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Time Series Analysis of Philippine Agricultural Rice Productivity using Cobb-Douglas Production Function from 2017 To 2022

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Abstract**—** *One of the main agricultural industries in the Philippines, particularly in Central Luzon, has been rice production. This study investigated the influences and determinants on national rice production. Labor, capital, credit to agriculture, spending, irrigated areas, land, and fertilizer are the relevant factors. The Cobb-Douglas Production Function was used in the study. The relationship between production output and production inputs (factors) is modeled by the Cobb-Douglas Production Function. It is used to calculate ratios of inputs to one another for efficient production and to estimate the technological change in production methods. It measured the elasticity, marginal rate of contribution, and marginal returns of capital, labor, fertilizer, irrigation, production loan, farm area, and government spending to the total agricultural rice productivity of the Philippines. This paper also analyzed the production in terms of its input and output and estimated the relationship between each input and output. The results of this study showed that capital, expenditure, and land do not significantly affect the volumes of production of rice. While labor, credit to agriculture, irrigated areas, and fertilizer significantly affect the volume of production of rice.*

Keywords**— Agricultural rice production, capital, Cobb-Douglas production function, fertilizer, irrigated areas.**

I. INTRODUCTION

Agriculture is our wisest pursuit because it will in the end contribute most to real wealth, good morals, and happiness. - Thomas Jefferson

Productivity growth in agriculture has captured the interest of economists for a long time. As agriculture develops, it releases resources to other sectors of the economy. This has been the base of successful industrialization in now-developed economies such as the United States, Japan, and countries in the European Union. Thus, agricultural development becomes an important precondition of structural transformation towards industrial development, as it precedes and promotes industrialization.

Agriculture is the industry that stands as the basic foundation of other industries. It provides wheat for a bakery, grapes for your wine, tobacco leaves for your cigar, and roses for a flower shop. It is the root of most industries because it provides raw materials or inputs that other industries cannot survive without. So this makes the agriculture industry to be developed hand in hand with infrastructure. In the Philippines, agriculture plays a vital role in the economy. Rice is the most important agricultural commodity. As a major staple food, it accounts for 35% of the average calorie intake of the population and as much as 60-65% of the households in the lowest income quartile.

However, the Philippines' agricultural sector was indeed rendered less competitive over time caused by some

identified factors. The immigration of the youths to the urban centers in pursuit of wage employment in the non-agricultural sectors, erratic weather conditions, poor input supply such as fertilizers to resuscitate the depleted soils, low capital expenditure, and poor financial resources available to farmers in the forms of loans and advances necessary in all the stages of production.

Therefore, it is good to look into the factors that influenced the most and least in agricultural rice production. Thus, this paper would like to study agricultural rice productivity at a national level. Making use of the well-known Cobb-Douglas Production Function, this paper aims to determine the statistical impact of capital, labor, fertilizer, irrigation, credit to agriculture, land, and government spending on the total agricultural productivity of the Philippines.

The general aim of the paper is to measure the total factor productivity (TFP) of the agriculture sector in the Philippine economy and analyzing input-output in the said industry. Specifically, the study intends to achieve the following:

1. To expand the Cobb-Douglas production function with the inclusion of production loans, agricultural spending, irrigation, farmland area, and fertilizer.
2. To determine if there is a significant statistical impact of the independent variables on the output.

II. METHODOLOGY

Data

National accounts analyzed in this paper were obtained through the website of the Philippine Statistics Authority (PSA), and Food and Agricultural Statistics (FAOstat). It was time-series data. The variables are defined in the table as follows:

Variable	Definition
The volume of Production – in metric tons	It accounts for the quantity of rice production.
Labor (L) – in million persons	It accounts for the manpower (labor force) in the agricultural sector for both males and females.
Capital (K) – in million pesos	These are tangible properties other than buildings or land that are used in the operations of a farm. It accounts for the machinery, specifically tractors and combine harvester-threshers that are in use.
Credit to Agriculture (C) – in million pesos	These are the loans that are available for the purpose of agricultural production.
Expenditure (E) – in million pesos	This is the amount spent in the agricultural sector by the government for the years.
Irrigated Areas (I) – in hectares	It is the artificial application of water to land for agricultural production. The data used is the total irrigated areas in the country by different irrigation systems.
Land (L) – in thousand hectares	It accounts for the farm area that is being used for farming and other agricultural activities.
Fertilizer (F) – in million tons	These are any chemical or natural substance added to soil or land to increase its fertility. What is analyzed in this study is the total consumed fertilizers throughout the country irrespective of their kind.

Econometric Model

The agricultural input-output potential model is focused on eight (8) variables: volume of production (Y), capital (K), labor (L), credit to agriculture (C), expenditure (E), irrigation (I), land (Ln), and fertilizer (F). Rewriting the production function from the theoretical framework section, the relation between output and input is expressed as:

$$Q = A\,K^{\propto}\,L^{\beta}\,C^{\theta}\,E^{\delta}\,I^{\sigma}\,Ln^{\gamma}\,F^{\tau}$$

Hypothesis

Relating the expectation is that variables capital, labor, credit to agriculture, expenditure, farmland, and fertilizers will be positively affecting agricultural production function.

The hypotheses for the study are stated as:

Null Hypotheses, H_o: $\beta_0 > 0, \beta_1 < 0, \beta_2 < 0, \beta_3 < 0, \beta_4 < 0, \beta_5 < 0, \beta_6 < 0, \beta_7 < 0$

Alternative Hypotheses, H_a: $\beta_0 < 0, \beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0, \beta_5 > 0, \beta_6 > 0, \beta_7 > 0$

The statement in the null hypothesis assumes that β_0 will take a positive sign while on the other hand $\beta_1\ to\ \beta_7$ will negatively impact the output. For the alternative hypothesis, it is vice versa.

III. RESULTS AND DISCUSSION

1. Expanding the Cobb-Douglas production function with the inclusion of credit to agriculture, expenditure, irrigation, farmland area, and fertilizer is as follows:

$$Q = K^{\propto} L^{\beta} C^{\theta} E^{\delta} I^{\sigma} Ln^{\gamma} F^{\tau}$$

Whereas: Q = volume of production

K = capital

L = labor

C = credit to agriculture

E = expenditure

I = irrigation areas

Ln = land

F = fertilizer

2. Determining if there is a significant statistical impact of the independent variables on the output is shown as follows:

Variables	Mean	Standard Deviation	Minimum	Maximum
ln Volume of Production (Y)	19,282.46	190.3998	18,814.8	19,960.2
ln Labor (L)	10	0.23	9.33	10.66
ln Capital (K)	340,226.3	12,816.37	314,445.6	385,008.5
ln Credit to Agriculture (C)	84.8	1.63	80.7	89.1
ln Expenditure (E)	137,837.2	0.06	112,420	179,742
ln Irrigated Areas (I)	14.54	0.06	14.35	14.7
ln Land (Ln)	4,757.54	31.45	4,651.5	4,811.8
ln Fertilizer (F)	4.73	0.03	4.66	4.78

The table above shows the statistics of the dependent and independent variables. The double log form of volume of production has a mean of 19,282.46 which ranges from 18,814.8 to 19,960.2. The double log form of labor input has a mean of 10 and a minimum and maximum of 9.33 and 10.66 respectively. The double log form of the capital input has an average of 340,226.3 and ranges from 314,445.6 to 385,008.5. The double log form of the credit to agriculture has a mean value of 84.8 and a minimum value of 80.7 and a maximum value of 89.1. The double log form of expenditure has an average of 137,837.2 and ranges from 112,420 to 179,742. The double log form of irrigated areas has a mean of 14.54 and a minimum and maximum value of 14.35 and 14.7 respectively. The double log form of land has an average of 4,757.54 and ranges from 4,651.5 to 4,811.8. And lastly, the double log form of the fertilizer input has an average of 4.73 and is minimum of 4.66, and is maximum of 4.78.

Regression Results

This study aims to measure the total factor productivity (TFP) of the agriculture sector in the Cordillera Administrative Region (CAR) and analyze input and output in the said industry. This portion of the paper discusses the findings on the regression results done in manipulating the data.

Variables	Coefficient	T-Statistics	P-Value
Intercept	26,443.83		
Labor (L)	745.0513	3.231148	0.048174
Capital (K)	-0.00092	-0.1072	0.921398
Credit to Agriculture (C)	88.91443	2.023963	0.136134
Expenditure (E)	0.003955	0.432459	0.69461

Irrigated Areas (I)	2,593.678	2.382901	0.097363
Land (Ln)	3.626575	1.295698	0.285765
Fertilizer (F)	6,045.469	2.33579	0.10161
Adjusted R^2	0.9867		

Interpretation of results is as follows:

$$lnY_i = 26{,}443.83 + 745.0513lnX_2 - 0.00092lnX_3 + 88.91443lnX_4 + 0.003955lnX_5 + 2{,}593.678lnX_6 + 3.626575lnX_7 + 6{,}045.469lnX_8$$

a.) Adjusted R^2

The R^2 is a measurement for the goodness of fit. We could say that about 98.67% is explained by the variation of the independent variables which are labor, capital, credit to agriculture, expenditure, irrigated areas, land, and fertilizer to the rate of the dependent variable which is the volume of production.

b.) T-test

So that we could identify if the independent variable has a significant relationship with the dependent variable, we will use the Rule of Thumb as the basis of the level of significance whereby the t-values should be greater than the value of 2.

The t-value for capital, expenditure, and land are -0.1072, 0.432459, and 1.295698 respectively, and the t-value there are all less than 2. Therefore, β2, β4, and β6 are not statistically significantly different from 0.

Whereas the labor, credit to agriculture, irrigated areas, and fertilizer have t-values of 3.231148, 2.023963, 2.382901, and 2.33579 respectively, all t-values are greater than 2. Therefore, β1, β3, β5, and β7 are all statistically significantly different from zero.

c.) P-value

P-value measures how much evidence we have to reject the null hypothesis. The smaller the p-value, the more evidence we have to reject the null hypothesis and the other way around. The p-values of labor, capital, credit to agriculture, expenditure, irrigated areas, land, and fertilizer are 0.048174, 0.921398, 0.136134, 0.69461, 0.097363, 0.285765 and 0.10161 respectively. Therefore, the p-values of labor, credit to agriculture, irrigated areas, and fertilizer have evidence to reject the null hypothesis.

IV. CONCLUSION AND RECOMMENDATIONS

The Philippines is still primarily an agricultural country despite the plan to make it an industrialized economy. Most citizens still live in rural areas and support themselves through agriculture, mainly farming.

Based on the results, it can be concluded that changes in capital, expenditure, and land do significantly affect rice production in the Philippines. This paper recommends that the government create projects and training on how to maximize the use of capital (e.g. machinery), expenditure, and land to see how these inputs can improve and increase the production of rice.

However, other inputs such as labor, credit to agriculture, irrigated areas, and fertilizer significantly affect the production of rice. This paper recommends that labor must be trained more and enhanced to maximize its capacity. The government must educate farmers to avail more of the credit to agriculture. Irrigated areas must be increased because it positively affects rice production. There must be more government intervention and subsidies for fertilizers because as of this time, it costs are high. Fertilizers greatly influence the production of rice in the country.

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