003)
PE	**-0.0011**	**-0.0006****	**-0.0009**
	(0.0007)	(0.0003)	(0.0008)
IR	**0.0061*****	**0.0004**	**0.0072*****
	(0.0018)	(0.0005)	(0.0019)
Constant	**17.7038*****	**18.6597*****	**14.8308*****
	(1.5361)	(0.7301)	(1.6022)
Adjusted R^2 (overall)	0.4681	0.9719	0.4692
F-test	$p < 0.0001$	$p < 0.0001$	–
Wald's test	–	–	$p < 0.0001$

Note. Coefficients are in bold; standard errors are in parentheses; *, **, and *** denote significance at the 10, 5, and 1% levels (two-tailed), respectively.

The fixed effects model revealed that population size exhibited a statistically significant impact on rice consumption at the 1% significance level. The price of rice and income levels were found to be statistically insignificant determinants of rice consumption. Nevertheless, interpreting the population coefficient, rice consumption increases by 8,930 metric tons when the population marginally increases by 1,000 people. The results are consistent with the research of Hsiaoping (2005) and Bashir and Yuliana (2019) regarding rice consumption intake in China and Indonesia, respectively. Given that rice is a staple commodity in Filipino households, it is economically intuitive that the rising population exhibits a positive impact on consumption levels.

In the price of rice model, the fertilizer cost exhibited a significant inverse relationship with the price of ordinary or regularly milled rice. However, the researcher observed that a peso increase in fertilizer cost per hectare has virtually no impact on the per-kilo price of rice. Amidst being weakly significant, the inverse relationship between the cost of labor, fertilizer, and pesticide proved to be an interesting research finding. This may indicate that farmers in Philippine regions opt to find other low-cost or no-cost alternatives when faced with rising input costs. For instance, rice farmers may source labor from family members, wherein these individuals work for free to help or contribute to the household, thus leading to zero labor costs. Nevertheless, the model R-squared showed that the regressors explained 98.22% of the variability in the rice prices per region.

5.4.3 Time Series Estimation Analysis

5.4.3.1 Unit Root Test

The VAR system requires that all of the variables are stationary for it to be transformed into its infinite moving average representation. Such a representation is utilized to derive both the forecast error variance decomposition and the impulse response functions (Sims, 1980). Hence, prior to building the VAR model, the researcher tested for the stationarity of the yearly time series data on rice self-sufficiency, price, consumption, and production by using the Augmented Dickey-Fuller test (Dickey & Fuller, 1979) and the Phillips-Peron test (Phillips-Peron, 1988). In both tests, the null hypothesis posed that the series has a unit root. The rejection of the null hypothesis entailed that the series is stationary. The results ADF and PP test show that rice self-sufficiency and production were of I(0), which means that these data series are stationary in their level form. Meanwhile, rice consumption and price were found to be non-stationary. In order to get the stationarity series, the researcher took the first difference between consumption and price and found that such variables became stationary only after taking their first differences. In the succeeding analysis, the first-difference form of the variables except for rice self-sufficiency and production. As to these two variables, the researcher employed the level form given that it was stationary and easier to be explained.

Table 5. Results of the Augmented Dickey-Fuller and Phillip Peron Tests for the Presence of Unit Root

Variables	ADF test statistic	*p*-value	PP test statistic	*p*-value	Order of Integration
Rice self-sufficiency	-4.399	0.0003	-4.324	0.0004	I(0)
Rice production[1]	-4.698	0.0001	-4.515	0.0002	I(0)
Rice consumption[1]	-2.251	0.1884	-2.266	0.1831	I(1)
Price of rice[1]	-0.918	0.7821	-0.916	0.7826	I(1)

Note. [1]in natural logarithm for easier interpretation

5.4.3.2 Granger Causality Test

Table 6 displays the chi-squared test statistics and the p-values of the Granger causality test. The researcher found that consumption Granger-cause the price of rice. Intuitively, the positive direction of Granger causality makes economic sense based on the tenet of the price-demand relationship. That said, an increase in consumption would dwindle the rice supply, which could pose an upward effect on prices.

Interestingly, rice self-sufficiency, consumption, and prices Granger cause the volume of rice production at the 1% level of significance. If a country is self-sufficient in rice, the positive Granger causality of self-sufficiency to production might indicate the ability of local rice production to be the only one responsible for the availability of national rice without sourcing from external providers. However, such findings need to be interpreted cautiously given that self-sufficiency in rice can be driven by both net imports and production. Consumption, on other hand, Granger-cause production volume. An increase in consumption signals farmers and rice industry stakeholders to prop up production, thus exhibiting positive Granger-causality. The same signals could be observed in how prices Granger-cause rice production as rising prices may provide greater incentives for rice farmers and even non-rice farmers to bolster production as a means to increase their income. Nevertheless, the findings of Conteh, Yan, and Sankoh (2012) emphasized that rising prices of rice, amidst being an incentive for producers, might undermine production and result in importation efforts.

Table 6. Granger Causality Test Results

Granger Causality Tests	χ^2	df	p-value
RP does not granger cause SSR	1.1255	2	0.5700
RC does not granger cause SSR	7.9048	2	0.0190**
PR does not granger cause SSR	4.1068	2	0.1280
SSR does not granger cause RP	48.1510	2	0.0000***
RC does not granger cause RP	11.6530	2	0.0030***
PR does not granger cause RP	75.4360	2	0.0000***
SSR does not granger cause RC	1.9804	2	0.3720
RP does not granger cause RC	0.1985	2	0.9060
PR does not granger cause RC	17.7710	2	0.0000***
RSS does not granger cause PR	2.3022	2	0.3160
RP does not granger cause PR	1.7693	2	0.4130
RC does not granger cause RC	0.0576	2	0.9720

5.4.3.43 Impulse Response Function Test

The Granger causality test only displays the direction of the Granger causality. To examine the impact or magnitude of the statistically significant Granger-causality results in Table 6, the researcher performed variance decomposition, otherwise known as the Cholesky factorization. This was done to ascertain to observe how the anticipated changes in production, consumption, and prices are explained by each type of different shock.

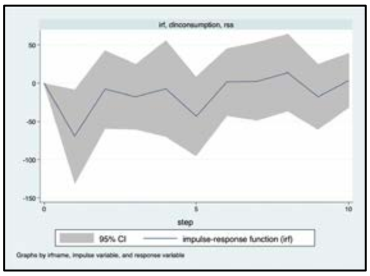

Figure 7. Response of rice self-sufficiency to consumption

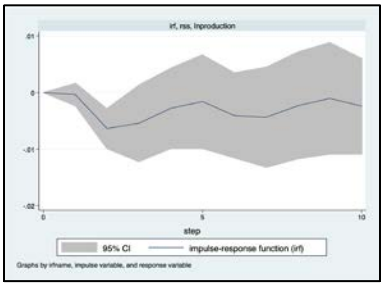

Figure 8. Response of production to rice self-sufficiency

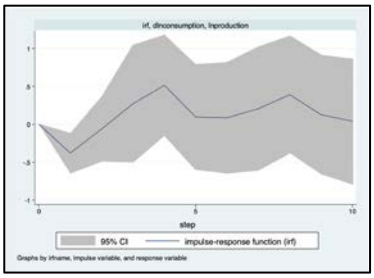

Figure 9. Response of rice production to rice consumption

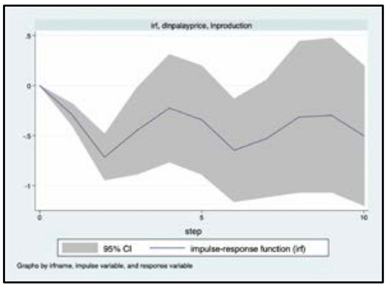

Figure 10. Response of rice production to rice prices

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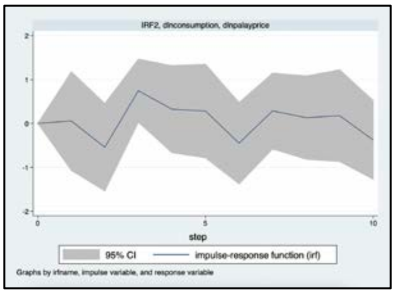

Figure 11. Response of rice prices to consumption

Recall in the Granger causality test, consumption of rice Granger-cause self-sufficiency positively, which is not aligned with economic intuition as increasing consumption negatively impacts the availability of rice supply (Cardona & Garcia, 2016; Hsiaoping, 2005; Bashir and Yuliana, 2019). Yet in Figure 7, it can be observed a one-time shock in consumption would decrease rice self-sufficiency. This illustration is pivotal for policymakers given that increasing consumption levels could cast negative effects in the short run. Consequently, the government may need to respond to consumption shocks through importation efforts to support the local rice supply.

Rice production exhibited virtually no response in rice self-sufficiency shocks in the first period as observed in Figure 8. However, production started to dwindle in the second and third periods. Amidst a rise in self-sufficiency, policymakers might need to bolster their initiatives and avoid complacency in production efforts to keep up with the country's rice supply. Additionally, Figure 9 shows that a shock in consumption would at first negatively impact production. It can be observed, nevertheless, that production moderately adjusts to the sudden increase in consumption levels over time, thus meeting consumption demand.

Figure 10 shows that a shock in rice prices would decrease rice production. As consumers experience declining buying power, greater preference for relatively cheaper imports might dampen incentives for local production of rice. Policy-wise, it would be prudent for the government to maintain an open trade stance with regard to rice importation. Moreover, Figure 11 presents that a drastic increase in Filipino consumption of rice would have minimal impact on the price at first, yet the price started to observably increase as a consequence of the rice consumption in the third period. As such, there might be a lagged response in prices given consumption shocks. On this note, policymakers should be wary of increasing consumption levels as this could result in upward pressure on rice prices.

6. CONCLUSION AND POLICY IMPLICATIONS

Given that rice is a key component in the Filipino consumption basket, rice self-sufficiency surfaces as an integral dimension of food security in the country (Siwar et al., 2014). To achieve rice self-sufficiency, PRRI (2011) underlined that the country's rice supply should meet the national rice production requirement whilst having a reserve in times of shock. This study analyzed factors affecting the production, consumption, and prices in fifteen rice-producing regions in the Philippines from 2003 to 2020 using fixed effects panel estimation. Withal, this study employed a vector autoregressive approach in exploring possible dynamic relationships between self-sufficiency, production, consumption, and price of rice using time series data from 1998 to 2020.

In the production model, the area of production and cost of irrigation were significant at the 1% level in predicting the volume of rice production. In terms of production area, production volume marginally increases by 5,963 metric tons per additional area of 1000 hectares of land. Thus, to bolster production efforts, the Philippine government, specifically the Department of Agriculture (DA), can explore the expansion of areas dedicated to rice farming. The researcher found a significant positive relationship between the cost of irrigation and production levels at the 5% level. This is an interesting finding as rising input costs generally dampen farm output (Barrett & Mutambatsere, 2008). But the rising cost of irrigation may entail refined irrigation system or technology which improves rice yields. That said, future research could explore the moderating effect of the quality and/or technology of the irrigation system on the relationship between production volumes and irrigation cost. Further, the fixed effects estimation of the price of rice model showed that fertilizer cost has a negative relationship with the price of rice. The parameter coefficient, nonetheless, indicated virtually zero impact on the price of rice for every additional fifty bags of fertilizer.

Through VAR estimation of time series data of rice production, consumption, prices, and self-sufficiency ratio, the researcher found that rice consumption Granger-cause the self-sufficiency ratio positively. Contrastingly, Cardona and Garcia (2016), through logistic regression, found a negative relationship between rice consumption and self-sufficiency. This is because increase in consumption could led a declining rice supply in the country, then threatening self-sufficiency levels. However, the IRF test revealed that a shock or sudden increase in the volume of rice consumption among Filipinos resulted in downward movements in the rice self-sufficiency indicator. Having said that, it is imperative for the government to craft a policy response when faced with consumption spikes. Cuevas (2019) have found that a declining trend in the rice buffer stocks of the National Food Authority (NFA) from 2011 to 2018. Given this, policymakers and government offices from the DA and NFA must heighten their scrutiny to rice self-sufficiency measures and improve monitoring efforts in the NFA’s buffer rice supply.

Moreover, the VAR model findings revealed that the rice self-sufficiency level, prices, and consumption Granger-cause the volume of rice production positively. Examining the magnitude of their relationship, the results of the IRF test revealed intriguing findings about the impact of exogenous shocks of the said variables on rice production. A sudden increase in rice self-sufficiency, which may be driven by large inflows of net imports of rice (see Equation 1), caused a decline in rice production. Amidst achieving rice self-sufficiency, this may indicate the local rice production might not be able to compete with imports. The Department of Agriculture must bolster its policy efforts in improving the competitiveness of the national rice industry. For example, ADB (2020) crafted a program proposal to strengthen the competitiveness of the country’s agriculture sector through policy-based loans. The DA could then formulate policies to improve farmer’s access to credit, education, and the value chain as means to keep the rice industry competitively afloat. Furthermore, the IRF test demonstrated that sudden upward movements in rice prices could hamper production. From the producer’s end, the rise in price generate incentives for further production. However, as the purchasing power of consumers weaken due to local price increase in rice, the clamor for lower rice prices may lead to further importation efforts. This could breed the expectation of a declining market share of local producers in the Philippine market and hence, negate further incentives for production. Dawe and Timmer (2012) emphasized that stable prices in staple foods (e.g., rice) help mitigate farmers and consumers from falling into deep poverty levels, lessen the “noise” in prices, and encourage farm investments as a result of lower volatility levels. Therefore, domestic stability in rice prices must be a policy agenda among rice industry authorities.

The Philippine government, through the Department of Agriculture and the National Food Authority, holds a pivotal role in the development of the agricultural sector. With rice being a staple commodity in the Filipino diet, the government should pay close attention to the issues of the rice industry. Furthermore, future studies could delve deeper into other factors that can cause rice self-sufficiency (i.e., production and consumption of other rice substitutes) to have a comprehensive gap of key aspects impacting the dynamics of rice self-sufficiency in the country.

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