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Rice Farm Productivity in the Philippines: An SUR Application

Kathleen Ivy Bolotaolo
University of Southern Mindanao
Email address: kizbolotaolo @ usm.edu.ph

Abstract**—** *Increasing productivity of rice farms in the Philippines remains to be of great concern despite the heavy investments in the industry. The impact of Rice Tarrification Law is yet to be studied and also how the Rice Enhancement Competitiveness Fund (RCEF) can help depressed rice farms. If skyrocketing price of farm inputs is inevitable and price stabilization policies on rice is not enough, focus should then be made on making sure there is available lower-interest loans to qualified and poor rice farmers as suggested by both OLS and SUR estimates across most Regions under study. In addition, farm laborers should be trained and equipped as well on modern farm technologies and machineries. However, the effect of hired labor on rice yield should be evaluated and investigated further due to its negative estimates*.

I. INTRODUCTION

The Philippines is the world's eighth-largest rice producer with a total arable land of 5.4 million hectares. However, the country's rice area harvested is still very small compared with that of the other major rice-producing countries in Asia. More than two-thirds (69%) of its rice area is irrigated with seventy-one percent (71%) of rice production came from these areas. Although yield improved from 2.8 t/ha in 1995 to 3.6 t/ha in 2010, it was still way below the yield potential of modern varieties, (IRRI, 2013).

Rice is a staple food for most Filipinos across the country. Apart from this fact, the country's population is consistently rising which further exacerbated the food security concerns the nation have. Numerous programs and policies have been made to enhance and support rice farmer's productivity like price stabilization policies, provision of free seedlings of modern varieties; farm mechanization; free irrigation and the latest is the Rice Enhancement Competitiveness Fund which aims to give additional subsidy in the form of farm mechanization, credit, training, seed provision, and other programs to aid farmers eventually compete with the low-cost Southeast Asian neighbors, (Galang, 2020).

While there are already empirical studies comparing the nation's rice productivity against other top producing countries with the aim of identifying their good agricultural practices on rice and hopefully replicate it domestically, any policies that the agricultural sector of this country must design should be derived from our own scenario and data. This is crucial to formulate effective strategies to solve problems which has long been besetting the rice industry of the country. Assessing first what factors (it could be environmental, physical, economic, technological, marketing) contribute to the successes and failures with in the local rice production is the first step so an appropriate policy intervention could be applied. This may mean looking at costs and returns trends of rice production and analyzing the whole rice system in the country using Seemingly Unrelated Regression. This notion is heavily grounded on the theory of the firm on which agricultural productivity is deeply rooted from.

Objectives of the Study

The study delved at the factors that contributed to rice farms productivity among the 6 top rice producing regions in the Philippines, namely, Ilocos Region, Cagayan Valley, Central Luzon, Bicol Region, Western Visayas and SOCCSKARGEN. The success significant indicators that will be identified could be replicated to other rice producing regions in the country as well which needs improvement and would have relevant repercussion on policies concerning rice production in the nation.

II. METHODOLOGY

Data

Data utilized for this study was taken from Philippine Statistical Authority (PSA) specifically on their Agriculture, Forestry, Fisheries Agricultural Accounts updated average production costs and returns by type, geolocation, item and season from 2002 to 2018. Data available are expressed in peso values per hectare per year except for yield which is expressed in kilograms per hectare per year and farm gate price which is peso/kilogram. Only data from the top producing rice in the Philippines were taken specifically Central Luzon, Western Visayas, Cagayan Valley, Ilocos Region, SOCCSKARGEN and Bicol Region.

Data on the averages of yield, farm gate prices (Php/kg), seeds paid in cash, fertilizer paid in cash, hired labor paid in cash, interest payment on loans for farm operations, irrigation fees, and rentals or payments for the use of land, tools, machines, animals and farm machineries were taken from the said regions. The variables taken coincides with the results of the study conducted by the World Bank on factors affecting rice farm productivity amongst rice producing countries.

Model Specification and Statistical Treatment

Productivity measurement has its origins in microeconomics "theory of the firm" in which, after simplifying assumptions, it can be shown that inputs can be combined optimally to allocate scarce resources and produce an output. In its simplest form, productivity measures describe the relationship between the production of a commodity — good or service — and the inputs used to produce that

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commodity. It can be the relationship between one or more products and one or more inputs. Generally, this means that the physical relationship between output and input mathematically and in simpler terms is;

$$Y \text{ or } Q = f(x),$$

where y or q = output and x = inputs

In this paper, the relationship can be expressed as;

$$Y_{it} = f(x_{1it}, x_{2it}, x_{3it}, x_{4it}, x_{5it}, x_{6it}, x_{7it} + e_{it})$$

Specifically, the variables represents as;

Y_{it} = average yield of rice farms per kilogram/hectare of the t^{th} observation in ith equation

X_{1it} = farm gate price (peso/kg) of the t^{th} observation in ith equation

X_{2it} = seeds paid in cash t^{th} observation in ith equation

X_{3it} = fertilizer paid in cash t^{th} observation in ith equation

X_{4it} = hired labor paid in cash t^{th} observation in ith equation

X_{5it} = interest payment on borrowed loan for operations of the farm t^{th} observation in ith equation

X_{6it} = irrigation fees t^{th} observation in ith equation

X_{7it} = rentals on farm tools, equipment's, animals and farm machineries t^{th} observation in ith equation

e_{it} = error term t^{th} observation in ith equation

The choice of the variables is also based on the World Bank's study that a rice farm's productivity is affected by physical factors such as irrigation, climate change and farm to market roads; economic factors such as sufficiency of farm inputs and access to credit; technological factors such as good agricultural practices, climate-resilient varieties, direct seeding, mechanized land preparation and harvesting and farm consolidation; and lastly, marketing factors such as quality farm to market roads, scale of harvest and access to transport units.

Irrigation fees are used to represent the physical factors; fertilizer costs, labor costs, farm gate price and interest payments on loans represent the economic factors; seed costs and rentals represent the technological factors. No data was available to best represent the marketing factors.

Since not all variables are included in the estimate, the above estimation is subjected to Seemingly Unrelated Regression (SUR) analysis to access the impact of other variables not included into the estimate. The use of SUR is further validated with the result of correlation between residuals of each equations. We found a statistical evidence to conduct an SUR due to correlation of the residuals of the 6 equations. Correlation results however vary from equations to equations with some showing very weak correlation (in Table 1).

Here a set of equations that have no endogenous regressors are presented and estimated jointly. There are 6 equations to be jointly estimated with dependent variables Y_1, Y_2, Y_3, Y_4, Y_5, and Y_6; sets of regressors (which might overlap) X_{1it}, X_{2it}, X_{3it}, X_{4it}, X_{5it}, X_{6it} and X_{7it} and error terms u_1, u_2, u_3, u_4, u_5, and u_6. These equations can be written in the form as: $Y_1 = X_1\beta_1 + \ldots.+X_7\beta_7 + u_1$; $Y_2 = X_1\beta_1 + \ldots.+X_7\beta_7 + u_2$; $Y_3 = X_1\beta_1 + \ldots.+X_7\beta_7 + u_3$; $Y_4 = X_1\beta_1 + \ldots.+X_7\beta_7 + u_4$; $Y_5 = X_1\beta_1 + \ldots.+X_7\beta_7 + u_5$ and $Y_6 = X_1\beta_1 + \ldots.+X_7\beta_7 + u_6$ with a block diagonal matrix with X_{1t} , …….X_{7t} on its diagonal matrix, $U_t = u_{1t}$,…… u_{7t} and $A(\beta) = \text{diag}\ (\beta_1 \ldots \beta_n)$ to be a (LxN) block diagonal coefficient matrix, then the above equation can be represented in the form $Y_t = A(\beta)'X_1 + U_1$ such that the coefficient $A(\beta)$ would satisfy vec $A(\beta) = G\ \beta$, for some *(NLxL)* full rank matrix G.

III. Results and Discussion

This paper run 2 methods of estimation; an OLS and Seemingly Unrelated Regression on the time-series rice farm data of 6 top rice producing regions in the Philippines. Ordinary least squares method was included as a way to validate the efficiency of the SUR results by comparing the standard of errors and as well as the coefficients. Generally speaking and based on our a priori expectations and as well as theory, SUR results are proven to be more efficient with smaller standard of errors on the coefficients and smaller Root MSE.

Results of both the OLS and the SUR are presented in Table 2. Farm gate prices are found to have a significant effect on rice farm productivity in Region 2 (Cagayan Valley), Region 5 (Bicol Region) and Region 6 (Western Visayas). However, it can be observed that in Region 2, higher farm gate prices tend to reduce rice yield or productivity. This is unexpected since rising farm gate prices should encourage farmers to produce more however, in the presence of sky-rocketing prices of other rice inputs, a peso improvement of palay's farm gate prices won't significantly impact rice productivity. The continuing increase in oil prices and the government's continuing implementation of the deregulation policy in the oil industry have contributed greatly to the deterioration of the country's rice production. Costs of production per hectare has shot up to a minimum of P75,000, ($ 1,744) covering land rent, fertilizers, pesticides, and machinery rentals, (Silverio, 2012).

Investment on seeds by farmers was seen significantly affecting rice productivity in Regions 5 and 12. It can be gleaned based on the SUR estimates that in Bicol Region, as more is invested in acquiring rice seeds, rice yield did not improve at all. One of the reasons that can be pointed out is the quality of seeds bought by the farmers. If the seeds are not modern and high yielding varieties, then any increase in seed expenses will not improve yield at all. In Region 12, it's the opposite; the more investments on rice seeds made by farmers, the better their yield is. High yielding varieties are more expensive than the ordinary seeds thus increases in seed costs by the farmers in Region 12 could only mean two things; more seeds are procured or high yielding seeds are procured.

Positive effects on rice farm productivity can be observed when more fertilizer is applied in both Western Visayas and SOCCSKARGEN. On the contrary, Central Luzon has shown that more fertilizer doesn't automatically increase rice yield. The right amounts of NPK and proper fertilizer application is the key to optimum plant health not necessarily the quantity of fertilizer applied. It is also highly probable that rice farms in Central Luzon have started experiencing diminishing marginal returns in terms of fertilizer applied. The region has long been since cultivating rice and thus soil productivity as well might have declined to the detriment of plant yield. Also, soil

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fertility declines through time especially when farmers do not practice crop rotation.

It is noteworthy to point that in terms of hired labor costs, its coefficients are negative across all regions and in both OLS and SUR estimates. Also, hired labor costs are significant in all regions except for Region 1. Hiring more laborers in the farm doesn't necessarily augment rice yield except when these hired laborers utilized farm machineries in production as well. We also know of large labor displacements in the farm due to massive farm mechanization right now. Further, it is the quality of hired labor not the quantity per se of labor that would positively impact yield or rice productivity hence why capacity building is almost always a major component of most programs of the government.

Access to credit is needed by farmers to sustain farm operations especially if they wanted to move from traditional agriculture to modern agriculture. For farmers, credit is used for purchase of inputs, farm implements, land improvements, marketing of the farm produce and even to cover farm production from unnecessary losses thru crop insurance. Unfortunately, most of our farmers resort to loan sharks or 5/6 to finance their farm operations and this greatly affects not only farm profitability but farm yield as well. The influence of availability of credit or loans to yield can be observed evidently in the results as all of the regions except Region 1 showed significant and positive estimates in the loan payments coefficient. This serves to prove the importance of availability of credit as a means to boost production and to sustain important farm operations and purchase sufficient amounts of inputs. Credit is important because economic agents in the agricultural sector who suffer from a cash-flow problem and a liquidity constraint may produce sub-optimal inputs use and, therefore, output (Khandker and Binswanger 1989 as cited by Llanto, 1993).

Table 1. Correlation matrix of residuals and the Breusch-Pagan test of Independence.

	y1	y2	y3	y5	y6	y12
y1	1.0000					
y2	0.2218	1.0000				
y3	0.3644	0.4027	1.0000			
y5	0.3863	0.6284	0.5531	1.0000		
y6	0.3559	0.0836	0.1484	0.2640	1.0000	
y12	0.3030	-0.2084	-0.0368	0.2473	0.0807	1.0000

Breusch-Pagan test of independence: chi2(15) = 27.603, Pr = 0.0242

Table 2. Estimation of Rice Productivity using OLS and SUR, 2002-2018.

	Region 1 (Ilocos Region)		Region 2 (Cagayan Valley)		Region 3 (Central Luzon)		Region 5 (Bicol Region)		Region 6 (Western Visayas)		Region 12 (SOCCSKARGEN)	
Variables	**OLS**	**SUR**	**OLS**	**SUR**	**OLS**	**SUR**	**OLS**	**SUR**	**OLS**	**SUR**	**OLS**	**SUR**
Constant	2960.53*** [688.43]	2842.2*** [454.87]	3469.6*** [500.77]	3437.35*** [340.79]	3352.92*** [457.47}	3393*** [312.57)	1848.03* [973.63}	1903.9*** [569.12]	3987.02*** [1113.11]	4297.67*** [763.68]	3320.81*** [291.74}	3467.5*** [189.01]
Farm gate price (P/kg)	-224.34^{ns} [221.08]	-93.67^{ns} [134.19]	-226.02^{ns} [205.42]	-223.75** [109.95]	226.38^{ns} [165.25]	129.57^{ns} [100.71]	602.30** [258.00]	464.73*** [132.44]	399.60* [201.64]	280.06** [136.37]	35.92^{ns} [54.26]	47.59^{ns} [32.10]
Seeds	1.63^{ns} [1.15]	.6471^{ns} [0.714]	3.32^{ns} [3.76]	3.2746^{ns} [2.05]	3.43^{ns} [3.79]	1.85^{ns} [2.41]	-4.014** [1.41]	-3.14*** [.896]	-.529^{ns} [1.43]	-.317^{ns} [.990]	4.48* [2.19}	5.47*** [1.35]
Fertilizer	.089^{ns} [.083]	.100^{ns} [.056]	.062^{ns} [.061]	.038^{ns} [.0326]	-.251*** [.068]	-.199*** [.044]	0.087^{ns} [.175]	.095^{ns} [.097]	.221^{ns} [.136]	.223** [.094]	.050^{ns} [.039]	.065** [.026]
Labor	-.152^{ns} [.176]	-.0578^{ns} [.112]	-.254^{ns} [.17]	-.357*** [.097]	-.432** [.149]	-.311*** [.09]	-.426^{ns} [.261]	-.362** [.144]	-1.21* [.607]	-1.21*** [.412]	-.238** [.078]	-.228*** [.052]
Interest on Loan	19.24^{ns} [10.61]	13.28^{ns} [6.96]	1.34^{ns} [.98]	1.95*** [.601]	1.79** [.728]	1.64*** [.47]	30.52* [16.15]	24.58** [9.586]	21.33* [10.59]	22.39*** [7.396]	2.20* [1.07]	2.66*** [.675]
Irrigation	6.09^{ns} [6.63]	2.88^{ns} [4.08]	-4.65^{ns} [5.72]	-4.65^{ns} [3.21]	-11.66^{ns} [14.12]	-5.27^{ns} [8.94]	-28.33^{ns} [24.03]	-19.70^{ns} [12.13]	-23.96^{ns} [56.60]	-8.517^{ns} [38.42]	-8.43^{ns} [5.55]	-11.01*** [3.36]
Rentals	-3.48* [1.75]	-2.51** [1.19]	10.47^{ns} [9.07]	12.40** [4.89]	6.24^{ns} [4.81]	4.03^{ns} [3.06]	1.38* [.625]	1.25*** [.430]	-5.92^{ns} [33.54]	-10.76^{ns} [23.02]	.056^{ns} [1.99]	-.852^{ns} [1.20]
R^2	**0.75**	**0.72**	**0.77**	**0.75**	**0.87**	**0.86**	**0.80**	**0.79**	**0.67**	**0.66**	**0.96**	**0.96**
RMSE	**232.56**	**178.15**	**209.08**	**158.14**	**171.43**	**132.64**	**228.05**	**170.71**	**192.12**	**142.82**	**53.02**	**39.46**

*** = 1%, ** = 5%, *= 10%, ns = not significant,
Figures in parenthesis are standard errors.

Irrigation's role as a component of the agricultural system cannot be downplayed. It raises land productivity by providing sufficient water to crops to increase yield and ensure the stability of production, even under extreme weather conditions like El Niño and La Niña. However, despite receiving the bulk of major public investments year after year, the country's national irrigation systems have always performed below par. This poor performance has been attributed by Philippine Institute for Development Studies (PIDS) to overly optimistic technical and economic assumptions, inadequate water supply, inappropriate designs, and difficulties in operation and maintenance, (AGRIMAG, 2018). Thus, SUR estimates in irrigation fees and its influence to rice yield for majority of regions studied is not significant. Conversely, in Region 12, irrigation fees negatively impact rice yield. Farmers have been paying for irrigation in this region but positive results to yield have not been very evident for the past 17 years.

In this paper, the variable rentals include payments on farm tools, land, animals, farm equipments and farm machineries for rice farm operations. This variable represents what kind of farm technology the rice farmers have on the average. Only 3 regions showed significant results in SUR for this variable, namely, Ilocos Region, Cagayan Valley and Bicol Region. However, only Ilocos Region shows negative effects. According to the Food and Agriculture Organization of the United Nations, farmers need to choose the most

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appropriate power source for any operation depending on the work to be done and on who is performing it. The level of mechanization should meet their needs effectively and efficiently. For instance, women play an important role in many farming based communities, and in some countries, up to 80 percent of the total farm labour comes from women. This rental payments for such (human, animal or motor-based power sources) need to be adapted to such necessities from an ergonomic, social, cultural and economic point of view. The negative influence of rentals to yield is a sign of inefficient usage of either human, animal and or motor-based farm equipment rented at least on the part of Ilocos region. It's not the absence of machinery or technology in the farm, but how and who is doing specific farm activities.

Based on the r-squared results of each equations presented, the regressors used are relatively good in explaining variations of rice yield or productivity in all regions. Region 12 showed to have relatively the best equation with an r-squared value of 0.96. This could be attributed to the fact that the rice industry in SOCCSKARGEN has been fairly infant compared to the other regions which might have been experiencing diminishing marginal returns of production already.

IV. Conclusion and Recommendation

The SUR is a relatively efficient tool to assess the factors affecting rice farm productivity among the 6 top rice producing regions in the Philippines as shown by the modest R^2 estimates.

Hired labor and loan payments showed consistent influence on rice yield among most of the regions. However, the effect of hired labor on rice yield should be evaluated and investigated further due to its negative estimates. More readily affordable credit terms and facilities must be made available since this serve as a life line for most poor farmers to sustain efficient farm operations. Farm credit therefore, could be seen as a positive influence that could spur the quality and adequacy of all other farm inputs used in the context of the findings of the study.

Increasing productivity of rice farms in the Philippines remains to be of great concern despite the heavy investments on the industry. The impact of Rice Tarrification Law is yet to be studied and also how the Rice Enhancement Competitiveness Fund (RCEF) can help depressed rice farms. If skyrocketing price of farm inputs is inevitable and price stabilization policies on rice is not enough, focus should then be made on making sure there is available lower-interest loans (to solve the problem on loan sharks and reduce the debt burden of the farmers thereby boosting their morale) to qualified and poor rice farmers. In addition, farm laborers should be trained and equipped as well on modern farm technologies and machineries. A good venue for this is the RCEF. This has an important role concerning rice production if only to achieve rice self-sufficiency and raise the competitiveness of the industry in the future.

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