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Transport and agricultural productivity: a cross-national analysis

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ABSTRACT: The transportation infrastructure plays a significant role in the development of agriculture. In this study we examine the relationship between transport and agricultural performance by employing the World Bank's roads infrastructure indicators. Based on a cross-country sample, a classic method is employed to test the hypothesis that better transport fosters agricultural productivity. The empirical results of the method support the hypothesis. As for this method, the estimation results of the widely-used inter-country aggregate agricultural production function describe that a country with better transport can produce more agricultural outputs given the same amounts of agricultural inputs and the same education level. Our empirical work lends support to the claim of Gollin and Rogerson (2010) [19]that transport is a basic factor explaining the poor economic performance of many developing countries, apart from physical and education investments, more emphasis should be placed on improving the transport infrastructure of these countries.

Keywords: transport; agricultural productivity; road; road transport

1 PREFACE

This paper aims that the differences in the condition of the nation's transport infrastructure can contribute to the heterogeneity of agricultural productivity across nations. Transport infrastructure has direct and indirect impacts on agricultural, unlike capital and technology, they can influence across countries more easily. Our study follows the disputation of Gollin and Rogerson (2010) [20], which argue that the basic factor restriction agricultural productivity is neither the meagre endowment of natural resources nor the lack of technological potential to improve output based on the variable resources, but the rather bad road infrastructures that discourage both the use of advanced technology and the organizational innovation. The roads affecting economic growth can be referred to as the transport infrastructure of a nation (Fedderke and Bogetic, 2009) [15]. The transport infrastructure might have impact on agricultural productivity in several ways. For instance, the good transport infrastructure can well meet the demands for the goods transportation of households. If the major roads are limited, the transportation costs may be increased by the deficient transport. Then the farmers could accept a lower price for selling the goods near their farm so as to reduce the transportation costs. As a result, the real income of households would be decreased. But if the transport infrastructure is good, the households can deliver the goods freely with low transportation costs. In addition, good transport infrastructure benefits the free labor mobility. The transport acts a crucial role in the activities of mobile people shuttling back and forth between the rural and urban. The transport also determines other infrastructures that affect both agricultural productivity and investment. In some nations, agricultural development has been seriously hindered by the high transportation cost, which is a feature of bad transport infrastructure.

We collect the whole road network data from World Bank (2010), which provides the transport infrastructure for a sample of 71 countries in the year of 2010. This study adopts a method to examine the hypothesis that better transport infrastructure improves agricultural productivity. By means of the method, the inter-country aggregate agricultural production function, which has been widely used to test the determinants of the disparities in agricultural productivity across countries (Antle, 1983; Kawagoe et al., 1085; Fulginiti and perrin, 1993) [3], is estimated to investigate the effects of the transport infrastructure on agricultural performance.

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2 DATA,MEASUREMENT AND SAMPLING PROCEDURE

Assessing quantitatively the effect of the transportation sector on the level and composition of aggregate agricultural productivity requires international comparable aggregate and agricultural productivity data. The available sample consisting of the data in 2010 from 71 countries are used in this study. Because the data of independent variables is the most complete in this year. Data are collected from official website of Food and Agricultural Organization (2010), official website of World Bank (2010) and official website of United Nations Development Programme (2010). There are three main datasets in this study: transport infrastructure, agricultural inputs (land and machinery) and education.

2.1 *Data*

2.1.1 *Transportation infrastructure measure*

The first main data is obtained from the official website of World Bank, which provides total road network (km) cross the countries in the year of 2010. The transport indicator is the total road network including motorways, highways, and main or national roads, secondary or regional roads, and all other roads in a country.

2.1.2 *Agricultural production based on PPP per capita production*

The second main dataset incorporates the figures from the FAOSTAT (2010) on value of agricultural production. The agricultural total output is measured by net production value in constant 2004-2006 1000 I$.

2.1.3 *Agricultural inputs*

The third main dataset figures of agricultural inputs are obtained from FAOSTAT (2010). For estimation of the aggregate agricultural production function, two basic agricultural inputs are used, including land and machinery. The definitions of the two inputs are as follows. (1) Land. It is measured by thousands of hectares of arable land and permanent cropland. (2) Machinery. It is measured by the number of agricultural production function.

2.1.4 *Education*

In addition to agricultural inputs, the control variable is considered in the agricultural production function. It noted that the control variables are also significant in agricultural production. I collect the most significant control variable, EDU, which is the general education level. We pick up the enrolment ratio of schooling from the educational part in the 2010 Human development Report.

2.2 *A model of cross-regional transportation*

The specifications of the production and functions follow the former classical production function approach. I use the aggregate agricultural production function according to the Cobb-Douglas form, which is the most common specification used in the previous research.

The approach includes two main variables: the dependent variables and the independent variable. The dependent variable is a country's total agricultural output. The author uses the net value of agricultural production for this variable. The main independent variables consist of two crucial agricultural inputs (land and machinery). Although the labour is also an important agricultural input, the calculation of agricultural production involves this element. The agricultural production is based on the PPP per capital production. Therefore, we do not consider the element of labour in the independent variables. Another independent variable that we consider is the educational level, and this variable shows the ratio of schools enrolment cross countries.

A model is employed in this study to examine the hypothesis that better transport infrastructure generates higher agricultural productivity. This model is the widely-adopted inter-country aggregate agricultural production function. The complete model for the agricultural aggregate production of the country is specified as follows:

$$\mathrm{LnAGTP}i = \alpha 0 + \alpha 1\ \mathrm{lnTRANSPORT}i + \alpha 2\ \mathrm{lnLAND}i + \alpha 3\ \mathrm{lnTRACTOR}i + \alpha 4\ \mathrm{lnEDU}i + \varepsilon i$$

Where, i=1, 2, 3…N. AGTP is the agricultural output. The TRANSPORT is the transport infrastructure. The LAND, TRACTOR and EDU are the agricultural inputs.

The four detailed regressions can be expressed as follows:

(1) $\ln\ \mathrm{AGTP}i = \alpha 0 + \alpha 1\ \mathrm{lnLAND}i + \alpha 2\ \mathrm{lnTRACTOR}i + \varepsilon i$

(2) $\ln\ \mathrm{AGTP}i = \alpha 0 + \alpha 1\ \mathrm{lnTRANSPORT}i + \alpha 2\ \mathrm{lnLAND}i + \alpha 3\ \mathrm{lnTRACTOR}i + \varepsilon i$

(3) $\mathrm{Ln}\ \mathrm{AGTP}i = \alpha 0 + \alpha 1\ \mathrm{lnLAND}i + \alpha 2\ \mathrm{lnTRACTOR}i + \alpha 3\ \mathrm{lnEDU}i + \varepsilon i$

(4) $\mathrm{Ln}\ \mathrm{AGTP}i = \alpha 0 + \alpha 1\ \mathrm{lnTRANSPORT}i + \alpha 2\ \mathrm{lnLAND}i + \alpha 3\ \mathrm{lnTRACTOR}i + \alpha 4\ \mathrm{lnEDU}i + \varepsilon i$

The available samples have 71 countries and observations for the year 2010. Four regressions with different specifications were estimated. In regressions (1) and (2) we estimated the basic model in which the independent variables involved two agricultural inputs. All variables are in the logarithmic form. The transport infrastructure index (TRANSPORT) entered regression (2) in the logarithmic form. In regressions (3) and (4) the education level was involved and the

lnTRANSPORT entered regression (4).

In statistics and economics, the term data refers to multi-dimensional data. The data include observations on multiple phenomena observed in one period for the same firms or individuals. The following are the advantages of this model: firstly, it can control individual difference (unobserved effect) by setting the dummy variable. Secondly, it can improve the degree of freedom and decrease the collinearity among the explanatory variables. Therefore, the estimation effectiveness is improved. Lastly, it can repeatedly observe the unit set on a cross-section, thus engaging a better study on the dynamics of changes in economic behaviour. We can see the performance in the Figure 1.

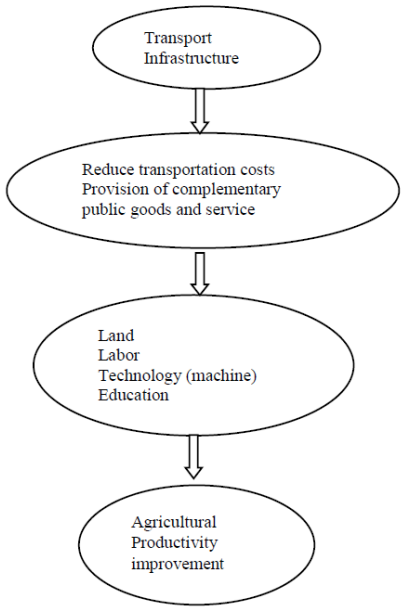

Figure 1. Transport and agricultural performance

3 EMPRICAL RESULTS

In this section, the author assesses quantitatively the role of transport infrastructure in generating cross-country disparities in aggregate agricultural productivity in the context of the structural transformation mechanism of the model.

3.1 *Analyse results of the regression*

The estimation results are presented in Table 1. The R2 for all four regressions exceed 0.81, which suggests that the fitted regression outcome explains the variation in cross-country agricultural outputs by a significant level. The table contains 4 results of fixed effects regression so that it is clear to analyse the results on the whole, From the table we can see that: as an independent variable, transport infrastructure is always significant and it always affects agricultural inputs and the aggregate agricultural output, because its p value is often smaller than 0.01; the relationship between transport and agricultural productivity is significantly positive correlation. In addition, the coefficients of agricultural inputs: land, machinery and education that explain the four agricultural inputs also do positive impact on agricultural productivity. In regression (1)-(4), the coefficients of two agricultural inputs, lnLAND and lnTRACTOR, show the expected position sign and achieve high statistical significance. The coefficients of the land and machinery variables, LAND and TRACTOR, exhibit positive and significant signs in regressions (1)-(4), including that better inputs of land and machine enhance agricultural productivity. The coefficients of the education variable, EDU, also present positive and significant signs in regressions (3)-(4), implying that the education variable plays positive role in improving the agricultural productivity. As shown in regressions (1)-(4), more investments of land, tractor, and education can increase the agricultural output, and they have positive impacts on a country's agricultural productivity.

Our empirical results support the hypothesis that better transport raises agricultural productivity. In the case of the roads infrastructure, they have statistically significant, positive, and often economic impacts on the agricultural productivity. As shown in regressions (2) and (4), the coefficients of lnTRANSPORT are positive and highly statistically significant. This demonstrates that a nation with a better condition of transportation infrastructure will produce more agricultural output with the same amounts of agricultural inputs. In regression (4), the figure for production elasticity of T is 0.520, which indicates that an increase with 1% of T will raise the agricultural output by 0.520% given the same amounts of agricultural inputs.

Table 1. Estimates of the aggregate agricultural production function

	(1)	(2)	(3)	(4)
lnTRANSPORT		0.601***		0.520***
		(0.059)		(0.074)
lnLAND	0.018**	0.090*	0.229***	0.140**
	(0.079)	(0.050)	(0.077)	(0.060)
lnTRACTOR	0.759***	0.330***	0.371***	0.277***
	(0.072)	(0.062)	(0.091)	(0.070)
lnEDU			0.272***	0.078*
			(0.047)	(0.045)
Constant	8.881***	5.104***	7.696***	5.277***
	(0.354)	(0.433)	(0.365)	(0.443)
R^2	0.819	0.928	0.879	0.931
# of observations	71			
# of countries	71			

Notes: Figures in parentheses are heteroskedastic corrected standard errors. Asterisks indicate significance at the 10% (*), 5% (**) and 1% (***) levels.

3.2 *Impacts of good transport on agricultural productivity*

It is well known that good transport reduces transportation costs. The road infrastructure plays an essential role in the transportation. Large amounts of funds invested in roads or other transport infrastructure caused a reduction in transportation costs in economic activities, particularly in the developing countries. A good condition of transport infrastructure that necessarily eliminated transport costs. Due to lack of transport infrastructure in many poor nations, most householders in agricultural sector indirectly purchase the transport services by selling their goods in a lower price. The major roads are limited and the farmers cannot freely transport their goods to the distant market or the urban area. They sell the agricultural goods in a lower price at the near market or intermediate points. We can understand the demand for good level of transport infrastructure.

Actually, transport construction also contributes to the economic growth. More investments for transport generate the transportation costs at a low level. If the transportation costs are lower than before, the households can sell their goods at the distant markets or the cities. Then they can gain more profits than before. Not only the households in rural areas can obtain more advantages due to the reduction in the cost of goods transport, the urban people also benefit a lot. The rural areas can deliver more agricultural goods to the cities, and then there would be more goods in urban markets. The population in cities might buy the goods in a lower price than before. In a word, the exports and imports both could benefit from the low costs of good transport.

This implies that keeping a balance between transport infrastructure and agricultural productivity growth is essential for rapid economic development. The low transportation cost is only one of the advantages from the development of transport infrastructure. There are many other benefits of transport investment. The transport infrastructure is a crucial element in the construction for a nation. The various public infrastructures are the relationship of interaction. The transportation needs other public infrastructure for the perfect delivery. The other public infrastructures also demand the function of transport. The excellent transportation supports the advancement of the other infrastructure. Provision of transport infrastructure is one of the effective means that the government might enhance economic growth. The overall public infrastructure is the foundation of economic development for a country. A serious argument regarding infrastructure is how efficiently the government manages the existing stocks. Then the transport infrastructure plays an indispensable role in this system.

3.3 *Transport and agricultural marketing in Uganda*

3.3.1 *Agriculture in Uganda*

Uganda is a typical nation in the middle of Africa. It produces almost all of its own food, and most of its agricultural production is oriented towards domestic consumption. In other words, this country is agricultural autarky. Besides, a significant amount of its agricultural production is mainly for export. Almost all agricultural production in Uganda takes place on smallholder plots, with mixed copping systems predominating.

3.3.2 *Transport-deficient and access to market*

Because of the rough situation of transport in Uganda, the rural households need to face the high transportation costs. More than 60 percent of Uganda' populations live in rural areas, and most of them make their living from subsistence agriculture (Uganda Bureau of Statistics 2007b, pp: 16-17). Using headcount measure, the poverty rate for rural households was 34.2%, which almost triple the rates for urban households (Uganda Bureau of Statistics 2006, pp: 60). Why the rural areas are so poor, the populations still live in the small countries? The transport is a significant reason for this issue.

3.3.3 *Uganda's less transport infrastructure is an important factor to cause low agricultural productivity*

First, many people live in the rural. Because of the bad transportation condition, people only can choose live close to their farm. Second, the transportation costs are very high. The major roads are limited in Uganda. Only a few roads improve the transportation costs. So the households need to pay much more money for goods shipping. Last but not least, it is poverty. According to a headcount measure, the poverty rate for rural people was 34.2 percent, which was almost three times as the rate of unban people (Uganda Bureau of Statistic 2006, pp: 60). The average income of rural people only account for one-thirds of that of urban people. The rural population paid about half of their total income to the food. For example, 15 percent of people in rural areas only have less than two sets of clothes and 43 percent of the population just have a pair of shoes in positive situation.

4 CONCLUDING REMARKS

Agricultural development has been considered to be one of the most important tasks that developing countries face, and a great deal of effort has been taken to improve the agricultural technologies, physical infrastructure and education. However, in recent years, researchers and policy-makers have been attaching more importance to the impact of transportation on agricultural performance. This trend also reflects the

recent advancement in the theory of economic development, which the emphasis, in addition to capital, technology and education, has been on the dominating position in the institution in charting the course of economic development.

With the use of World Bank's transport in road indicator, this study examines whether the differences in the quality of transport infrastructure can explain the cross-country heterogeneity in agricultural productivity. To this end, we use a simple method to employ the hypothesis. By means of the method, the widely-used inter-country aggregate agricultural production function was estimated on the basis of the sample of 71 countries in 2010. The empirical results imply that, with same agricultural inputs and education level, a country with better transport can generate more agricultural outputs. With comparison of the data of different categories, we can see that better transport not only enhance the agricultural productivity directly (that is, given the condition of same resources and education, a nation will produce more with better transport) but also improve the agricultural productivity indirectly by fostering the accumulation of infrastructure in a country.

Although our model is simple and stylized, we believed it still captures some important economic forces. Nonetheless, we want to emphasize three important directions for the future research. The first is to gather more systematic data of the nature of transport infrastructure. The second is to develop richer versions of our model that can provide better estimates of the quantitative effects of transportation infrastructure. Third, it is important to incorporate the costs associated with transportation infrastructure in order to provide better guidance regarding optimal policy.

The empirical works of this study supports Gollin and Rogerson (2010) [20] who claimed that transport is a basic factor explaining the poor economic performance of many developing countries, and also confirms the findings of Adamopoulos (2009)[1] that institutions and transport infrastructure are the determinants of the differences in levels of economic success across countries. The economy development needs the support of transport infrastructure. Good transport infrastructure is a basic condition for the advancement of economic in a country. As for the different kinds of efforts, apart from providing human resources, transferring technologies, and investing lands, the improvements of the transport infrastructure need more emphasis in order to ensure the success finally.

In terms of policy, the author suggests one way to enhance agricultural and aggregate productivity in poor countries that is to encourage the improvement of transportation networks. Moreover, the analysis has revealed that the international organizations (such as the FAO) might collect more funds for the transportation infrastructure. According to the analysis, it is believed that the developing countries are the ones that would obtain most of the productivity gains from the improvements in their transport infrastructure.

As seen above, transport infrastructure is an extremely complex revolution, which can affect the whole society. Not only can it bring economic benefits and facilitate economic development, but it can promote social harmony and political stability. With the challenge of how to improve agricultural productivity and promote economic growth, the government should fulfil its leadership and decision-making ability of political initiatives, and especially, should seriously focus on the development of transport infrastructure.

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