SELF-SUFFICIENCY IN RICE: ANALYSIS OF PRODUCTION, CONSUMPTION, AND IMPORTATION OF THE RICE-PRODUCING REGIONS IN THE PHILIPPINES

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Abstract

Self-sufficiency is the objective of every agricultural country. This study determined the self-sufficiency in rice status of the Philippines by analyzing the fourteen rice-producing regions in the Philippines from 1992 to 2012. The researcher raised three hypotheses. Results of the analysis showed rejection of these three hypotheses implying that (1) Input factors affect production, consumption, and importation; (2) CAR and Central Visayas are the two most productive and efficient regions; and (3) Rice production and rice importation affect rice self-sufficiency positively, while rice consumption affects rice self-sufficiency negatively. Overall, the Philippines is not rice self-sufficient due to increasing gap between production and consumption.

Keywords: consumption; Data Envelopment Analysis; importation; production; rice self-sufficiency; Stochastic Frontier Analysis

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Introduction

The Philippines is the world's eighth largest rice producer. According to statistics, its arable land totals 5.4 million ha (Global Rice Science Partnership (GRISP), 2013). The country's production increased from 9.129 million mt in 1992 to 18.439 million mt in 2013 (Bureau of Agricultural Statistics, 2014). According to London-based International Grains Council (IGC), global consumption of rice is expected to exceed the production of rice as it forecast that rice consumption will increase from 458 million tons in 2011 – 2012 to 482 million tons in 2014 – 2015 (International Grains Council, 2015). With the wake of some reports of growing rice consumption and population growth in the Philippines, rice production efficiency is certainly a cause of substantial concern of the government.

Self-sufficiency is the goal of every agricultural country. A country is rice self-sufficient if it relies on its own production to meet the domestic requirements of the populace (Bureau of Agricultural Statistics, 2014). The Department of Agriculture has targeted rice self-sufficiency in 2013, yet this time frame was not met and the country is likely to import rice from neighboring countries beyond 2016 (Reuters, 2014).

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The present administration has not achieved its rice self sufficiency target in 2013. However, according to the Bureau of Agricultural Statistics (BAS), palay production has increased from 15.7 MT in 2010 to 18.0 MT in 2013. Given these figures, however, critics have been thinking on the possible reason why the Philippines has been importing massive metric tons of rice and is still considered as the top rice importer of the world. A great concern for rice production efficiency presents a clear and substantial interest. This study aims to determine the self-sufficiency status of rice production in the Philippines by analyzing the fifteen rice-producing regions and concentrating on the following principal issues: (a) increasing demand for rice; (b) challenges in rice production; and (c) escalating amount of rice imported.

Given the principal issues pertaining to rice self-sufficiency, the researcher conducts this study to analyze the production, consumption, and importation of rice to determine the rice self sufficiency status of the country. There have been studies conducted pertaining to rice. As a step forward, this study incorporates determinants of production, consumption, and importation and their relationship to rice self sufficiency.

The researcher used cross-sectional time series data gathered from the 14 rice-producing regions in the Philippines. Data analysis includes Data Envelopment Analysis – Malmquist Productivity Index, Data Envelopment Analysis – Slack Based Measure of Efficiency (SBM), Stochastic Frontier Analysis, and Logistic Regression.

The objective of this study is to (1) determine the self-sufficiency in rice status of the Philippines, (2) determine the effect of input factors of production, consumption, and importation against rice self-sufficiency, (3) determine the most productive and efficient rice producing regions in the Philippines, and (4) recommend actions that will help the country attain its rice self-sufficiency. The next sections of this paper will discuss the methodology, results and discussions, and the recommendations of the researcher.

Methodology

This study gathered data concerning the 14 rice-producing regions. Aggregate data for these regions were obtained from different government agencies namely Bureau of Agricultural Statistics (BAS), Department of Agriculture (DA), Food and Nutrition Research Institute (FNRI), National Food Authority (NFA), National Statistical Coordinating Body (NSCB), Philippine Center for Postharvest Development and Mechanization (PhilMech), and Philippine Statistics Authority (PSA). There are three major data taken into account in this study in order to achieve rice self-sufficiency namely: production, consumption, and importation. The output is (1) rice self-sufficiency while the inputs are (1) rice production, (2) land area harvested, (3) human labor, (4) irrigation, (5) thresher, (6) tractor, (7) seed, (8) fertilizer, (9) pesticide, (10) flooding, (11) drought, (12) infestation, (13) rice consumption, (14) buyer's preferences, (15) price of rice, (16) rice importation, (17) price of imported rice, (18) per capita income, and (19) exchange rate. These variables are divided into three (3) groups, specifically, production, consumption, and importation. First group includes the variables for production namely: rice production, land area harvested, human labor, irrigation, thresher, tractor, seed, fertilizer, pesticide, flooding, drought, and infestation. Second group includes variables for consumption such as; rice consumption, buyer's preferences, and price of rice. And lastly, variables rice importation, price of imported rice, per capita income, and exchange rate falls under importation.

These data were then processed using four statistical tools namely Data Envelopment Analysis (DEA) – Malmquist Productivity Index, Slacked Based Measure of Efficiency, Stochastic Frontier Analysis, and Logistic Regression.

Data Envelopement Analysis – Malmquist Productivity Index

Cooper et al. (2004) defined Malmquist Productivity Index as an index representing the Total Factor Productivity (TFP) growth of the set of producers or firms or also known as Decision Making Unit (DMU). This reflects the mixture of efficiency and technology over time under the structure of multiple inputs and multiple outputs. The index is created by determining the distance of an input and output vectors from a specified period to reference technology (Coelli et al., 2005).

The study opts for output-oriented productivity measures because the regions focus on achieving maximum level of outputs using a given input vector and a given production technology relative to the observed level of outputs (Coelli et al., 2005).

Equation 3.1 shows the output-oriented Malmquist Productivity Index (Coelli et al., 2005).

$$Mo(q_s, q_t, x_s, x_t) = \frac{d_o^t(x_t, q_t)}{d_o^s(x_s, q_s)} \left[\frac{d_o^s(x_t}{d_o^t(x_t} \right. \qquad (1)$$

Where:
i= represents regions 1,2, ………, 14

t = represents years 1, 2, ………, 21

$x1,2,\dots,9$ = Land Area Harvested, Human Labor, Seed, Fertilizer, Pesticide,

Irrigation, Threshers, Calamities, Tractor
q = Volume of rice production

Mo = Malmquist Productivity Index

$d_o^t(x_{it}, q_t)$ = Distance function measuring the efficiency of conversion of input

x_{it} to output q_t during period t.

$d_o^s(x_{is}, q_s)$ = Distance function measuring the efficiency of conversion of input

x_{is} to output q_s during period s.

$d_o^s(x_{it}, q_t)$= Distance function measuring the efficiency of conversion of input

x_{it} to output q_t during period s.

$d_o^t(x_{is}, q_s)$= Distance function measuring the efficiency of conversion of input

x_{is} to output q_s during period t.

Equation 1 presents factors of Malmquist Productivity Index. The ratio outside of the square brackets measures the change in the output-oriented measure of technical efficiency between given periods, s and t, and the geometric mean of the ratios inside the square brackets captures the shift in technology between two periods, evaluated at x_s and x_t (Coelli et al., 2005). The remaining part of the index in equation 3.1 is a measure of technical change. It is the geometric mean of the shift in technology between two periods, evaluated at x_t and also at x_s (Coelli et al., 2005). Geometric means are used because DEA does not account for measurement noise.

Since Malmquist productivity index captures the performance relative to best practices in the regions, results can be interpreted as a value greater than one (> 1). This indicates a positive performance while a value lesser than one (< 1) indicates negative performance over the period. If value will be equal to one, it means no improvement in the performance of the regions.

DEA – Slack Based Measure of Efficiency (SBM)

Subsequent to the conduct of DEA – Malmquist Productivity Index, each input variables will be tested and analyzed using Slack Based Measure of Efficiency (SBM) so as to determine if each of the input variables has zero slacks or wastes. SBM can be defined as the ratio of mean input and output mix inefficiencies (Cooper et al., 2000). This study is an output oriented DEA under VRS scale assumption. VRS scale assumption will be used thinking that the regions operate at different sizes of operation (variable returns to scale).

The formula for SBM is (Cooper et al., 2000):

$$\rho = \left(\frac{1}{m}\sum_{i=1}^{m}\frac{x_{io}-s_i^-}{x_{io}}\right)\left(\frac{1}{s}\sum_{i=1}^{s}\frac{Y_{ro}-s_r^+}{Y_{ro}}\right)^{-1} \qquad (2)$$

The first part of equation 2 corresponds to the mean proportional reduction rate of inputs or input mix inefficiencies. While the second part of the equation evaluates the relative proportional expansion rate of output, thus measuring the output mix inefficiencies (Cooper et al., 2000). The results of this method can either be: $0 \leq \ \rho \leq$; if ρ is equal to zero (0), then we can conclude that X input has zero slacks, which means that the usage of an input is efficient. Alternatively, if ρ is greater than zero (0), it can be concluded that a slacks exist in X input and that the usage of an input is inefficient.

Stochastic Frontier Analysis

In the second stage of statistical analysis, the researcher will use the stochastic frontier analysis. The econometrics of Stochastic Frontier Analysis (SFA) provides techniques for modeling the frontier concept within a regression framework so that inefficiency can be measured (Cornwell & Schmidt, 2008). Stochastic frontier analysis uses econometric estimation of the production function to allow the frontier to vary with random disturbances (Mariano et al., 2011). The great virtue of stochastic production frontier models is that the impact on output of shocks due to variation in labor and machinery performance, vagaries of the weather, and just a plain luck can at least in principle be separated from the contribution of variation in technical efficiency (Kumbhakar & Lovell, 2000).

According to Kumbhakar and Lovell (2000), stochastic production frontier model, takes the log-linear Cobb-Douglas form, written as:

$$\ln y_i = \beta_o + \sum_n \beta_n \, ln x_{ni} + v_i - u_i \qquad (3)$$

Where:

y_{i1} = Production of the ith region in natural logarithm

y_{i2} = Consumption of the ith region in natural logarithm

y_{i3} = Importation of the ith region in natural logarithm

y_{i4} = Self-sufficiency of the ith region in natural logarithm

x = vector of n input variables in natural logarithm

$x1_{1,2,\ldots,9}$ = Land Area Harvested, Human Labor, Seed, Fertilizer, Pesticide,

Irrigation, Threshers, Calamities, Tractor

$x2_{1,2,3}$= Price of domestic rice, amount of corn consumption, incidence of

calamities

$x3_{1,2,\ldots,6}$ = Domestic output of rice, Consumers demand for rice, Price of imported

rice, Price of domestic rice, Per capita income, Exchange rate

$x4_{1,2,3}$ = Volume of rice production, Amount of rice consumption, Amount of rice

importation

i= Regions 1,2, ………, 14

v_i = two-sided "noise" component

u_i = nonnegative technical inefficiency component

β_o and β_n = unknown parameters to be estimated

Given that the present study will use 21-year panel data type particularly both cross sectional and serial, the model with time-variant technical efficiency is more suitable. Equation will now be:

$$\ln y_{it} = \beta_{it} + \sum_n \beta_n \, ln x_{nit} + v_i \qquad (4)$$

Where: $\beta_{it} = \beta_{ot} - u_i$

In this equation (4), β_{it} is the intercept for producer i in period t, and all other variables that are previously defined. The only difference of equation 4 to equation 3 is the addition of time subscripts to the output, to the inputs, and to the statistical noise (Kumbhakar

& Lovell, 2000). In this case, t corresponds to 21 years of analysis from 1992 – 2012.Time

variant measure is relevant for this study in order to determine the technology change over time.

Logistic Regression

Logistic regression is statistical tool that measures the relationship between dependent and one or more independent variables by evaluating probabilistic values of independent variables against dependent variable. It measures the odds ratio of an event occurring versus an event not occurring. In the case of rice self-sufficiency, this predicts the odds ratio of rice self-sufficient and not rice self-sufficient.

Results and Discussions

This section serves to accomplish the objectives and hypotheses of the study. Data pertaining to production, consumption and importation of the 14 rice-producing regions were gathered and analyzed in order to satisfy the objectives and hypotheses of this study.

Input Variables viz Production, Consumption and Importation Factors

Production Factors

The study used a panel data composed of 14 regions and 21 years for a total of 294 total observations. The actual volume of rice production (1,000 m.t.) behaves properly in an error components frontier of SFA assuming the general truncated normal distribution ($\mu \neq 0$) and half-normal distribution with time varying efficiencies. There were seven factors used as explanatory variables, such as, land area harvested (1,000 hectares), labor (1,000 person), seed (Php), fertilizer (Php), pesticide (Php), irrigation (Php), threshers (unit), calamities (0 = without loss, 1 = with loss due to calamities), and tractors ($1 \geq 1{,}000$, $0 < 1{,}000$ units).

Results showed the factors affecting volume of rice production in the 14 regions of the Philippines. Additional hectare of land area (1,000 hectares) use for rice production increases the volume of rice production (1,000 m.t.) by 1.005%. This implies that more land area use in rice production contributed to the volume of rice production in the regions. Increasing cost of labor amounting to P1,000 decreases volume of rice produce by -0.061% in a region implying high wage of human labor and scarcity of farm labor in a region in rice production. Observation shows that family members after graduating in college opted for high paying jobs elsewhere rather than tend their farms. High cost of certified seed (P) decreases rice production by -0.099% in a region. Mariano et al. (2011) noted the decline to the quality of seed used due to intensified adoption to certified seed. Money spent to fertilizer increases rice production (1,000 mt) by 0.141% implying that improved plant nutrition helps in producing more rice. Similarly, Mariano et al. (2011) found an increase of 0.10 percent in rice production for every one percent increase in fertilizer. Expenditures to pesticide also improve rice production by 0.032 percent implying appropriate pest control was applied in the region. This is parallel with the findings of Balcombe et al. (2007) in which applications of pesticide are positively related to output. Insect pest outbreaks decrease rice production and income of farmers in the regions. Increase in the number of threshers contributes to volume of rice produce by 0.027% implying availability of threshers and facilitating the detaching of rice panicles (palay) from stalks during the harvest season. Regions with less than 1000 units of tractors experienced decline in the volume of rice production by -0.031% implying that regions were late in the preparation and planting of rice seedlings in the onset of rainy season. Although not statistically significant, regions with increasing cost of irrigation suffer a decline in the volume of rice production. This implies that water availability could be scarce in some part of the region causing the farmer to rely on rain water for irrigating their rice paddies. Moreover, the incidence of calamities such as flooding, drought and infestation decrease the volume of rice produce by -0.012% implying regions that experience million of pesos losses have declining volume of rice production. This is similar with the study conducted by Villano and Fleming (2005), in which farm lands under rain-fed conditions usually have a high risk due to unpredictability of rainfall which may lead to instability in yield and output.

Hypothesis testing on the parameters that bi = 0 was rejected because 7 parameters are significant at 5% level indicating b1≠ 0. The hypothesis on the value of Sigma -squared (σ^2) is equal to zero indicating all regions are efficient was rejected because the value of Sigma-squared (σ^2) is 0.056 > 0 representing some regions are inefficient at 5% level of significance. The hypothesis test on the value of gamma (γ) is equal to zero was rejected because the value of gamma is 0.899 > 0 showing that the distance from the frontier best practice is not entirely due to random variation or noise but by inefficiency.

The hypothesis test on the assumption that the model assumes a half-normal distribution where mu is equal to zero ($\mu = 0$) was rejected in favor of the general truncated normal distribution where mu is not equal to zero (mu, $\mu \neq 0$) at 5% level of significance. The hypothesis test on the embedded corrected ordinary least squares (COLS) in the SFA program as the appropriate model to approximate the regional data on the volume of rice production was rejected in favor of the maximum likelihood estimate (mle) of SFA at 5% level of significance. The likelihood ratio (LR = 415.86) test of the one-sided error is greater than the Kodde & Palm value (15.357) computed for this purpose of testing at 5% level and 3 degrees of freedom.

Consumption Factors

The section used an error component stochastic frontier with 294 total observation in a panel data assuming half-normal distribution ($\mu = 0$) and annual variation in technical efficiencies of the different regions in the Philippines from 1992 to 2012. The dependent variable which is the amount of rice consumed in 10,000 metric ton was regressed to three independent variables: price of domestic rice, and regular milled at constant pesos; amount of corn consumed at 10,000 metric ton; and dummy variables: calamities: 1 = with incidence, and 0 = without incidence.

The constant suggests that at the beginning of year 1992, the average amount of rice consumed is about 632,886 metric ton. One percent amount of corn consumed (10,000 m.t) influences a 0.123% increase in amount of rice consumed (10,000 m.t). This indicates that some regions were eating corn as a substitute for rice. Other regions particularly in the Visayas and Mindanao were mixing rice with corn to maintain daily nutritional intake of calories. Amount of rice consumed (10,000 m.t) declines to -0.003% or about 9,972 m.t for every Php1 increase in price of regularly milled domestic rice. Consumption of rice decreases because of available substitute for rice like corn, bread, and cereal products. In developed economies, rice is considered as an inferior good, implying that an increase in the income will lead to a decrease in the amount of rice consumed. Amount of rice consumed increases by 0.036%, about 10,373 metric ton, for every incidence of calamities such as flooding, and drought in a region. Annual rice consumption trend is 0.05% (10,517 metric ton) in a region.

The test for the sigma-squared and gamma showed that there is an incidence of inefficiency in the rice consumption and the resulting distance from the frontier is due to inefficiency and not entirely in random noise at five percent level of significance. The mle predicted value of the amount of rice consumed assumed the half-normal distribution because the mu ($\mu = 0$) is restricted to zero. The eta (η) indicates that the model incorporates the time varying inefficiency as represented by the cross-sectional and serial data at five percent level of significance. The error component model appropriately estimated the amount of rice consumed than the corrected ordinary least squares as shown by likelihood ratio test (LR = 565.63 > 17.612) at 2 degrees of freedom and 5% level of significance.

Importation factors

This section used an error components frontier in a Cobb-Douglas production function specified under Battese and Coelli (1996). The model specification assumes a half-normal distribution (μ = 0) with time varying efficiencies. The six regressors namely domestic output of rice in 10,000 metric ton, consumer's demand for rice in 10,000 metric ton, price of imported rice in US$, price of regularly milled domestic rice in constant Php, per capita income (GNI at constant prices), and exchange rate were regressed to volume of imported rice at 1,000 metric ton. The data is panel type with 14 regions and 21 years of test period.

Literally, the constant suggests a zero importation of rice if all the variables were held constant at the beginning of year 1992. A one percent increase in domestic output of rice decreases rice importation by 0.35% annually in a region. This indicates that regions don't have to import rice if it will be sustained at an increasing level of the domestic yield of rice. Statistically insignificant, one percent increase in the consumer's demand for rice tends to increase rice importation by 0.27%. This event is true at times when the demand for rice in the regions surpassed the production of rice. As price of imported rice increases, volume of imported rice continues to rise by 1.19% from 1992 – 2012. This result is contrary to the study of Ogundele (2007) in which price of imported rice has a negative relationship against imported rice. This situation is true because rice trading is a lucrative business in the Philippines. Rice producers tend to import rice and postponed its allocation in the regions to maximize on profit. Increase in price of domestic rice suggests influences of 0.12% increase in the volume of imported rice. It is observed that domestic price of rice is above the imported rice encouraging more importation of rice. Higher growth in per capita income enhances a 0.34% increase in the volume of imported rice. Similarly, Ogundele (2007) found per capita income to be positive implying a higher demand for imported rice. Rice is a necessity and consumers purchase rice regardless of an incident in price increase. If the peso has a higher value against the US dollar, the importation of rice increases by 2.3%. This implies that more bags of rice can be imported with lesser US dollars.

The above model passed the test for the parameters, sigma squared, gamma, likelihood ratio at five percent level of significance. The model assumes a half-normal distribution and time-varying inefficiency of the regions from 1992 – 2012. The hypothesis test on the assumption that the model did not assumes a half-normal distribution where mu is equal to zero (μ = 0) was rejected at five percent level of significance. The hypothesis test on the likelihood ratio (LR = 31.11) test of the one-sided error is greater than the Kodde & Palm value (12.812) computed for this purpose of testing at 5% level and 2 degrees of freedom. Therefore, the maximum likelihood estimate of error components frontier model adequately measured the volume of rice importation at five percent level.

As the result of the above findings, the hypothesis that *production, consumption, and importation are not affected by any factors* was rejected.

Determine Self-sufficiency Status of the Philippines

This section used logistic regression to predict rice's self-sufficiency in the regions of the Philippines. The probable effects of volume of rice production (10,000 m.t.), amount of rice consumed (10,000 m.t.) and volume of imported rice (1,000 m.t.) to self- sufficiency (%) of the Philippine regions from 1992 to 2012 in absolute values is shown in this section. Self-sufficiency is in ratio (%) given by the Bureau of Agricultural Statistics (BAS).

The results of Omnibus tests of model coefficients indicate the predictors: volume of rice production, amount of rice consumed and volume of imported rice, influence to the likelihood of self-sufficient and not self-sufficient regions at 5% level of significance. The chi-square of 74.6 on 5 degrees of freedom is significant at 5% level (0.000 < 0.05) indicating the ability of the predictors to affect the events of sufficiency at 10% and insufficiency at 90% of rice producing regions in the Philippines.The model summary of logit model prediction reveals that -2 log likelihood statistic is 110.32 implying how appropriately the logit model predicts "self-sufficiency". The Cox & Snell R^2 (22.4%) is better than zero indicating interpreted relationship of the predictors to the dependent variable, self-sufficiency. The Nagelkerke R^2, a correction of Cox & Snell R^2, indicate that the logit estimate is a better fit at 48.0%. The pseudo R-squared (Cox & Snell R^2 and Nagelkerke R^2) are always lower than the traditional ordinary least squares (OLS) R-squared values.

The classification the odds events of self-sufficient and not self-sufficient allows us to correctly classify 258/266 at 97.0% of the predicted event, and insufficiency in rice production was observed. This is known as the sensitivity of prediction, the percentage that an event occurred or insufficiency did occur, that is, the percentage of occurrences or insufficiency correctly predicted. Moreover, this allows us to correctly classify 4/28 = (14.3%) that the predicted event was sufficient. This is known as the specificity of prediction, the percentage that correct event is sufficient, that is, the percentage of sufficient correctly predicted. Overall, the predictions were correct that resulted to 262 out of 294 times, for an overall success rate of 89.1%.

The EXP(B) value associated with volume of rice production is 1.010. Hence, when volume of rice production in 10,000 metric ton is raised by one unit, the odds ratio is 1.010 times as high and therefore, region's rice sufficiency is 1.010 more times likely to be sufficient. This implies that self–sufficiency is achieved if the regions sustained improvement in rice production annually. Similarly, Oyinbo et al. (2013) recommended an increase in the volume of rice production in achieving rice self sufficiency. Although statistically insignificant, the odds ratio for the amount of rice consumed (10,000 metric ton) indicates that a region is 0.997 times more likely to be insufficient. This indicates that if rice consumption is higher than rice production, then rice is not sufficient in the regions. The EXP(B) value associated with imported rice is 1.167. Hence, when importation of rice is raised by one unit the odds ratio is 1.167 times higher and therefore, rice sufficiency is 1.167 more times likely to be sufficient. This means that rice sufficiency is high because of additional stock coming from imported rice.

The above results indicated that the null hypothesis: "P*roduction, consumption, and importation have no significant effect on rice self-sufficiency*" was refuted or rejected in favor of the alternative hypothesis. The study found that two of the declared independent variables affect the dependent variable, rice self-sufficiency. Hence, there is a greater chance that the rice producing was self-sufficient because of the increasing rice production and volume of imported rice integrated with local rice produced. Removing imported rice makes the regions insufficient in rice.

Efficiency of rice-producing regions in the Philippines

Most productive and efficient rice-producing regions in the Philippines

This section illustrates the DEA measurement of productive and efficient performance of 14 regions of the Philippines from 1992 to 2012. Five indices are standard measures of performance of Data Envelopment Analysis (DEA), namely total factor productivity change (tfpch), efficiency change (effch), technological change (techch), pure efficiency change (pech) and scale efficiency change (sech).

Results show the Malmquist index of productivity and efficiency for the 14 regions of the Philippines (1992 – 2012). CAR and Central Visayas experience growth in productivity (tfpch > 1.000) while the rest of the regions was below the desired level of productivity growth (< 1.000). These two regions show improved productivity because of increase performance in overall efficiency (cost efficiency, effch = 1.007, 1.014) and modern farming technology (as in the case of CAR, techch = 1.005). CAR's overall efficiency or cost efficiency (effch = 1.007) is improved by good scale condition (sech =1.007) and the same farm level efficiency (pech = 1.000). Central Visayas' overall efficiency (effch = 1.014) is enhanced by advantageous condition (displayed by its farm scale size, sech = 1.014) and constant efficient operation (pech = 1.000).

Above the average productivity of the region (tfpch = 0972), Northern Mindanao (= 0.989), SOCCSKSARGEN (= 0.987), CARAGA (= 0.982), Davao Region (= 0.981) and Southern Tagalog (=0.976) perform better in productivity than the rest of the regions. Although above the average productivity index, Northern Mindanao's regresses in productivity (tfpch = 0.989) because of obsolete farm technology (techch = 0.989) but maintained cost efficiency (effch = 1.000) in the farming industry. This status quo in cost or overall efficiency is preserved by efficient operation (pech = 1.000) and "*advantageous conditions displayed by scale efficiency" (Cooper et.al 2006).*

SOCCSKSARGEN's old farm practices (techch = 0.991) and cost inefficiency (effch = 0.996) in rice production resulted to its productive decline (tfpch = 0.987). The cost inefficiency is driven down by inefficient farm operation (pech = 0.997) and disadvantageous scale conditions (sech = 0.999) in the region. CARAGA suffers low productivity (tfpch = 0.982) because of overall inefficiency (effch = 0.987) and obsolete farm technology (techch = 0.995). Overall or cost inefficiency declines because of the disadvantageous scale condition (sech = 0.987). At least, CARAGA's farm level of operation (pech = 1.000) is kept at the efficient level. Davao region's obsolete farm technology (techch = 0.983) and cost inefficiency (effch = 0.998) influence the decline in productivity (tfpch = 0.981). Cost inefficiency is caused by disadvantageous scale condition (sech = 0.998). Davao region is keeping farm management of inputs (pech = 1.000) at efficient level.

Southern Tagalog's productivity (tfpch = 0.976) declines because of obsolete farm practices (techch = 0.981) and overall inefficiency (effch = 0.994). Cost inefficiency in the Southern Tagalog region is caused by inefficient farm operation (pech = 0.985) as such improper post harvest practices, late planting of crops, and others. However, Southern Tagalog enjoys improved advantageous scale condition (sech = 1.009) because of good climate and road connectivity of farm to market.

Western Visayas displays low productivity index (tfpch = 0.964) because of old farm practices (techch = 0.962). However, its overall efficiency (effch = 1.002) shows improvement because of the advantageous scale of operation (sech = 1.002) and maintained level of administration of inputs (pech = 1.000). However, it failed to show improvement in rice productivity (tfpch = 0.960) because of obsolete farm technology (techch = 0.960). It is ironical that regions closest to the source of farm technology are the least to practice the new techniques in farming. Similarly, Villano and Fleming (2005) indicate the incidence of high variability in technical efficiency in Central Luzon. Central Luzon maintains overall efficiency (effch = 1.000) because of efficient farm level operation (pech = 1.000) and advantageous scale of farming operation (sech = 1.000).

Bicol region displays no improvement in productivity (tfpch = 0.959) because of low level of technology (techch = 0.956). Bicol region is always hampered by the incidence of typhoons all year round and this could be a cause of low level of productivity. However, Bicol region shows improvement in cost efficiency in rice production because of advantageous scale of operation (sech = 1.005). Its farm level operation is not efficient (pech = 0.998) because of inputs wastage absorbed during the incidence of calamities.

Ilocos region, Cagayan Valley and Eastern Visayas show no improvement in productivity because of low level of technology in farm operation. Overall efficiency (effch = 1.000) is constant while maintaining efficient farm operation (pech = 1.000) and advantageous scale condition in rice production from 1992 – 2012. ARMM shows the lowest productivity index (tfpch = 0.951) that is influenced by obsolescence in farm practices (techch = 0.959) and cost inefficiency (effch = 0.991). Overall inefficiency in rice production is hindered by inefficient management (pech = 0.993) of farm inputs and disadvantageous scale condition in operation (sech = 0.998). The land of tenure in some rice-producing areas in ARMM and farming activities were disrupted by armed conflicts and other political issues.

On the average, the findings on rice productivity and its causes implied the rice-producing regions of the Philippines reveal declining productivity caused by obsolete farm practices rather than cost efficiency. Although there were improvements in cost efficiency, managerial inefficiency or farm level of administering farm inputs was declining during 1992 – 2012. Typically, a region enjoyed advantageous scale condition in rice farming.

The summary of productivity and its factors implied that the rice-producing regions in the Philippines suffers low productivity (tfpch = 0.972) because of old farming practices and low level of pieces of equipment (techch = 0.973) rather than overall efficiency (effch = 1.000). Cost efficiency was maintained at status quo (effch = 1.000) because of advantageous scale of rice farming operation (sech = 1.001). However, there was poor management of resource inputs in the regions (pech = 0.998).

Strongly and weakly efficient rice-producing regions in the Philippines

This section used the DEA – slack based model in determining the technical (crste and vrste) and scale efficiencies of the rice-producing regions in the Philippines. The slack based model has two assumptions: constant return to scale (crs) and variable return to scale (vrs). The crs assumption was developed by Charnes, Cooper and Rhodes (commonly known as CCR). Cooper, Seiford and Tone (2006) discussed that the CCR model takes no account of the scale or size of operation of a rice-producing region and its score is called global technical efficiency (crste) or overall efficiency (also cost efficiency).

On the other hand, not all rice-producing regions are operating at constant return to scale (crs) and CCR model is too restrictive for the analysis of rice-producing regions of the Philippines. Banker, Charnes and Cooper (BCC) offered a modification to CCR-crs model in 1984 that incorporate variable return to scale technical efficiency score (vrste). The BCC-vrs model includes varying level of efficiency in relation to scale of operation (increasing, deceasing and constant). Variable return to scale score (vrste) measures local pure technical efficiency (Ramanathan 2003). Local pure technical efficiency (vrste) is also called (in)efficiency of operation of a particular rice-producing region or managerial efficiency (Cooper, Seiford and Tone 2006).

Overall (cost) efficiency (crste) can be decomposed into pure technical efficiency (vrste) and scale efficiency (scale) or (dis)advantageous conditions of the scale of operation of the rice-producing region (Cooper, Seiford and Tone 2006). Scale efficiency is a ratio derived from the crste and vrste. A 100% scale efficiency means overall efficiency (crste) and managerial efficiency (vrste) have 100% scores. Ramanathan (2003) and Cooper et.al (2006) refer to the 100% efficient scale of operation of the rice-producing regions as the most productive scale size (mpss).

The study derived three groups of rice-producing regions in the Philippines. The strongly efficient group refers to the most productive scale size (mpss) rice-producing regions that exhibit 100% scores in cost (crste) and managerial (vrste) efficiency. Rice-producing regions in MPSS condition suggest efficient use of inputs that is no slacks observed in the output and inputs.

The seven strongly efficient regions are enumerated in order of rank as: Central Luzon, Davao, Eastern Visayas, Ilocos, Northern Mindanao, ARMM, and Cagayan Valley. The strongly efficient regions enjoy 100% cost efficiency that is enhanced by managerial efficiency (vrste = 100%) and advantageous condition (scale = 100%) in their scale of operation. The seven rice-producing regions operate at constant returns to scale (represented by a dash) implying that the 100% use of resource inputs (land area harvested (ha*1000), labor, seed, fertilizer, pesticide, irrigation and thresher) generates a corresponding 100% volume of rice produce.

The weakly efficient rice-producing group reveals a decline in overall or cost efficiency (crste = 0.777) during 1992 – 2012. The decline in cost efficiency of the rice-producing regions was caused by disadvantageous condition in their scale of operation (scale = 0.777). However, weakly efficient rice-producing regions maintain good management of inputs (vrste = 1.000) in their operation. Bicol, Central Visayas, CAR, and CARAGA operates in increasing return to scale (irs) implying that this rice-producing regions operates at lower scale sizes to achieve greater economies of scale if they increase their volume of operation. Western Visayas operates at a decreasing return to scale (drs) indicating that rice production is declining at a gradual rate. The efficiency score of self-sufficiency (= 0.957) is below the average score of 0.959 for the Philippines indicating that self sufficiency in rice in weakly efficient group is achieved at higher cost of operation and mixed (increasing and decreasing) scale of operation. The performance of the weakly efficient group revealed that cost inefficiency in the regions was caused by disadvantageous condition related to scale operation. Efficient administration of inputs (vrste = 1.000) was maintained from 1992 to 2012.

The inefficient group is composed of Southern Tagalog and SOCCSKSARGEN. The inefficient group failed to reach the 100% ratings in overall cost efficiency, managerial efficiency and scale efficiency suggesting excessive use of inputs in their rice production activities from 1992 to 2012. Southern Tagalog registers high efficiency score in self-sufficiency (0.982 > 0.959) but displays the lowest cost efficiency (0.614) managerial efficiency (0.660) scores among the 14 rice-producing regions. SOCCSKSARGEN is also inefficient in its rice production activities due to cost, low level of management of inputs and disadvantageous condition of its operation (irs). The region was operating at increasing return to scale (irs) to generate higher volume of rice produce while operating at lower scale sizes.

The above findings implied that strongly efficient rice-producing regions in the Philippines that achieved cost efficiency, managed efficiently the use of inputs, and operates at the most productive scale size (mpss) were more self-sufficient in rice production than the weakly efficient and inefficient groups. Strongly efficient group shows that there is no shortage in their target volume of rice produce and no excessive use of inputs in land, labor, seed, fertilizer, pesticide, irrigation and threshers. As a result, the strongly efficient group achieved self-sufficiency at the most productive scale size (mpss).

The weakly efficient group also reveals that there are no shortage in rice production and no excess use of inputs in their operation. However, they have not achieved 100% efficiency in cost, management of inputs and scale of operation. Self-sufficiency in rice can be sustained at higher cost such as importation and disadvantageous condition in scale of operation. This is the reason why they are called weakly efficient because they are not operating at their most productive scale size (mpss). Hence, the weakly efficient group achieved self-sufficiency in rice production at higher cost of operation and diseconomies of scale (irs or drs).

The inefficient group failed to reach the 100% efficiency in cost, management and scale condition of operation. The rice-producing regions have no shortage in rice production but displayed excessive use of the following inputs: idle land area (6.84 thousand hectares), idle labor (30.78 thousand persons), excess cost of seed (P20.95), surplus of fertilizer (P0.61), abundance of budget allocated for pesticide (P30.58), (excess expense on irrigation (P5.38) and idle items of threshers (0.29).

All of these slacks or excesses in input usage indicate that some rice farming regions are inefficient in their operation because of cost inefficiency, inefficient management of inputs and disadvantageous conditions in their scale of operation during the test period 1992 – 2012. Cost, management and scale inefficiencies lead to low level of self-sufficiency as proven in Tables 7 and 8. A region operating at the most productive scale size (mpss) tends to exhibit high level of self-sufficiency in rice produce.

As the result of the above findings, the hypothesis that *there are no productive and efficient rice-producing regions in the Philippines* was rejected.

Conclusion

This chapter summarizes answers to the objectives and hypotheses that were raised in the study. To recall, the objectives of this study are as follows: (1) to determine the effect of input factors against rice production, rice consumption and rice importation in attaining rice self-sufficiency; (2) to determine the self-sufficiency in rice status of the Philippines; (3) to determine the most productive and efficient rice-producing regions in the Philippines; and (4) to recommend actions that will help the country attain rice self sufficiency. The fourth research objective addressed the recommendations part of this study.

Stochastic Frontier Analysis was used in determining the effect of input factors against rice production, rice consumption, and rice importation in attaining rice self-sufficiency. Production input variables namely land area harvested, fertilizer, pesticide, threshers and tractors contribute positively in the amount of rice production. On the other hand, remaining production input variables such as labor, seed, and irrigation contributes negatively in the amount of rice produce, implying that these inputs were becoming scarce in rice production due to their high cost of utility. Consumption input variables namely: amount of corn consumed and incidence of calamities contributes positively on rice consumption, implying that increasing these inputs corresponds to an increase in the amount of rice consumed. Price of domestic rice, on the other hand, contributes negatively on rice consumption. This means that consumers purchase lesser quantity of rice for every increase in the price of rice. Importation input variables namely: consumer's demand for rice, price of imported rice, price of domestic rice, per capita income, and exchange rate has a positive impact on rice importation. Conversely, domestic output of rice corresponds to a negative effect on the amount of rice importation.Thus, based on the findings of the analysis, input factors do affect rice production, rice consumption, and rice importation.

Logistic regression showed that rice production has positive impact on self-sufficiency, implying domestic rice production increases self-sufficient status of Philippine regions from 1992 - 2012. Similarly, rice importation indicates additional stocks that increase the self-sufficiency rating of the regions. Without imported rice, the regions were insufficient in rice. Conversely, rice consumption has a negative impact on rice self-sufficiency implying that a country needed to produce more in order to meet the escalating demand of the populace for rice and be rice self-sufficient. Overall perspective showed that the Philippines was not rice self-sufficient due to increasing gap between production and consumption, and escalating amount in importation of rice from 1992 to 2012.

DEA – Malmquist Productivity Index was used in determining the most productive and efficient rice-producing regions in the Philippines. Findings of the study showed

Cordillera Autonomous Region and Central Visayas as the top most productive regions for having an increase in the overall performance in efficiency and model farming technology. Northern Mindanao, SOCCSKSARGEN, Caraga, Davao, and Southern Tagalog are the above average regions in the Philippines. These regions perform better in productivity than the rest of the regions. In contrast, Western Visayas experienced low productivity index due to old farm practices. However, the region's overall efficiency was improved due to beneficial scale conditions and maintained level of input administration. Findings of the study showed failure of Central Luzon, Bicol region, Ilocos region, Cagayan Valley, and Eastern Visayas failed to show improvement in rice productivity because of obsolete farm technology in farm operation. Finally, among the fourteen (14) rice-producing regions, ARMM shows the lowest productivity index due to obsolescence in farm practices and cost inefficiency.

Data Envelopment Analysis – Slack Based Model (SBM) was deployed in determining strongly and weakly efficient rice-producing regions in the Philippines. Findings showed seven strong regions enumerated according to their rank: Central Luzon, Davao, Eastern Visayas, Ilocos, Northern Mindanao, ARMM, and Cagayan Valley; five (5) weak regions namely; Bicol region, Central Visayas, CAR, Caraga, and Western Visayas; and the two (2) inefficient regions namely: Southern Tagalog and SOCCSKSARGEN.

Recommendations

Based on the findings, the researcher recommends the government through Department of Agriculture to invest on the following inputs namely; land area harvested, fertilizers, pesticides, threshers, and tractors, given that these inputs showed positive impact on rice production. The government through Department of Agriculture should also promote hybrid rice, such as the 'golden rice', the byproduct of rice and corn, to further give options to the consumers. Hybrid and certified seeds should be available at affordable price. The government should accord protection to local farmers by prescribing rules that will control the amount of rice being imported into the country. Furthermore, the government should prioritize programs and explore more feasible ways that will make our local farmers globally competitive in terms of rice production and quality. Regions that experience low productivity due to obsolescence in farm technology, must evaluate the farming technologies being used to determine if additional technology is beneficial in increasing rice production. Regional Department of Agriculture should administer training programs, through farm technicians and agri-technologist, in order to increase the rice produced by the region. The farmers in Bicol region, as being hampered by natural calamities, should utilized seeds that can withstand heavy rains.Further investigation on the declining trend in land area devoted to rice farming is needed to evaluate its cause and significance in rice production and efficiency.

References

Balcombe, K., Frase, I., Rahman, M., & Smith, L. (2007). Journal of International Development, 19, 1-16. DOI: 10.1002/jid.1284

Bureau of Agricultural Statistics (Philippines) – Major Domains and Selected Indicators of Agricultural Statistics, Retrieved 2015, Bureau of Agricultural Statistics Website,http://countrystat.bas.gov.ph/?cont=2&pageid=7951465556564053595643 1B5F514656585350505C061C554147&fil=2-2-3-1

Coelli, T.J., Rao, P., O'Donnell, & C.J., Battese, G.E. (2005). An Introduction to Efficiency and Productivity Analysis (2nd Edition). United States of America: Springer Science+Business Media, Inc.

Coelli, Tim J. (1996). A Guide to Frontier Version4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation. CEPA. UNE. Australia. ISSN 1327 – 435X, ISBN 1 86389 4950

Cooper, W.W., Seiford, L.M., & Tone, K. (2000). Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Massachusetts: Kluwer Academic Publishers.
Cooper, W.W., Seiford, L.M., & Zhu, J. (2004). Handbook on Data Envelopment Analysis. Massachusetts: Kluwer Academic Publishers.
Cooper, William W., Lawrence M. Seiford and Kaoru Tone. (2006). Introduction to Data Envelopment Analysis and Its Uses. Springer Sciences + Business Media, Inc. USA.
Global Rice Science Partnership (GRiSP) (2013). Rice Almanac (4th Edition). Los Baňos (Philippines): International Rice Research Institute.
International Grains Council – Forecasted Global Rice Consumption for 2014 – 2015, Retrieved March 26, 2015, International Grains Council Website, http://www.igc.int/en/grainsupdate/sd.aspx?crop=Rice
Kumbhakar, S.C., & Lovell, C.A.K. (2000). Stochastic Frontier Analysis. United Kingdom: Cambridge Univeristy Press.
Mariano, M.J., Villano, R., & Fleming, E. (2011). Asian Economic Journal: Journal of the East Asian Economic Association, 25(3), 245-269.
Ogundele, F. (2007). Trade Liberalization and Import Demand for Rice in Nigeria: A Dynamic Modelling. Journal of Economic and Rural Development, 16(1), 34-45.
Oyinbo, O., Omolehin, R.A., & Abdulsalam, Z. (2013). Analysis of the Demand for Rice in Kaduna State, Nigeria. Agris on-line Papers in Economics and Informatics, 5(3), 45-50.
Oyinbo, O., Rekwot, G.Z., & Sadiq, N.M. (2013). Trend Analysis of Nigerian Rice Sub-sector Indices: Lessons for Rice Self Sufficiency in Nigeria. Journal of Management and Science, 3(4), 36-40. ISSN 2250-1819/ EISSN 2249-1260
Ramanathan, R. (2003). An Introduction to Data Envelopment Analyses: A tool for Performance Measurement. Sage Publications. New Delhi.
Reuters, INTERVIEW-Philippines abandons timeframe for rice self-sufficiency, Retrieved July 8, 2014, CNBC Website, http://www.cnbc.com/id/101818394#
Villano, R., & Fleming, E. (2005). Technical Inefficiency and Production Risk in Rice Farming: Evidence from Central Luzon Philippines. Asian Economic Journal, 20(1), 29-46.