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Infrastructure and Philippine Rice Productivity

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ABSTRACT

Efforts to increase third-world food supplies have concentrated on improving agricultural production with better varieties, diffusion of technology, and subsidies to fertilizer and other yield enhancing inputs, but have ignored the benefits of developing transportation infrastructure. This study examines the yield responsiveness of Philippine rice farmers to changes in national and local roads from 1972 through 1990. Using time series data from 12 regions, the study finds that various roads have a significant positive relationship with rice yield, with elasticity estimates ranging from 0.14 to 0.39.

INTRODUCTION

Increasing agricultural output is a key concern for economic planners in low-income countries. An adequate domestic food supply reduces the necessity of using foreign exchange for food imports. A thriving agricultural sector can also provide resources for other sectors of the economy. Most development strategies have focused on ways to improve production, especially after the spectacular gains of the Green Revolution during the late 1960s. However, a concomitant requirement for increasing agricultural output must be an infrastructure network that allows market access.

Increases in production due to the adoption of new technology need to reach the market if individual earnings and aggregate consumption are to be positively affected. Improvements in production without adequate roads, bridges, and ports can reduce the impact of technological advances. Transportation infrastructure is especially important in the Philippines, which is spread across numerous islands and has other geographic and climatic impediments to transportation.

While the benefits of developing transportation infrastructure have long been recognized (Smith 1776, Wharton 1967, Owen 1968), quantitative empirical studies were undertaken only recently. Most of the initial empirical studies were aggregate in nature (Liang 1981, Antle 1983;1984, Binswanger et al. 1987). Yet much of agricultural transport is local, or at least regional. Several regional and state-level studies have since been undertaken to fill this void (Easter et al.1977, Evenson 1983;1991, Evenson and McKinsey 1991, Binswanger et al. 1993).

Most past works have approached the problem from a production function perspective, implying that better roads increase productivity. (Liang 1981, Antle 1983, 1984, Ahmed and Hossain 1990) Past empirical studies indicate that, in general, transportation infrastructure positively affects agricultural output. Many of the benefits of better roads, such as increased output prices at the farm, decreased prices of inputs, reduced transportation cost, and improved marketing opportunities, are less related to productivity than to price levels.

The main objective of this study is to examine the economic impact of public roads on Philippine rice yield from 1972 through 1990. Using data from the country's 12 administrative regions, this study evaluates the effect of roads by distinguishing between national and local highways. National roads, defined as national and provincial highways, allow agricultural output to reach urban centers and other regions. On the other hand, municipal, city, and village roads are crucial in providing rice farmers with access to local markets and to market intermediaries, who in turn, ship the output to the cities.

METHODOLOGY

The yield of Philippine rice producers by region is specified as

$$\log Q_{it} = \beta_0 + \beta_1 \log P_{it} + \beta_2 \log PF_{it} + \beta_3 \log R_{it} + \beta_4 \log I_{it} + \beta_5 DU_{it} + \epsilon_{it}, \quad (1)$$

where $i = 1,2,\ldots,N$ is the region index, $t = 1,2,\ldots,T$ is the time index, and there are altogether $n = N \times T$ observations. The yield of rice, Q_{it}, depends on the price of rice, P_{it}, price of chemical fertilizers, PF_{it}, rainfall, R_{it}, infrastructure network, I_{it}, and a dummy variable, DU_{it}, which captures political unrest.

The function is expressed as log-linear because the assumption of constant elasticities over time and regions is more appropriate than an assumption of common slopes. The β_i are the elasticities of the explanatory variables, and the disturbance term is captured by ϵ_{it}.

The coefficient of the rice price, β_1, is expected to have a positive sign. A higher output price encourages farmers to produce more because their revenues increase.

A negative sign, in turn, is expected for fertilizer price, β_2, because an increase in retail cost discourages the application of chemicals. Fertilizer price is used as an explanatory variable because the productivity of high yielding varieties (HYVs) is dependent on the application of fertilizer. In addition, fertilizer is the most costly input for Philippine farmers because it is imported, and therefore, sensitive to fluctuations in exchange rates, tariffs, and transportation cost.

Rainfall, β_3, is expected to have a positive sign because farmers generally depend on seasonal rains to irrigate the farmland.

The effect of infrastructure is measured through public roads. The construction of highways provides farmers with greater market access. Similar to studies cited earlier, this paper hypothesizes a positive relationship between roads, β_4, and output per hectare.

A dummy variable, DU, is used to measure the effect of political unrest on rice yields. The last twenty years have witnessed significant political changes in both the rural and urban areas. As such, the growth of Communist, Muslim, anti-Marcos, and Rightist movements may have disrupted the agricultural operations, and therefore rice yields. Hence, the coefficient for the political unrest variable, β_5, is expected to have a negative sign because the rise of insurgency disrupts the flow of inputs to farms, and of goods to markets.

Although other determinants of yield might be included, such as prices of alternative crops, regional data are not consistently available for many items in the Philippines. One especially important excluded input is the price of capital. For small farmers, capital is accessible mainly through informal markets. Most of the time capital is borrowed from money lenders, landlords, and relatives in exchange for a share of the expected output. Hence, while capital is clearly an important determinant of yields, it is likewise very difficult to measure.

This study uses time series data for 12 regions. This data introduces the possibility of correlation in the error terms because of events affecting several regions in a given year or peculiarities in a particular region being present over several years. Therefore, the yield equation of rice is estimated using the error components formulation for pooled time-series and cross-section data. The specific algorithm is the Fuller-Battese method (Fuller and Battese 1974), as adapted through the TSCSREG feature of the Statistical Analysis System (SAS).

DESCRIPTION OF DATA

The yield model is applied using regional data from the Republic of the Philippines from 1972 through 1990. A summary of the dependent and independent variables, together with their respective means and standard deviations, is given in Table 1.

The unrest variable requires further explanation. The unrest variable equals 1 when a region has significant Communist, Muslim, or Rightist armed operations in a year and 0 otherwise. In any given year, two regions might have different values for DU because the disturbances are often limited to one island.

Production, land, and price data come from the Bureau of Agricultural Statistics. The production statistics are variety-specific. Rice, for instance, refers to traditional varieties(TVs) and HYVs grown on both rainfed and irrigated land. Yield functions for each variety and for both together are estimated.

Actual rainfall per year, quoted from the Philippine Statistical Yearbook, is monitored from central stations around the country. From 1972 through 1976, rainfall data was available for all regions except for region 12. To complete the series, the region 11 data are used for region 12 since the two are contiguous. In 1976, four stations were closed. Consequently, rainfall data for region 1 are used for region 2; region 5 for regions 4 and 8; region 7 for region 10; and region 11 for region 12 from 1976 to 1990.

The Department of Public Works and Highways identifies the roads by type for selected years. National and provincial highways are generally made of concrete, asphalt, and gravel, while municipal, city, and village highways are of lesser quality (asphalt, gravel, and earth). Two road variables are created, the sum of the kilometers of national and provincial highways, and the sum of the kilometers of municipal, village, and city highways. The latter represents farm-to-market roads, which link the farms to local markets.

RESULTS

A relatively high correlation (0.871) between the log of the price of unmilled rice, P, and the log of the retail price of urea, PF, suggests a problem of multicollinearity. When the yield equation is estimated using the price of fertilizer, the estimated model shows many of the symptoms of a multicollinearity problem. Replacing fertilizer price with the volume applied per hectare does not help the equation. Hence, the final results of this paper exclude the price of chemical fertilizer.

TABLE 1

Summary of Dependent and Independent Variables (1972-90)

Variable	Units	Mean	Standard Deviation
Dependent Variables			
Rice Yield			
Rainfed Rice	Met. Ton/Hect.	2.093	1.444
TV* on Rainfed Land	Met. Ton/Hect.	2.327	3.342
HYV* on Irrigated Land	Met. Ton/Hect.	2.624	0.717
Independent Variables			
Unmilled Rice Price	Peso/Kilogram	1.935	1.356
Fertilizer Price	Peso/50 Kg.	142.09	70.905
Infrastructure			
Total Roads	000 Kilometers	11.325	3.940
National Roads	000 Kilometers	4.341	1.316
Local Roads	000 Kilometers	6.984	3.088
Others			
Rainfall	000 Meters	2.162	1.336
Unrest	Dummy	0.531	0.500

*TV refers to traditional rice varieties, while HYV refers to high yielding rice varieties.

Source: Bureau of Agricultural Statistics; Department of Public Works and Highways; Philippine Statistical Yearbook; relevant years.

Table 2 summarizes the estimated yield equations for rice yield in the Philippines. Equations 1 and 2 examine the elasticities of rice price, rainfall, roads, and political unrest on the rice yield of TVs and HYVs grown on rainfed agricultural land. Equation 3 analyzes the impact of the independent variables on the yield of TVs planted on rainfed land. Finally, equation 4 examines the output responsiveness of HYVs planted on irrigated land.

In the first equation, all coefficients are of the expected signs, and all but the coefficient on rainfall are statistically significant at the 5 percent level. Equation 1 shows that the national roads variable has a higher elasticity (0.39) than the local roads variable (0.25). If only the local roads are considered (Equation 2), the estimated elasticity of the local roads is 0.30.

Equation 3 shows that the rice price, rainfall, total roads, and unrest are each significant explanatory variables of TVs planted on rainfed land. The independent variables are, likewise, jointly significant at the one percent level.

Annual rainfall is expected to be more important for farmers growing purely TVs on rainfed land, because crops grown on irrigated land are not as dependent on the vagaries of the weather. While rainfall is positive but not significant in the first two equations, it has a

TABLE 2

Estimated Coefficients of Rice Yield[a], 1972-1990

Independent Variables	HYV+TV[b] Rainfed 1	HYV+TV Rainfed 2	TV Rainfed 3	HYV Irrigated 4
Intercept	-4.860	-2.013	-3.192	-0.300
	(-4.06)	(-5.44)	(-3.30)	(-0.98)
Rice Price	0.135	0.139	0.235	0.038
	(4.19)	(4.40)	(5.33)	(1.49)
Rainfall	0.034	0.031	0.208	-0.095
	(0.89)	(0.81)	(3.34)	(-2.87)
Total Roads			0.377	
			(3.62)	
National Roads	0.391			
	(2.51)			
Local Roads	0.250	0.297		0.142
	(5.54)	(7.17)		(4.02)
Unrest	-0.107	-0.104	-0.181	0.057
	(-3.35)	(-3.25)	(-3.59)	(2.05)
n	228	228	228	228
R^2	0.823	0.816	0.788	0.633
Adj. R^2	0.820	0.813	0.786	0.628
F-Value	206.4	247.2	207.2	96.2

[a]Pooled Time-Series Using Fuller-Battese Method, Log-Linear.
[b]HYV = High Yielding Varieties; TV = Traditional Varieties.

Note: T Statistics appear in parentheses.

significant positive relationship on rice yield in equation 3. The elasticity of rainfall shows that a one percent increase in rainfall improves rice yield by 0.21 percent.

The last model looks at the effect of the explanatory variables on the yield of HYVs planted on irrigated land. The national roads variable is excluded because it had the wrong sign and was statistically insignificant at the 10 percent level.

Equation 4 shows that rainfall, local roads, and unrest are individually significant at the 5 percent level. Rice price, however, is not statistically significant. The explanatory variables can only explain 63 percent of the variation in the yield of irrigated, HYVs. The relatively lower F-value and the contrary signs of both rainfall and unrest suggest that other factors may be needed to capture the economic environment of irrigated farms. On the other hand, roads and other factors are more important to the TVs, which are grown by the more isolated, less resource-favored farmers. It is from these farmers which the added production and increased yields will need to come in the future, as those who have already adopted the HYVs have already realized much of the potential gains in productivity.

The negative sign of rainfall is interesting because it is contrary to the expected relationship. Surprisingly, while rainfall is an insignificant factor in improving rainfed yields when both TVs and HYVs are grouped, rainfall is highly significant in explaining declines in the productivity of irrigated HYVs. The elasticity of rainfall implies that a one percent increase in the amount of annual rainfall reduces HYV rice yields by about 0.1 percent. The negative sign of rainfall may be explained by the fact that HYVs were introduced for irrigated land, and the experience of other Asian nations confirms that yields are higher in countries with more developed irrigation systems.

While the first three equations exhibit a significant negative relationship between political unrest and rice yield, equation 4 shows a significant positive relationship and contradicts the hypothesis of this paper. A possible explanation is that during times of unrest, farmers in irrigated areas may benefit because their relatively developed infrastructure facilities may provide better access to the markets. Since most larger farmers use HYVs, unrest may also lead landowners to mobilize their private armies to secure transportation routes, thereby profiting from the reduced quantities in the market. Anticipating shortages in the market, they may take additional measures to maximize yields in times of unrest.

A comparison of the four equations reveals that the elasticities of the rice price are similar for equations 1 and 2, an average of 0.137, while equation 4 has a much lower price elasticity of 0.038. On the other hand, the own-price elasticity of traditional rice growers (equation 3) is 0.235. This finding suggests that traditional rice farmers on rainfed land are relatively more responsive to changes in output price, which implies they can be affected relatively more by price-enhancing policy efforts.

The road variables show elasticities on rice production that are greater than the own-price elasticity. In equation 1 where both national roads and local roads are included, the national roads variable has a larger impact. The results indicate that an increase in the kilometers of roads would have substantial effects on rice yield, presumably because the price at the farm gate would be higher as the cost of transporting the crop to market falls.

SUMMARY AND IMPLICATIONS

This paper found that the estimated equations for Philippine rice yield are generally consistent with the specified theoretical model. The estimated equations illustrate that the rice price, rainfall, roads, and unrest are significant in explaining the variation in rice productivity. The findings support the hypothesis that roads have significant positive effects on output per hectare.

Obviously roads have a much broader impact than just on agriculture and investments in rural roads is an expensive way to improve the lot of farmers, if that is the only goal. More and better roads reduce transportation costs for all people served by those roads, including many non-farm businesses. Better roads improve market access, making exports from a region more competitive and reducing the costs of imports to a region, including consumer goods and inputs to agriculture and other businesses. However, within the broad setting of development, investments in rural roads can benefit the rest of the country by increasing food production.

This paper's findings show that national and provincial highways are important, but local roads are also crucial in boosting rice productivity. Investing in these relatively cheaper roads may be an attractive option for policy makers faced with growing budget deficits and rising public debts. Although local roads are only made of asphalt, gravel, and earth, this study shows that there are significant positive effects on the yield of rice farmers as isolated rural areas become linked with markets and marketing agents.

As such, the construction of village roads may also serve to more widely distribute the gains from economic growth. The increase in rice yield, due to easier access to markets and lower transportation costs, could lead to higher household incomes. In turn, the standard of living in rural areas may improve as the economy continues to grow.

The development of local roads is, likewise, consistent with the government's policy of becoming self-sufficient in the staple crop. The attainment of this goal could result in the reduction of the country's rice imports, and consequently improve the economy's balance of trade.

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ENDNOTE

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