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DISCUSSION PAPER SERIES NO. 2012-12

April 2012

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Recent literature indicates the significant role played by rural infrastructure in improving agricultural productivity in developing economies. While the availability and quality of rural infrastructure are never substitutes to efficient macroeconomic and agriculture-specific policies and the effective implementation of such policies, inadequate infrastructure can be a significant constraint to growth and productivity. Rural infrastructure, like other public investments, raises agricultural productivity, which in turn induces growth in the rural areas, bringing about higher agricultural wages and improved opportunities for non-farm labor. The rise in agricultural productivity, which reduces food prices, benefits both urban and rural inhabitants who are net food buyers. Thus, aside from its growth benefits, agricultural productivity has significant poverty reduction effects. The paper's overall empirical results indicate a significant link between rural infrastructure and agricultural productivity. Electricity and roads are significant determinants of agricultural productivity. This is consistent with a related finding on the constraints imposed on growth by inadequate infrastructure. Rural roads provide the important connectivity with growing markets adjacent to rural areas; they also lessen input costs and transaction costs of rural producers and consumers. Access to electricity creates various income-earning opportunities for rural households

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Gilberto M. Llanto[1]

1.   Introduction

Recent literature indicates the significant role played by rural infrastructure in improving agricultural productivity in developing economies. While the availability and quality of rural infrastructure are never substitutes to efficient macroeconomic and agriculture-specific policies and the effective implementation of such policies, inadequate infrastructure can be a significant constraint to growth and productivity. Research shows that productivity increase in agriculture, which is an effective driver of economic growth and poverty reduction, depends on good rural infrastructure, well-functioning domestic markets, appropriate institutions, and access to appropriate technology (Andersen and Shimokawa 2007).

The relatively low productivity of Philippine agriculture has tested the policymaking skills of the country's leaders and the implementation capacity of bureaucrats who have to make good use of the billions of pesos that are annually allocated and appropriated to the agriculture sector. The inadequacy of rural infrastructure has been cited as a major reason for low agricultural productivity. But how important is rural infrastructure in raising agricultural productivity?

This paper provides an empirical basis for the perceived link between rural infrastructure and agricultural productivity. It validates the hypothesis that deficiencies in rural infrastructure e.g., transportation, energy, and related infrastructure have an adverse impact on agricultural productivity. Rural infrastructure, like other public investments, raises agricultural productivity,

which in turn induces growth in the rural areas, bringing about higher agricultural wages and improved opportunities for non-farm labor. The rise in agricultural productivity, which reduces food prices, benefits both urban and rural inhabitants who are net food buyers. Thus, aside from its growth benefits, agricultural productivity has significant poverty reduction effects.

Good infrastructure has other ancillary and equally important effects. Fan and others (2004) show that improved roads lead to the rise of small rural non-farm businesses, such as food processing and marketing enterprises, electronic repair shops, transportation and trade, and restaurant services. Rural infrastructure provides a good stimulus to the growth of the rural economy.

The literature indicates that rural infrastructure fosters physical connectivity and promotes better integration of rural and agriculture areas with growing urban markets, which, in turn, are linked to the global trading markets, thereby stimulating economic growth and creating poverty reduction opportunities in those areas. With good infrastructure lagging regions can catch up with more progressive areas, leading to more balanced growth. Manasan and Chatterjee (2003) find that better allocation of infrastructure investments across regions helps lagging regions to catch up and increase their growth potential. Gill and Kharas (2007) note the growing regional integration of East Asian economies that have earlier successfully integrated into the global economy on an individual-nation basis. The high quality infrastructure of East Asian economies is an important factor behind their successful integration into the global economy.

It seems ironic that the Philippine government has under-invested in infrastructure and their proper maintenance despite of the "well-documented importance of rural infrastructure to promote growth and poverty reduction, high economic rates of return to investments in rural infrastructure, and significant deficiencies of rural infrastructure. . . (Andersen and Shimokawa

2007, page 1). The under-development of infrastructure has serious consequences for the country's competitiveness and in particular for its growth and poverty reduction targets, including the Millennium Development Goals (World Bank 2005). The inability of government to broaden its fiscal space has constrained the provision of infrastructure, and thus, years of neglect have resulted in ill-maintained irrigation systems, costly electricity, rural roads in extremely bad condition, all of which have taken their toll in terms of lower productivity and lower level of welfare in the rural areas.

The paper is organized as follows: after an introduction Section 2 provides a brief review of related literature. Section 3 gives an analytical framework, an overview of the approach taken for the empirical estimation, and a discussion of the data used in the estimation. Section 4 analyzes the results of the estimation and their implications. The last section gives some concluding observations.

2.   **Review of literature**

Empirical studies show that deficiencies in infrastructure could be a critical development constraint. The ADB (2007) finds that poor infrastructure and lack of investment in infrastructure have constrained growth. Poor infrastructure, a major factor for increasing the cost of doing business, has significant adverse impact on the perceived competitiveness and attractiveness of the Philippines as an investment destination.

That there is a critical link between infrastructure and regional growth has been indicated in t causality tests showing that the direction of causation runs from infrastructure to economic growth, and that regional imbalance in infrastructure availability has a negative impact on a region's economic growth prospects (Llanto, 2007a; Llanto, 2007b). Differences in availability of infrastructure have led to differences in regional growth in the Philippines (Basilio and Gundaya, 1997; Llanto, 2007b; Manasan and Chatterjee, 2003). There is evidence that infrastructure could be a key variable in regional convergence (Llanto 2007a; Cuenca 2004).

While there is varying opinion and contrasting empirical findings among researchers about the link between infrastructure and growth, the preponderance of evidence seems to show that inadequate supply of infrastructure or the unreliability of infrastructure services may constrain investments of productive capital and lead to a restriction or reduction of output.

Table 1 shows the significant role that rural infrastructure plays on agricultural productivity and development (Andersen and Shimokawa 2007).

Table 1. Effects of Infrastructure on Agricultural Productivity in Developing Countries

Country	Year	Method	Source	Endogeneity	Ag. Productivity	Infrastructure	Effect
China	1997	SEM	Fan, Zhang and Zhung (2002)	Yes	Ag. GDP	Inv. in Irrigation	1.88
						Inv. in Road	2.12
						Inv. in Electricity	0.54
						Inv. in Telephone	1.91
	1982-99	SEM	Fan and Chan-Kang (2005)	Yes	Ag. GDP	+1 km of High-quality Roads	- 1.6 million
					Ag. GDP	+1 km of Low-quality Roads	-
India	1970-71	CLS	Antle (1984)	No	Rice Production	Inv. in High-quality Roads	1.57 0.28**
	1960-81		Binswanger, Khandker	Yes	Aggregate Output Index	Inv. in Low-quality Roads	0.21** 0.026
	1970-94	SEM	and Rosenzweig (1990)	Yes	TFP	Irrigation	0.028*
						HYV	0.057*
			Fan, Hazell, and			Irrigation	0.036*

Country	Period	Method	Study		Dependent Var	Infrastructure	Coefficient
	1971-94	GMM	Thorat (2000)	Yes	TFP	Electricity	0.004
						Road	0.081**
			Zhang and Fan			Irrigation	0.042**
Indonesia	1971-98	PC	(2004)	No	Ag. GDP	Electricity	0.039**
						Irrigation	0.084**
Thailand	1971-95	PC	Mundlak, Larson	No	Ag. GDP	Road Density	0.083**
			and Butzer (2002)			HYV	0.081**
			Mundlak, Larson			Road	0.103**
	1977-	SEM	and Butzer (2002)	Yes	Ag. Output	Irrigation	0.045**
	2000				(baht)	Road	0.71
Philippines	1961-98	PC	Fan, Jitsuchon and	No	Ag. GDP	Irrigation	0.86
			Methakunnavut			Electricity	0.01**
Vietnam	1993-	SEM	(2004)	Yes	Ag. Total	Inv. in Irrigation	
	2003		Mundlak, Larson		Product Value	Inv. in Roads	0.42
67 LDCs	1961-90	CLD w/	and Butzer (2000)	No	Output per	Irrigation	3.01
		dummies	Fan, Huong and		Worker		0.012
43 LDCs	1980-98	CLS	Long (2004)	No	FAO Ag.	Inv. in Irrigation	-0.29**
			Craig, Pardey and		Output Index	Inv. in Roads	0.201**

Roseboom (1997)		Road Density	0.245**
Fan and Rao		% Irrigated Land	0.177*
(2003)		Road	
		Irrigation	
		Road Density	

Note: (1) Ag = Agriculture; Inv. = Investment; SEM = simultaneous equation model; TFP = total factor productivity.

(2) – indicates that data are not available.

(3) The coefficients with ** and * are statistically significant at the 5% and 10% level, respectively, when the test is applicable.

Following Andersen and Shimokawa (2007) deficiencies in transportation, energy, telecommunications, and related infrastructure translate into poorly functioning domestic markets with little spatial and temporal integration, low price transmission, and weak international competitiveness. The failure to invest in rural infrastructure would be a critical bottleneck for future growth in agricultural and economic output and poverty alleviation in developing countries. Indeed, severe rural infrastructure deficiencies undermine the huge potential of the agriculture sector in developing countries to contribute to growth and poverty reduction. Improved rural infrastructure will reduce poverty through improved agricultural productivity and through improved wages and non-farm employment. There are significant trickle-down benefits for the poor (Fan, Hazell and Thorat 2000).

The great interest in growth in agricultural output and agricultural productivity is well founded. Agriculture's relatively large share in GDP and employment underscores its great importance in developing countries. Andersen and Shimokawa call the agriculture sector a major "driver of economic growth," provides a "crucial foundation for economic growth in both agricultural and non-agricultural sectors" (page 2). The agriculture sector's growth and development can help address major development constraints, e.g., distributional issues and poverty reduction in developing countries (Hazell and Roell 1983; Delgado and others 1998; Fan and Rao 2003).

The elasticity of poverty reduction with respect to agricultural productivity is significant, positive and higher than the elasticity with respect to other sectors' productivity, especially in the early stages of development (Ravallion and Datt 1996; Thirtle and others 2003). This is certainly a highly significant finding, which supports the viewpoint that ensuring the productivity of agriculture is a critical development strategy that creates pathways to growth. Antle (1983)'s study of 47 less developed countries and 19 developed countries

confirms the hypothesis that transportation and communication infrastructure contributes to the explanation of aggregate agricultural productivity in those countries. Fan and others (2004) find that public investments in agricultural research and development, irrigation, rural education, and infrastructure (including roads and electricity) have positive marginal impacts on agricultural productivity growth and rural poverty reduction in Thailand. Mamatzakis (2003) indicates that public infrastructure reduces the total cost of Greek agriculture; specifically, a 1% increase in public infrastructure investment is found to reduce the total cost of livestock and crop production by 0.38%. Thus, the decline in public infrastructure investment in the 1970s and 1980s adversely affected the productivity of Greek agriculture. On the other hand, public investments in agricultural research, road density, and life expectancy are important explanatory factors in explaining cross-country differences in agricultural productivity (Craig and others 1997).

Webster and others (2003) find that investments in the rural areas, including rural infrastructure, are important for two reasons: (a) it creates an environment in which all citizens can enjoy basic living standards and (b) through better rural-urban linkage, it provides positive returns to both urban and rural dwellers.

Efficient transportation infrastructure lowers the costs of labor-market participation, that is, travel time and cost, including search cost and thus, eliminates an important barrier to labor market entry. Better physical infrastructure helps lower food costs for urban dwellers and allows rural labor to seek higher paying jobs in the urban areas. Thus, the provision of roads and human capital investment (schooling) has a positive impact on the welfare of poor households (Balisacan and Pernia 2002). Access to all-weather roads increases the level of consumption by 16% and reduces the incidence of poverty by 6.7% (Dercon and others 2007).

Studies using aggregative infrastructure data fail to reveal which types of infrastructure have the most significant impact on agricultural productivity. Dercon and others (2007) observe that those studies did not state whether it is the quantity of infrastructure that matters or its quality, and in the absence of distributional data, did not demonstrate the impact on poverty reduction. It is important to identify which type of rural infrastructure yields the most significant impact for a more efficient allocation of resources. Those studies that use household-level data usually generated from surveys provide a clearer picture of the effect of rural infrastructure on agricultural output and poverty alleviation.

A study of Indian agriculture, finds that government investment in roads had a positive effect on crop output, rural non-farm employment and agricultural wages (Khandker 1989). Government spending on productivity-enhancing investments such as agricultural R&D, irrigation, and rural infrastructure in rural India contributed to reductions in rural poverty and contributed to growth in agricultural productivity. The largest impacts on poverty reduction and growth in agricultural productivity are brought about by government expenditures on roads and R&D. Irrigation investment only has a modest impact on growth in agricultural productivity and poverty reduction (Fan, Hazell and Thorat 2000). In a study of rural high-quality roads were found not to have a statistically significant impact on agricultural GDP while low-quality roads were not only significant but also generated 1.57 yuan of agricultural GDP for every yuan invested. On the other hand, every yuan invested in low-quality roads yields more than 5 yuan of rural non-farm GDP (Fan and Kang 2005).

More recent research on rural China (Fan, Zhang and Zhang, 2002; Thorat and Fan, 2007) indicates that agricultural research investment has the largest impact on agricultural production. An interesting finding is that, for every 10,000 yuan invested, 3.2 poor are lifted above the poverty line. Roads, thus, rank third in poverty reduction impact, after education and

R&D. In contrast, for every 10,000 yuan invested in government poverty alleviation loans, only slightly more than one person is brought out of poverty. The effect is only 13% that for education, 15% that for agricultural R&D, 50% that for rural infrastructure and is even smaller than that for irrigation.

In the Philippines, there are few empirical studies on the impact of rural infrastructure on agricultural productivity. A study by Evenson and Quizon (1991) shows that roads have a significant impact on inputs and outputs with substantial net profit effects while rural electrification has a minimal impact on output. In their examination of the productivity performance of Philippine agriculture, Teruel and Kuroda (2004) find a higher total factor productivity (TFP) estimate during the late 1970s, followed by a discernible decline in the 1980s and 1990s. Public infrastructure was behind the higher productivity growth in the period 1974-1980. On the other hand during the 1980s, it was technological change that spurred productivity growth. Overall, the decline of productivity in Philippine agriculture could be partly explained by the reduced provision of rural infrastructure.

Table 2 shows the few local studies on productivity growth in Philippine agriculture.

Table 2: Productivity Studies on Philippine Agriculture, by Approaches: 1986-2005

Authors	Year	Years	Productivity	Methodology
Growth Accounting Approach				
Evenson and Sardido	1986	1950-1984	0.0190	Growth Accounting Method

Fulginiti and Perrin	1998	1961-1985	-0.0250	Growth Accounting Method
Martin and Mitra	1999	1967-1992	0.0207	Growth Accounting (Actual Factor Share)
Cororaton and Cuenca	2001	1980-1998	-0.0056	Growth Accounting Method
Index Number Approach				
Teruel and Kuroda	2005	1974-2000	0.0162	Index Number Approach (Törnqvist Index Procedure)
Coelli and Rao	2003	1980-2000	0.0130	Index Number Approach (Törnqvist Index Procedure)
Econometric Approach				
Fulginiti and Perrin	1998	1961-1985	0.0010 0.0180	Production Function (Variable Coefficient) Production Function (Fixed Coefficient)
Martin and Mitra	1999	1967-1992	0.0164 0.0157	Translog Production Function Cobb-Douglas Production Function
Mundlak, Larson and Butzer	2004	1961-1998	0.0025	Production Function (With State Variables)

Teruel and Kuroda	2004	1974-2000	0.0051	Translog Variable Cost Function
Teruel and Kuroda	2005	1974-2000	0.0091	Cobb-Douglas Production Function
Teruel and Kuroda	2005	1974-2000	0.0142	Translog Cost Function
Malmqvist Approach				
Trueblood and Coggins	1997	1961-1991	0.0119	Malmqvist Index
Arnade	1997	1961-1993	-0.0040	Malmqvist Index
Fulginiti and Perrin	1998	1961-1985	-0.0030	Malmqvist Index
Coelli and Rao	2003	1980-2000	0.0080	Malmqvist Index

Source: Teruel, R. (2007), "Productivity growth in Philippine agriculture: a literature review," unpublished paper.

Recently Manalili and Gonzales (2009) indicated that good road infrastructure and irrigation facilities improve farm profitability and productivity. They point out that nitrogen fertilizer, pesticides, and irrigation are positively correlated with yield and significantly affect it. Road structure affects the price of urea fertilizer, which is more expensive in areas with poor roads owing to higher transportation costs incurred in the purchase of this input. Farmers tend to apply more nitrogen fertilizer because of the lower price brought about by lower transportation costs.

3.   **Analytical framework**

From the brief review of literature the following questions are raised in this paper:

- Is rural infrastructure a significant determinant of agricultural productivity?

- How does rural infrastructure affect agricultural productivity?

- What type of rural infrastructure has the most pronounced impact on productivity?

- Can rural infrastructure explain regional differences in agricultural productivity?

- What explains the present state of rural infrastructure?

- What policy and investment levers may be tapped to address the gap in the provision of infrastructure?

To handle these questions and conduct an empirical investigation, Andersen and Shimokawa's analytical framework shown in Figure 1 is a convenient reference point.[2] The approach to the empirical estimation of this paper's hypothesis that physical infrastructure has a positive impact on agricultural productivity, and the discussion of the data and limitations are given in **Annex A.**

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[2] Their analytical framework echoes the earlier work on this area of research by Binswanger, Khander and Rosenzweig (1993).

Figure 1 describes the causal relationship between physical infrastructure and agricultural productivity. Other factors determining or influencing agricultural productivity such as agricultural research and technology, institutions, civil society organizations and farmers' behavior, are also shown. These other factors influence agricultural output and productivity in varying degree, given certain contextual factors such as agro-ecology, climate, cultural, legal, political and social factors. While an empirical investigation of these factors' impact on and interaction with agricultural productivity is interesting and important, it is outside the scope of the paper. Instead, the paper focus is limited to finding out whether there is empirical evidence to support the hypothesis that deficiencies in rural infrastructure exert a significant negative influence on agricultural output and productivity. Hence, failure to invest in rural infrastructure and maintain it will have a deleterious effect on the productivity of the agriculture sector.

Physical infrastructure has both direct and indirect effects on agricultural productivity. Physical infrastructure may be divided into two groups: (a) water supply and sanitation sectors and (b) other sectors, e.g., irrigation, energy, telecommunications and transportation sectors because infrastructure affects agricultural development through different channels. Water supply and sanitation influences the health status of rural dwellers and their productivity. Consumption of safe water and a healthy environment of the household through sanitation will contribute to the physical well-being of rural dwellers and the improvement of rural human capital that contributes to higher worker (agricultural) productivity.

The second group of infrastructure (electricity, telecommunications, irrigation and transportation) directly impacts on productivity by providing farmers and rural households with feasible options for production, processing, marketing and distribution. Investments in

these production-enhancing types of infrastructure create the conditions for improved agricultural productivity.

Physical infrastructure affects agricultural output and productivity through the facilitation of the creation of institutions such as domestic markets and financial institutions that enable rural inhabitants to have easier access to input and output markets and liquidity and credit, respectively. Community-based organizations such as farmer organizations will find it easier to assist farmers because of the mobility and ease of transportation and communications provided by good rural infrastructure. Better roads lower the transactions costs of farmers as inputs become more accessible and farm produce are more easily marketed. Greater mobility through physical infrastructure including telecommunications, which facilitates communication between consumers and producers, permits entry into new and possibly more profitable opportunities.

Microfinance institutions will be encouraged to provide credit to hard-to-reach areas, which have been excluded from the formal credit markets because of their inaccessibility. Because of improved rural roads and transport, and access to telecommunications facilities banks will find it easier to establish rural branches to provide financial services to farmers and other rural clients. In short, good infrastructure will contribute to improve rural financial intermediation. Community-based organizations such as farmers' organizations, agriculture-based cooperatives etc. can better assist farmers and other rural-based clients with information, and technical assistance in marketing, distribution and others that those clients need to exploit growth potentials in the countryside.

Figure 1. How Physical Infrastructure Promotes Agricultural Development
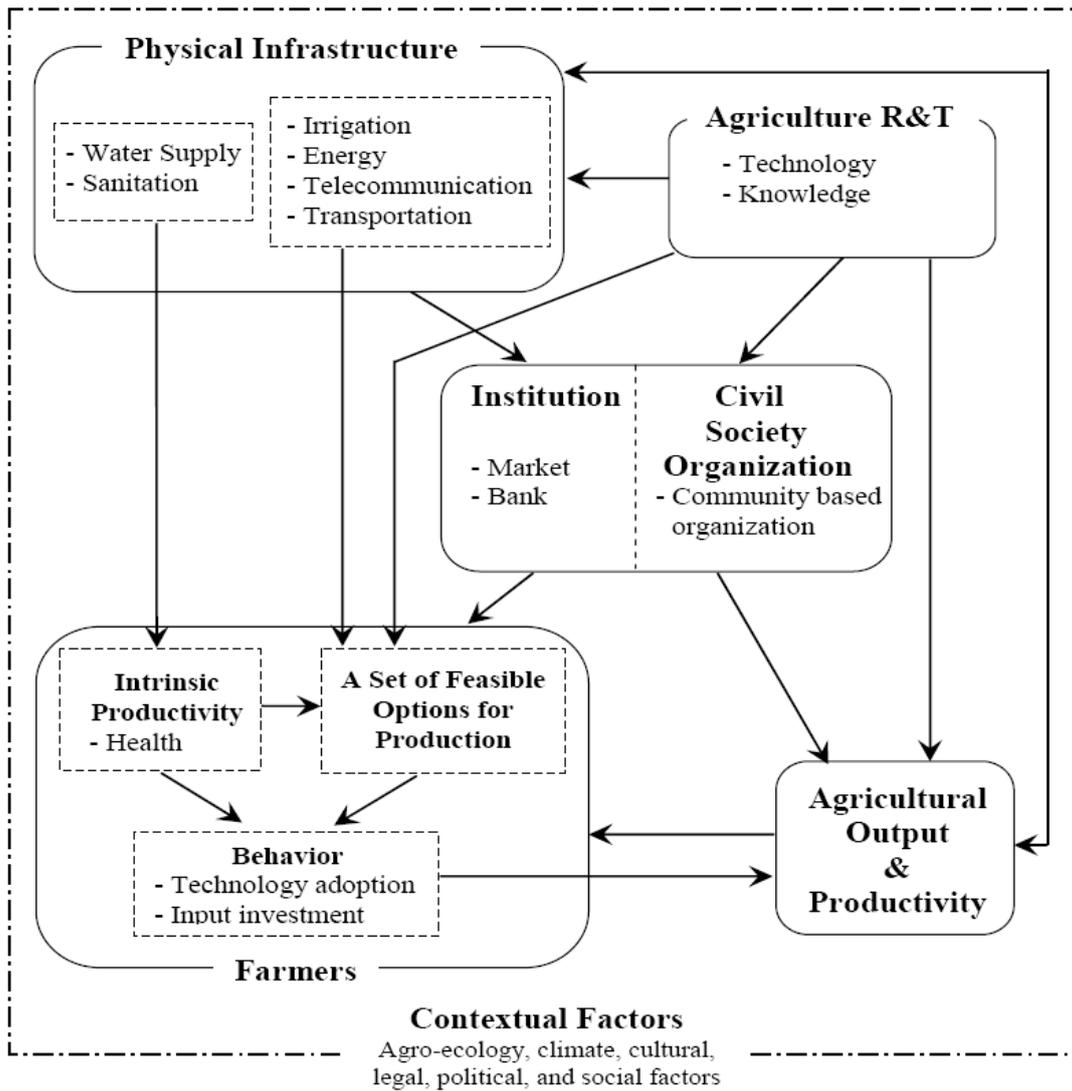
Source: Andersen and Shimokawa (2007)

4.   **Empirical findings**

The empirical estimation showed the positive and significant impact of access to electricity and paved roads on agricultural labor productivity (**Tables 3** and **4**). Irrigation has a positive but insignificant relationship with agricultural labor productivity. Agricultural labor productivity follows diminishing returns to wages. Because wages impact on the productivity of agricultural workers, they are included as an explanatory variable. The functional form for wages was specified to be quadratic in order to take into account diminishing marginal productivity of wages, that is, an extra unit of wage would result in less than 1 unit increase in agricultural labor productivity. The result on wages is consistent with the general observation about the incentive effect of wages on raising productivity. Diminishing returns set in once the level of productivity cannot anymore absorb the cost impact of rising wages.

Table 3. Infrastructure and Agricultural Labor Productivity (Model 1)

Random-effects GLS regression		Number of obs	=	54
Group variable: regions		Number of groups	=	9
R-sq: within	= 0.4223	Obs per group: min	=	6
between	= 0.5662	avg	=	6.0
overall	= 0.5491	max	=	6
Random effects u_i ~ Gaussian		Wald chi2(6)	=	37.21

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corr(u_i, X)   = 0 (assumed)   Prob > chi2   =

0.0000

| laborprod | Coef. | Std. Err. | z | P>|z| | [95% Conf. Interval] |

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laborprod	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnwage	6536.793	3032.094	2.16	0.031	593.9987	12479.59
lsqnwage	-6874.889	1853.869	-3.71	0.000	-10508.41	-3241.372
ltotal_irr area	514.9217	1680.942	0.31	0.759	-2779.664	3809.507
lrain	4497.903	1776.949	2.53	0.011	1015.147	7980.658
energy	18128.37	6235.531	2.91	0.004	5906.953	30349.78
ratpaved	303.5236	174.3923	1.74	0.082	-38.27908	645.3262
_cons	7246.2	21707.82	0.33	0.739	-35300.35	49792.75

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        sigma_u          7336.3157

       sigma_e           2644.9045

         rho                    .88497436   (fraction of variance due to u_i)

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The regression results of the second model in **Table 4** similarly indicate (a) diminishing returns to wages of agricultural labor productivity and (b) a positive and significant relationship of agricultural labor productivity with access to electricity and paved roads. For electricity, a 1 percentage point increase in the number of households with electricity relative to total number of households is associated with an increase of about 22 million pesos/agricultural worker in agriculture productivity. For roads, a 1 percentage point increase in the length of paved roads as a ratio to total length of roads is associated with an increase of about 285 thousand pesos/agricultural worker in agriculture productivity. The other variables, irrigation and rainfall, follow the expected sign but are not significant explanatory variables.

Table 4. Infrastructure and Agricultural Labor Productivity (Model 2)[3]

Random-effects GLS regression   Number of obs   =   54

Group variable: regions   Number of groups =   9

R-sq: within   = 0.4312   Obs per group: min =   6

   between = 0.6033   avg   =   6.0

   overall   = 0.5829   max   =   6

Random effects u_i ~ Gaussian   Wald chi2(6)   =   44.70

corr(u_i, X)   = 0 (assumed)   Prob > chi2   =   0.0000

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laborprod   Coef. Std. Err.   z   P>|z| [95% Conf. Interval]

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[3] *Laborprod*=the ratio of agriculture gva to total employment in agriculture ; *wage* =nominal wage per person employed in agriculture; *irrigdens* = irrigated area as a ratio of total area of the region; *rain density* = total amount of rainfall as a ratio to total area of the region; *energy* = the total number of households with electricity as a ratio to total number of households in the region; *ratpaved* – the ratio of the total length of paved roads to total length of road.

wage	-39.06324	19.01673	-2.05	0.040	-76.33535	-1.79113
sqnwage	.0186406	.0309676	0.60	0.547	-.0420547	.0793359
irrigdens	56.10786	350.6492	0.16	0.873	-631.152	743.3678
raindens	305500.3	270770.4	1.13	0.259	-225199.9	836200.5
energy	22170.35	5929.265	3.74	0.000	10549.2	33791.49
ratpaved|	285.0375	156.8935	1.82	0.069	-22.46817	592.5431
_cons	-1969.128	3429.14	-0.57	0.566	-8690.119	4751.862

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sigma_u | 3928.0442

sigma_e | 2542.8151

rho | .70469154   (fraction of variance due to u_i)



Overall, the results of the empirical estimation in this paper indicate the importance of physical infrastructure in raising agricultural labor productivity. The results are consistent with empirical findings of other researchers in various countries as discussed in the review of literature above. These results also tend to support earlier empirical findings showing that

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infrastructure has a significant impact on regional GDP growth (Llanto 2007b), that inadequate infrastructure acts as a binding constraint to economic growth and that infrastructure Granger-causes economic growth (Llanto 2008).

Good-quality roads, that is, paved roads, contribute to the physical integration of rural areas with urban areas, which result in access to faster growing urban markets. Paved, all-weather roads provide the connectivity to markets that rural producers and consumers must have in order to satisfy their respective investment and consumption requirements. Good roads create economic opportunities to which enterprising rural households may positively respond. They open opportunities for sourcing relatively cheaper inputs and for marketing or trading rural produce at better prices from diverse markets, which would have been out of reach without good roads. Olsson (2008) found that road improvements led to changes in investment, production and production system, employment, transport service supply and demand in a fishing community in the Philippines. Olsson counted as direct effects of improved road accessibility a 35% decline of fuel consumption, a 44% reduction in maintenance costs and a 40% decrease in travel time as reported by household-firms in the fishing community. Among the indirect effects cited was the stronger complementarity between the resource market (Manila, an urban area) and the resource area (fishing community in the Pacific side of the country), which released pent-up potential for trade and investment, competition and production. Before the road project (1995), around half of the medium-sized vessel owners delivered fish to Manila while others delivered to Infanta, a small neighboring municipality. After 1995, almost all of those vesssel owners delivered fish to Manila and a large neighboring city, Lucena; after 1997, 60% of small dealers who had only delivered fish to Infanta town began delivering to other destinations as well.

A cursory investigation of the data set revealed interesting patterns that tend to support the hypothesized relationship between physical infrastructure (roads) and agricultural productivity. **Figure 2** shows an increasing trend for agricultural labor productivity and paved roads in Regions 1 and 2 and the Cordillera Administrative Region over the period 1991-2006. A similar phenomenon is seen in Regions 3, 5, 6, 7 and 8 over the same period[4].
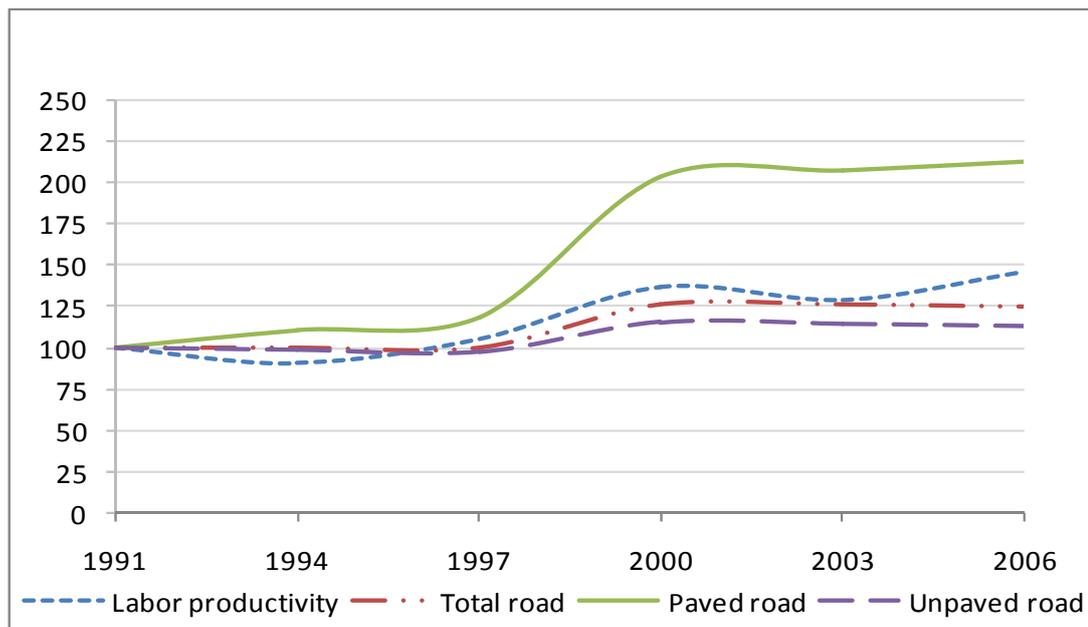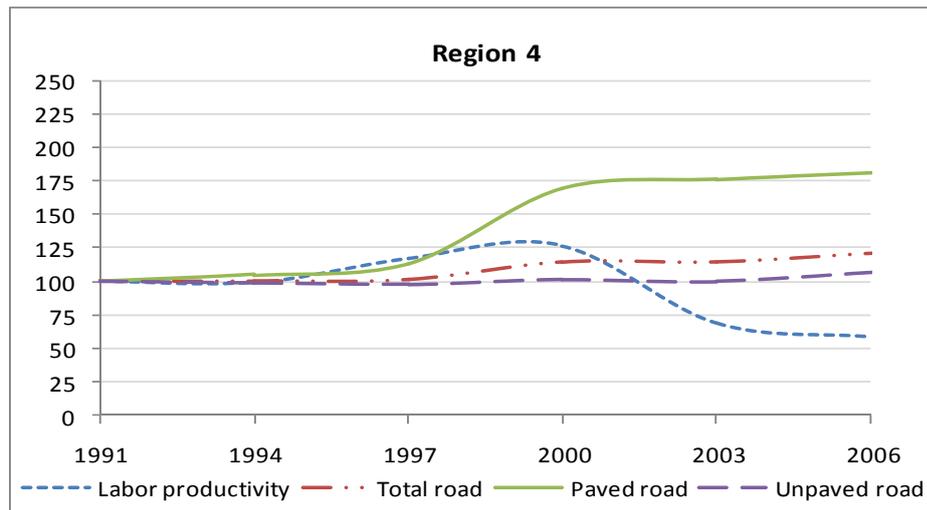

Figure 2. Trends in agricultural labor productivity and paved roads, Regions 1, 2 and the Cordillera Administrative Region, 1991-2006

The downside is that easier access contributes to greater mobility of productive labor who move to better paying non-agricultural sectors. The phenomenon of young rural and agricultural workers leaving the countryside in search of better opportunities in the urban areas and even outside the country has been noted by the popular press and a few academic studies. This may be the situation in Region 4 where data indicate an increasing trend for total length of paved and unpaved roads and a decreasing trend for agricultural productivity (**Figures 3** and **4**). Region 4 is one of the faster growing regions in the country with cities such as Lipa,

[4] Because of space limitations, the charts for some regions are not shown but may be shared upon request.

Batangas, Tanauan, San Pablo and Lucena attracting investors, professionals and rural folks alike. In Regions 10, 11 and CARAGA, the major city is fast-growing Cagayan de Oro City, which has become a prime investment destination because of such factors as good ports and road infrastructure and a business-friendly investment climate.
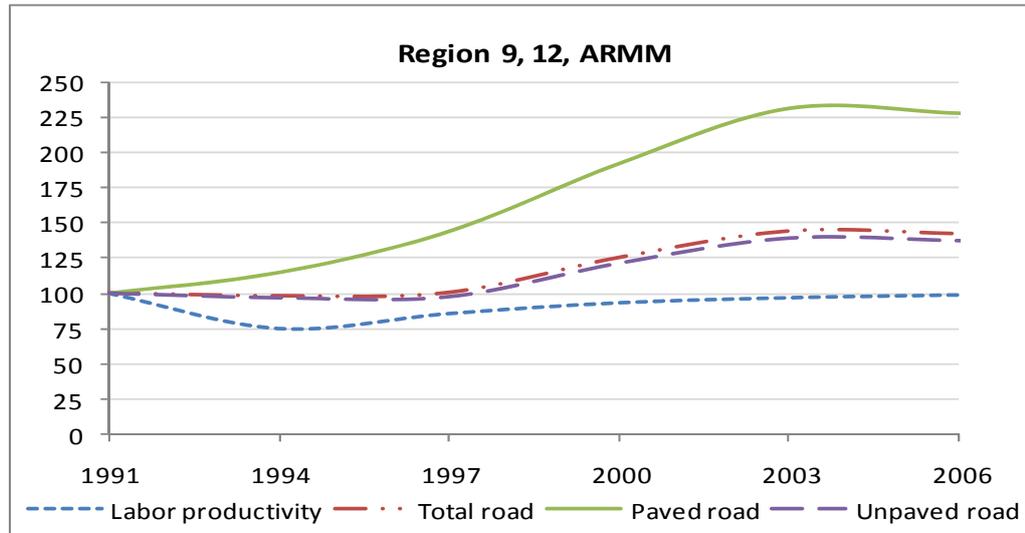

Figure 3. Trends in agricultural productivity and roads, Region 4, 1991-2006
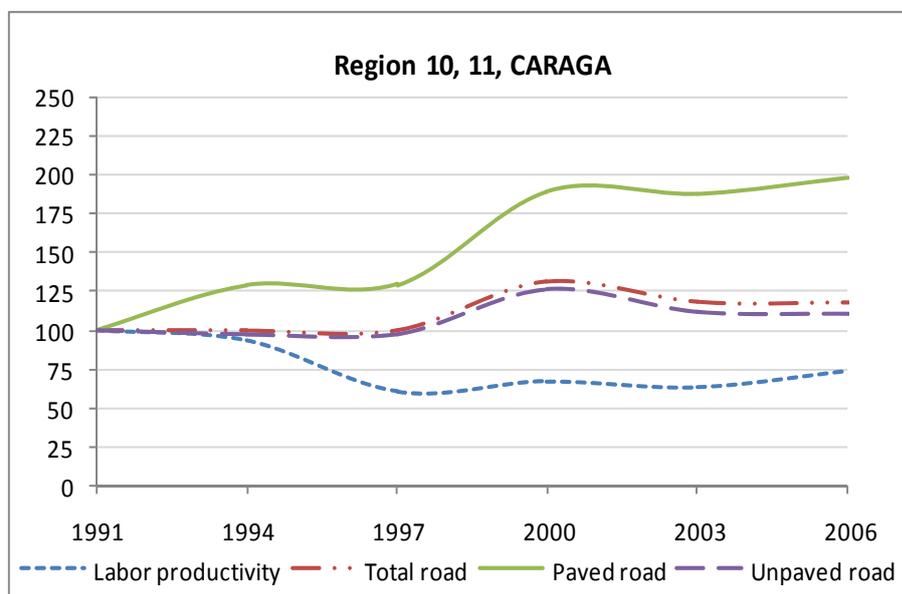
Figure 4. Trends in agricultural productivity and roads, Regions 10, 11 and CARAGA, 1991-2006

It is noted that improved physical connectivity brought by good roads may increase the mobility of labor resulting in a negative spillover effect in the form of emigration of young and productive labor from the countryside. However, this may be offset by remittances earned from employment in fast-growing urban areas. Good-quality roads also enable rural households to generate non-farm and off-farm incomes from economic opportunities that present themselves to those households. Thus, the emigration effect of good roads may be somewhat mitigated by a decision to stay in the familiar environment of the countryside where earning opportunities from non-farm and off-farm economic activities have been enhanced by a good road network. Olsson did not detect mass emigration from the fishing community to cities but rather an increase in selling activity to various urban markets that have been made accessible by the construction of all-weather roads.

In Regions 9, 12 and the Autonomous Region of Muslim Mindanao (ARMM), agricultural labor productivity is almost stagnant in contrast to the increasing trend of total length of paved and unpaved roads (**Figure 5**). Peace and order problems are contributory to the stagnation of agricultural labor productivity in spite of the increasing trend for quality (paved) roads.

Region 9, 12, ARMM

Legend: Labor productivity --- Total road — Paved road — Unpaved road

Figure 5. Trends in agricultural productivity and roads, Regions 9, 12 and ARMM

Rural households, microentrepreneurs, and other rural-based economic agents directly benefit from having access to electricity. Access increases agricultural labor productivity by expanding the range of economic activities available to rural households, e.g., operating poultry and livestock farms, more efficient storage of produce and food for home consumption and sale to urban markets through refrigeration and other facilities, non-farm and off-farm economic activities such as food processing and other micro-enterprise activities, and better telecommunications facilities in the countryside. Access to electricity by households may act as a proxy for access to and size of market. In general, this is because electricity distribution is extended only to where the density of purchasing power is high enough to justify the cost of expansion. Looking at access to electricity as indicative of the size of markets supports the earlier contention of this paper that improved roads connect rural areas to fast-growing markets. Physical connectivity makes it possible for rural dwellers to take advantage of fast-growing urban markets as exemplified by the findings of Olsson. On the other hand, visual

inspection of trends for Regions 1, 2, the Cordillera Autonomous Region, 5, 6, 8, 10, 11 and CARAGA shows the same upward trends for agricultural labor productivity and electrification. **Figure 6** shows it for Region 5.
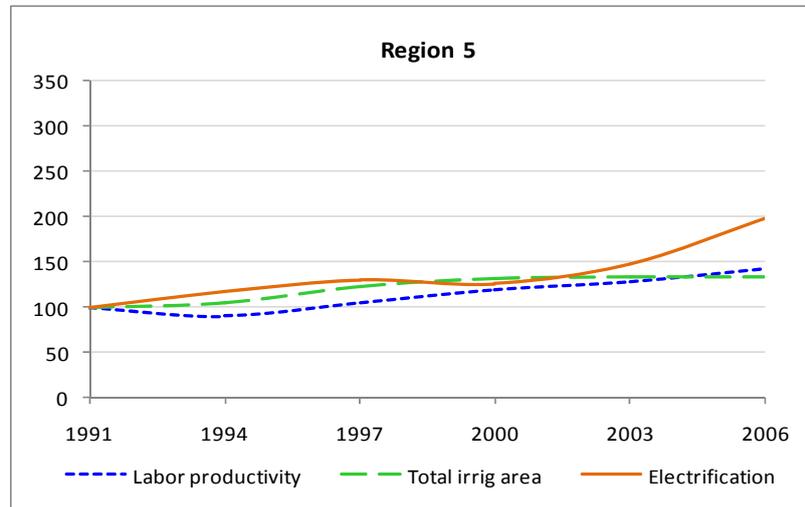
Figure 6. Trends for agricultural productivity, irrigation and electrification, Region 5, 1991-2006

In Regions 9, 12 and ARMM, agricultural labor productivity seems stagnant even as electrification shows an upward trend. Electrification looks stagnant for Regions 3 and 4, which could indicate a saturation point because these regions have faster electrification than other regions by virtue of their proximity to Metro Manila.

Irrigation did not turn in as a significant explanatory variable, although it is positively associated with agricultural labor productivity. There may be two reasons that may have muted the impact of irrigation on agricultural labor productivity: (a) it benefits mostly the rice sector, whose share in agricultural value added has been declining relative to other commodities and (b) since the 1990s, government has not made significant investments in

irrigation.[5] The first reason appears plausible. David (2003) points out that the growth rates of all commodities (rice, corn, etc.), except livestock and poultry, have been declining over the past four decades. The second reason has to be qualified. Inocencio and Barker (2006) observe that despite two key laws in the 1990s that mandated increased public funding for irrigation the expected significant investments in irrigation failed to materialize[6]. The Department of Agriculture has recently shifted to investments in relatively cheaper shallow tube wells and small water-impounding projects (SWIPs).[7] Decentralization under the Local Government Code transferred to local government units (LGUs) the major responsibility of providing communal irrigation systems (CIS). However, this strategy has failed to develop an extensive CIS that runs parallel to the more expensive national irrigation systems. LGUs, constrained by the lack of financial resources and technical expertise in planning and implementing the construction of CIS, have given low priority to agricultural support services and rural infrastructure.

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[5] The latter point was made by Roehl Briones, senior fellow at the Philippine Institute for Development Studies.

[6] Republic Act 6978 in 1991 and the Agriculture and Fisheries Modernization Act (AFMA) in 1997. Inocencio and Barker (2006) provide a detailed analysis of the status and policy challenges in water resources and irrigation development in the country.

[7] As of 2007, only 400 SWIPS covering 22, 170 hectares have been constructed. Most of those SWIPs are found in Regions 1, 2 and 3 (Source: Bureau of Soils and Water Management, Department of Agriculture).

5.   **Concluding remarks**

The country has underinvested in infrastructure at around 2% of gross domestic product (GDP) on average in contrast to the 5% norm for other ASEAN countries. The result was the failure of the country's infrastructure to keep up with the growing needs of the economy and the population. Poor and inadequate infrastructure has also been a reason for the lack of attractiveness of the country as an investment destination[8]. It has also become a significant growth constraint (Llanto 2007b).

Belatedly, the government has realized that it has to prioritize infrastructure investments to address significant growth constraints brought about by inadequate infrastructure. Because of infrastructure's important direct and indirect effects on agricultural productivity, the government has to pay special attention to rural infrastructure investments. Increasing agricultural productivity is an essential component of the government's development strategy, especially because most of Philippine poverty is with the rural areas.

Despite data constraints, the paper's overall empirical results indicate a significant link between rural infrastructure and agricultural productivity[9]. Electricity and roads are significant determinants of agricultural productivity. This is consistent with a related finding on the constraints imposed on growth by inadequate infrastructure. Rural roads provide the important connectivity with growing markets adjacent to rural areas; they also lessen input costs and

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[8] An important factor behind the high cost of doing business is the inadequacy of the country's infrastructure.

[9] Researchers investigating what type of public capital would have a significant impact on growth found that public transport, telecommunications, and electricity were positively correlated with growth. The majority of studies trying to establish a linkage between (public) investments or capital and economic growth indicate that (a) public capital is complementary and promotes private capital formation; (b) core infrastructure, such as roads and railways, tend to have the most impact on productivity; and (c) the direction of causation is from public capital to productivity and not the other way around (Infrastructure Canada, 2007).

transaction costs of rural producers and consumers. Access to electricity creates various income-earning opportunities for rural households[10].

Access to low cost electricity will provide rural households with feasible options for production, processing, marketing and distribution. Thus, it will help create the conditions for improved agricultural productivity. The Philippines' power rates are much higher than those of neighboring ASEAN countries and this situation has constrained the competitiveness of local and foreign firms operating in the country. A joint ADB-World Bank (2005) survey found that electricity (33%) was considered by businessmen as the most critical constraint compared with transport (18%) and telecommunications (10%). Losses owing to power failure amounted, on average, to 8% of production. Power outages hurt small and medium-size firms most, costing them an equivalent of about 8% and 11% of production, respectively, compared with 6% for large firms.

Recent reforms in the electricity industry pursued under the Electricity Power Industry Reform Act of 2001 (Republic Act 9136) have led to efforts to privatize generation assets and transmission, electricity tariff unbundling, among others, which will result in a restructured and competitive power sector. Competition in generation and supply and more efficient regulation of the transmission and distribution segments of the electricity market will lead to a more stable power supply and lower energy prices in the future. Policymakers should focus on the sustained implementation of the policy reform program, which includes as key elements the privatization of the National Power Corporation (NPC), an efficient regulation of the electricity market, and the creation of an attractive environment for private investors in the generation

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[10] Shiu and Lam (2003) found that real GDP and electricity consumption for China are co-integrated and there is unidirectional Granger causality running from electricity consumption to real GDP but not vice versa.

segment of the market[11].

The paper also showed that rural areas that have good road infrastructure and accessibility to electricity will experience higher rates of growth of agricultural productivity than those areas with inadequate roads and energy. Regions with high infrastructure investments tend to have higher economic growth, whereas regions with low infrastructure investments tend to have lower economic growth (Reyes, 2002; Manasan and Chatterjee, 2003; Manasan and Mercado, 1999; Basilio and Gundaya, 1997). Reyes (2002) finds that regions with the lowest GRDP are also those suffering from the most severe lack of basic infrastructure. Llanto (2007) finds that infrastructure has a positive and significant effect on regional growth (incomes).

There is an imbalance in the availability and quality of infrastructure at the regional, provincial, municipal and city levels. Richer and more advanced regions have better infrastructure while lagging regions are beset by inadequate infrastructure[12]. The linkage of the primary road network with secondary roads is critical for reducing high transport and logistics costs, which have contributed to low productivity and lack of competitiveness of domestic producers. Because of better access to fiscal (tax revenue) and financial (loans) resources, the national government can provide and maintain roads that are generally superior to local roads. Local government units have limited access to fiscal and financial resources; hence their capacity to provide better roads is also limited. Improving the fiscal and financial capacity of LGUs should be high in the agenda of policymakers. A recent paper (Llanto 2009)

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[11] Under RA 9136, NPC's generation and transmission facilities, real estate properties and other disposable assets, as well as its existing power supply contracts with independent power producers (IPPs), shall be privatized. The exact manner and mode by which these assets will be sold will be determined by the Power Sector Assets and Liabilities Management (PSALM) Corporation, a government-owned and -controlled corporation that will take over the ownership of all of NPC's assets. PSALM will also be tasked to manage the orderly sale, disposition and privatization of NPC, with the objective of liquidating all of NPC's financial obligations and stranded contract costs in an optimal manner (source: www. doe.gov.ph)

[12] Roads are classified into national and local roads. The national government is responsible for the main highways (national roads) while local government units are in charge of secondary roads (local roads).

points out that local fiscal autonomy is constrained because the Local Government Code limits the power of LGUs to set local tax rates and preserves the more revenue productive taxes in favor of the national government. It is equally timely to revisit the formula for inter-governmental fiscal transfers, that is, the 'internal revenue allotment' that is transferred to each LGU pursuant to decentralization and devolution under the Local Government Code. Some outstanding policy issues on local fiscal policy concerns (a) the size and appropriate distribution formula of the internal revenue allotment, (b) evaluating and improving the equalization features of the fiscal transfer system and (c) ensuring compliance by the national government to the commitment to the fiscal transfer. The LGUs also need to develop capacity for better planning and programming of local resources and implementation of local infrastructure.

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Annex A

Approach to empirical estimation, data used and limitations

The author undertook a review of literature and discussions with agriculture experts to identify the most suitable empirical approach for assessing the impact of rural infrastructure on agricultural productivity. Five approaches to measuring productivity growth are as follows: 1) growth accounting, 2) index number, 3) econometrics, 4) the distance function-basedMalmqvist approach and 5) the stochastic frontier approach. **Table 2** above summarizes the different productivity studies in Philippine agriculture. Many studies use a Cobb-Douglas type of production function and regress measures of agricultural output or agricultural productivity against various kinds of independent variables, including infrastructural indicators or some measure of infrastructure.

In this tradition, Fan and Rao (2003) estimated a production function specified as follows:

$$\text{Agprod= f(Agland, Labor, Fert, Tract, Anim, Irrig, Roads, Lite, u) Equation 1}$$

where Agprod is agricultural productivity, the dependent variable; the independent variables are labor (Labor), agricultural land (Agland), fertilizer (Fert), number of tractors (Tract), number of draft animals (Anim), percentage of crop areas under irrigation (Irrig), road density (Roads), literacy or some measure of educational attainment (Lite). The variable u is used to capture the other factors not included in the equation and is proxied by year, representing episodes of economic growth and decline. Fan (1991) defines total factor productivity (TFP) growth as the growth that cannot be explained by the changes in input. It may be in the form of technological improvement or improvement in efficiency given the same number of inputs.

Fan and others (2000) used TFP growth in agriculture as a dependent variable to show the impact of infrastructure and government spending in rural areas on agriculture growth as in Equation 4 below. They defined TFP growth index as the ratio of an aggregated output index to an aggregated input index. The advantage of using TFP growth instead of production growth is that the TFP function has significantly fewer independent variables than a production function. Fewer independent variables in the TFP function help reduce multicollinearity problems and increase the reliability of the estimated results.

$$TFP - f(RDE, RDE\_1, \ldots, RDE\_i, IR, ROADS, PVELE, LITE, GSCHEL, GERDEV,$$
$$GCSSL, GDP\_1, RAIN) \qquad \text{Equation 4}$$

where RDE is current and lagged government spending in agricultural research and extension; IR is the percentage of irrigated cropped area in total cropped area; ROADS is road density; PVELE is percentage of village electrified; LITE is literacy rate of the rural population; GSCHEL is capital stocks of government investments in health; GERDEV is government investment in rural development; GCSSL is government investments in soil conservation; GDP is gross domestic product and RAIN is annual rainfall. The first seven sets of variables capture the productivity-enhancing effects of technologies, infrastructure, education and other various government spending in rural areas. The lagged GDP controls for the effects of overall economic growth on TFP growth in agriculture. The rainfall variable captures the weather effects. The TFP index is the Tornqvist-Theil index given in Equation 2.

The paper uses the standard production function approach with agricultural productivity as the dependent variable and rural infrastructure and other variables as independent variables[13]. This

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[13] This approach was validated in a seminar-workshop with other researchers organized by SEARCA in 2009. It was agreed upon as the approach to be used in the estimation in view of data limitations.

approach was validated in a seminar-workshop with other researchers organized by SEARCA in 2009. Only the significant empirical results are discussed in Section 4.

Scope and limitations of available data

Agriculture data

Table A.1 shows a summary of available agriculture production data. However, data on prices of poultry and livestock are not available. There is also a rather short time frame for the rice and corn data, which run only from 1994 to 2007. Available data on agricultural inputs are presented in Table A.2. Data for fertilizer consumption are available only until 2002 or 2004, if fertilizer consumption is measured as 100 grams per hectare of arable land. Wages of agricultural labor and the cost of fertilizers are available from the Bureau of Agricultural Statistics (BAS).

Table A.1. Available data on agricultural production and prices

	Scope		Period	Source
Production of palay in metric tons	N	R	1994-2007	BAS
Production of corn in metric tons	P		1994-2007	BAS
Production of crops other than palay and corn in metric tons	N	R	1990-2007	BAS
Production of livestock in metric ton live weight	P		1980-2007	BAS
Production of poultry in metric ton live weight	N	R	1980-2007	BAS
Farmgate price of palay [paddy] fancy, dry (conv. to 14%mc)	N	R	1990-2007	BAS
Farmgate price of palay [paddy] other variety, dry (conv. to	N	R	1990-2007	BAS
14%mc)	P		1990-2007	BAS
Farmgate price of corn grain [maize], yellow, matured	N	R	1990-2007	BAS

	Scope	Period	Source
Farmgate price of corn grain [maize], white, matured	P	1990-2007	BAS
Farmgate price of selected commercial crops	N R		
	P		
	N R		
	P		
	N R		
	P		
	N R		
	P		

Note: N, R and P denote nationally aggregated, regionally aggregated and provincially

aggregated date respectively.

Table A.2 Available data on agricultural inputs

	Scope	Period	Source
Number of employed person in agriculture	N R	1990-2006	BAS
Total number of employed persons	N R	1990-2006	BAS
Agricultural wage rates of farm workers (nominal and real)	N R	1990-2006	BAS
Area harvested of rice, in hectares	N R	1994-2007	BAS
Area harvested of corn, in hectares	P	1994-2007	BAS
Area harvested/planted of selected crops other than rice and	N R	1990-2007	BAS
corn	P	60,71,80,91,0	NSO
Percent of irrigated area to total crop area	N R	2	BAS
Irrigated area (national irrigation system), wet season	P	1998-2007	BAS

Irrigated area (national irrigation system), dry season	N R		1998-2007	WB
Irrigated land (% of cropland)	P		1960-2004	WB
Land area (sq m)	N R		1960-2004	WB
Permanent cropland (% of land area)	N R		1960-2004	NSO
Number of equipment, by census year and by crop type	N		60,71,80,91,0	FAOST
Fertilizer consumption	N		2	AT
Dealers' prices of fertilizers in the Philippines	N		1961-2002	BAS
Fertilizer consumption (100 g per hectare of arable land)	N R		1990-2007	WB
	N		1960-2004	
	N			
	N			

Note: N, R and P denote nationally aggregated, regionally aggregated and provincially aggregated date respectively.

Data on inputs such as labor, land, fertilizer, machinery and livestock for the Philippines are also available in FAOSTAT. The quality of data for the Philippines from the FAO as a long time-series is a little bit problematic. The data on fertilizers and machinery are not very reliable (latter years have the same values).

Teruel (2007) criticized most of FAO data as "typically measured in relatively simple physical terms especially the conventional inputs" (page 63) and cited that various studies have all noted various shortcomings in FAO data.

Infrastructure data

A summary of the infrastructure data used in various studies is presented in Table A.3, which also indicates the scope and the availability of these data in the Philippines. The

infrastructure data are severely limited. Only roads (road density), electrification (electric energy consumption by sector) and airport facilities (number of registered airports) have data that span 3 decades or more. It is possible to assemble a panel data of regions by agricultural productivity for the years 1994 to 2007 but this would not be possible for infrastructure. The regional panel data, if assembled, would only include data on roads (existing roads) and telephones (telephone distribution by region) as infrastructure variables. Thus, a significant data asymmetry exists, constraining empirical estimation.

The author examined various data sources and related information and compiled a data set for the empirical estimation on the impact of rural infrastructure and agricultural productivity. The empirical estimation done in this paper is constrained by the availability and quality of pertinent data. There is very much to be desired in the quality, duration and coverage of the available data, e.g., the number of observations per variable is limited to a few years; there is an insufficient level of disaggregation, and there are missing data as in the case of fertilizer. Economic indicators related to rural infrastructure and other types of public investments are lacking and of poor quality. Data constraints imply that a time-series regression on the effects of infrastructure development on agriculture productivity is only possible if the aggregate national level data on agricultural production are used. Infrastructure data are also limited. Improved analysis requires that better quality data be collected in the future, especially on government infrastructure spending by sector, region, province, municipality and city, with desegregation by rural and urban areas and by current and capital expenditures.

Oftentimes, the constraint on data availability may make it difficult to implement a good econometric approach (Teruel, 2007). Empirical estimation of household-level effects of rural infrastructure, e.g., impact on poverty reduction of farmers, requires household-level data.

Future empirical work should also consider using household survey questionnaires designed to capture information on rural infrastructure utilization at the household level and related information. Notwithstanding these data limitations, this author proceeded with his empirical investigation using data as described below.

Description of data used in the estimation

Gross value added

Gross Value Added (GVA) in agriculture is calculated as the difference between gross output in agriculture and intermediate inputs. Following BAS definition, it is equivalent to total payment to factors of production, including capital consumption allowance and indirect taxes. Data for 1991 to 2006 with a 3-year interval were taken from the Philippine Statistical Yearbook for the applicable year.

Annual rainfall % normal

Percentage deviation from normal rainfall is estimated by PAGASA using the following formula:

$$\%N = \left(RR\middle/N\right) \times 100$$

where $\%N$ is the percentage deviation from normal rainfall, RR is the amount of rainfall (in mm), and N is normal rainfall, which is the average amount of rainfall for the period 1971-2000 (in mm) .

PAGASA assesses whether the amount of rainfall is below, near or above the normal amount of rainfall for a 30-year period. This classification results in a rainfall tercile, which is

actually the form of a seasonal rainfall forecast regularly issued by PAGASA. There are three levels of rainfall variable: below normal (0-80%); near normal (81-120%) and above normal (above 120%).

Road density

Road density is defined as the total length of road for a certain area. The road density for regions (or group of regions) was calculated by taking the total length of national and provincial roads divided by the area of the region (or in the case of group of regions, as the combined area of the regions). In an attempt to generate a better fit for the regression using roads as an independent variable, quality-adjusted road data were used.[14]

Service area of irrigation systems

The total service area in hectares is given as the total area irrigated under the National Irrigation Administration. This includes national irrigation systems, communal irrigation systems and private irrigation systems. The data were gathered from the Philippine Statistical Yearbook for the applicable years.

Access to telephones

For a given region, this variable is calculated as the ratio of the total number of telephone lines to the total population divided by one thousand. Data were taken from the Philippine Statistical Yearbook for the applicable years.

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[14] The adjustment of the raw road data to quality-adjusted road data followed the procedure suggested by Arsenio Balisacan wherein earthen roads and gravel roads were converted to an equivalent paved road (concrete).

Access to electricity

For a given region, this variable is calculated as the ratio of households that have access to electricity to the total number of households. Data were taken from the Family Income and Expenditure Surveys of various years.

Agricultural labor productivity

This variable is the ratio of agriculture gross value added to agricultural labor force. Data were taken from the Philippine Statistical Yearbook for the applicable years.

Table A.3. Description of infrastructure data in various studies and available data on infrastructure for the Philippines

Variable in the literature	Description	Available data (Philippines)			
		Indicator	Source	Period	Scope
Number of rural telephones per agricultural worker		• Telephone distribution	PSY	2000-2006	N,R
		• Number of employed persons in agriculture	BAS	1990-2006	N,R
				2000-2006	N,R
Rural telephones	Number of rural telephones is used as proxy for the development of rural telecommunication. Number of telephones by province.	• Number of telephones	PSY		
Number of telephones used in different districts		• Telephone distribution	PSY	2000-2006	N,R
		• Telephone density	PSY	2000-2006	N,R
Length of rural road per		• Length of local road	DPWH	as of 2005	N,R,P

agricultural worker		• Number of employed persons in agriculture	BAS	1990-2006	N,R
Road network (per capita road length)		• Length of road in km	DPWH	as of 2005	N,R,P
Length of rural roads in km		• Length of local road	NSCB	as of 2005	N,R,P
		• National roads by surface	PSY	1991-2006	N
Road density	Road density is the ratio of total length to the geographical area of the district. The road density augments the location advantage of farms with respect to transport of input and output and access to markets.	• Road density	WDI	1990-2003	N

Table 5. Cont'd….

Variable in the literature	Description	Available data (Philippines)			
		Indicator	Source	Period	Scope
Irrigated area	Irrigated area by region	• Irrigated area served by the NIA,	BAS	1998-2007	N,R
		wet and dry seasons	BAS	1999-2007	N,R
		• Irrigated area by type of irrigation	BAS	1999-2007	N,R
Irrigation (proxied by irrigated area)	Irrigation services in agriculture proxied by irrigated area	system • Total irrigated area	NSO	60,71,80,91,02	N,R,P
% of irrigated area to total cross-cropped area		• Total irrigated area	NSO	60,71,80,91,02	N,R,P
		• % of irrigated area to total crop area	NSO	2002	N,R,P
Canal Irrigation		• Area of irrigated land using			

		power			
Consumption of rural electricity per agricultural worker		pump method	NSCB	1995 HECS	N,R
		• Number of households using electricity by end-use and region, urban-rural	NSCB	1995 HECS	N,R
		• Annual average household			
Electricity consumption	Total rural electricity consumption for both production and residential uses by province	electricity Consumption by end-use and region, Urba-Rural	NSCB	1991-2006	N
Total number of villages electrified during a particular period of time		• Electric energy consumption by sector	DOE	as of 2006	N,R
		• Rural electrification			