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IMPACTS OF ROAD INFRASTRUCTURE ON THE SUPPLY OF OUTPUT AND THE DEMAND FOR INPUTS IN FOOD CROPS IN INDONESIA: A Multi Input-Multi Output Approach

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Abstract

The purpose of this study is to analyze the impacts of rural road infrastructure on the supply of output and the demand for inputs in food crops in Indonesia. The study was based on survey data from seven provinces across Indonesia, which was carried out in 2007 and 2010 by ICASEPS, JBIC, and IFPRI. The study adopts the multi-input multi output approach with a translog-profit-function as the method of analysis. Results of the study reveal that the elasticity of the supply of output and the demand for inputs on rural road infrastructure was in general inelastic. Road rehabilitation will lead to an increased supply of output and demand for inputs. This implies that improvements of rural road infrastructure are vital in stimulating food crop production, and accordingly the government needs to increase its budget allocation for rural infrastructure development.

Keywords: road infrastructure, elasticity, supply of output, demand for inputs.

1. Introduction

The government has implemented various policies and programs to increase food crop production to meet the growing demand of food consumption to keep up with the annual population growth of 1.52%. According to Bappenas (2013), between 2010 and 2014 the government aims to increase the annual production of rice by 3.22%, whereas its actual achievement was only 2.38% during the first two years of the period 2010-2012. At the same time, the target for corn production was a 10.02% increase, while its realization was only 3.55%.

Provision of adequate rural infrastructure and agricultural inputs are among the key factors in improving food crops production. Various studies indicate that rural infrastructure has significant impacts on the production and productivity of agriculture (Ahmed and Donovan, 1992; Yoshino and Nakahigashi, 2000a and 2000b; Gibson and Olivia, 2008; Hartono, Irawan, and Irawan, 2010; Hartoyo, 2013). A study by Inoni and Omotor (2009) concluded that an increase in rural road quality of 10% could result in an increase of agricultural outputs of 12% and the farmers' income of 2.2%. In addition, rural infrastructure development could reduce poverty and promote economic transformation of rural communities. A massive infrastructure development in China has successfully triggered economic development of the country. Direct investment in infrastructure development has boosted economic activities, reduced transaction and delivery costs, improved competitiveness and created employment opportunities (Saho, Dash, and Nataraj, 2010). Results of studies from other countries such as Nigeria, China and Congo are also in line with the previous research findings, which suggest that rural infrastructure (primarily roads) has positive impacts on agricultural development (Ajiboye and Afolayan, 2009; Kasali, Ayanwale, Idowu, and Williams, 2012; Usman, 2014; Ikejiofor and Ali, 2014; Adefila and Bulus, 2014; Adedeji, Olafiaji, Omole, Olanibi, and Lukman, 2014).

Since the decentralization era in early 2000, the pace of rehabilitation and/or expansion of rural infrastructure in Indonesia has slowed down (Sumaryanto, *et.al*, 2009). According to a study commissioned by the World Bank (2012), some 72% out of the total roads are under the responsibility of district administration ("district roads"). Unfortunately, 50% of the district roads are in poor condition, and only 19% are in good condition. This has unavoidably affected the costs of distribution of goods and services from/to rural areas.

At present, the condition of rural roads and infrastructure varies significantly among regions and districts. This variation affects transportation costs, which consequently results in the different prices of inputs and outputs across regions. This will further influence the production and productivity of the agriculture sector and the economy of the region. The purpose of this study is to analyze impacts of rural road infrastructure on supply of output and demand for inputs on food crops.

2. Methodology

2.1. Timeline and Data

This study is based on survey data and was conducted by the Indonesian Center for Agricultural Socio Economic and Policy Studies (ICASEPS) in cooperation with Japan Bank for International Cooperation (JBIC) and International Food Policy Research Institute (IFPRI). The surveys were carried out in 2007 and 2010 in seven provinces across

Indonesia. Data for this study were a subset of the overall survey results. The study used villages as a unit of analysis. A total of 45 villages were selected purposively as samples, namely those with wetland agro-ecosystems that produce rice and secondary crops. In 2007, data were collected from sample villages within 5 provinces, while in 2010 data were collected from 7 provinces. With a size ranging from 12-17 households per sample village, the total samples consist of 651 households. Acreage of wetland area, road infrastructure and transportation cost were generated from the village data.

2.2. Location of the Study

The study was focused on lowland villages, both with technical and simple irrigation systems, which primarily produce food crops such as rice, corn, and other seasonal food crops. The study mainly focused on 45 sample villages, which was a subset of the overall 98 sample villages surveyed by ICASEP, JBIC, and IFPRI. Sample villages were taken from seven provinces, two were from Java and the remaining five were from outside Java. The sample provinces include Central and East Java, Lampung, West Nusa Tenggara, South Kalimantan, North Sulawesi, and South Sulawesi.

3. Theoretical Framework

Theoretically, impacts of rural road infrastructure on agriculture can be illustrated using a production economic theory (Figure 1). Figure 1 consists of two panels, namely *panel 1* dan *panel* 2. *Panel 1* depicts the total production function which represents the relationship between one input variable (X) and output variable (Y) with an assumption that the other variables (L) are constant, while infrastructure (Z) is considered as *given*. *Panel 2* represents the marginal productivity function, which corresponds with the use of input X and price ratio of input and output (V).

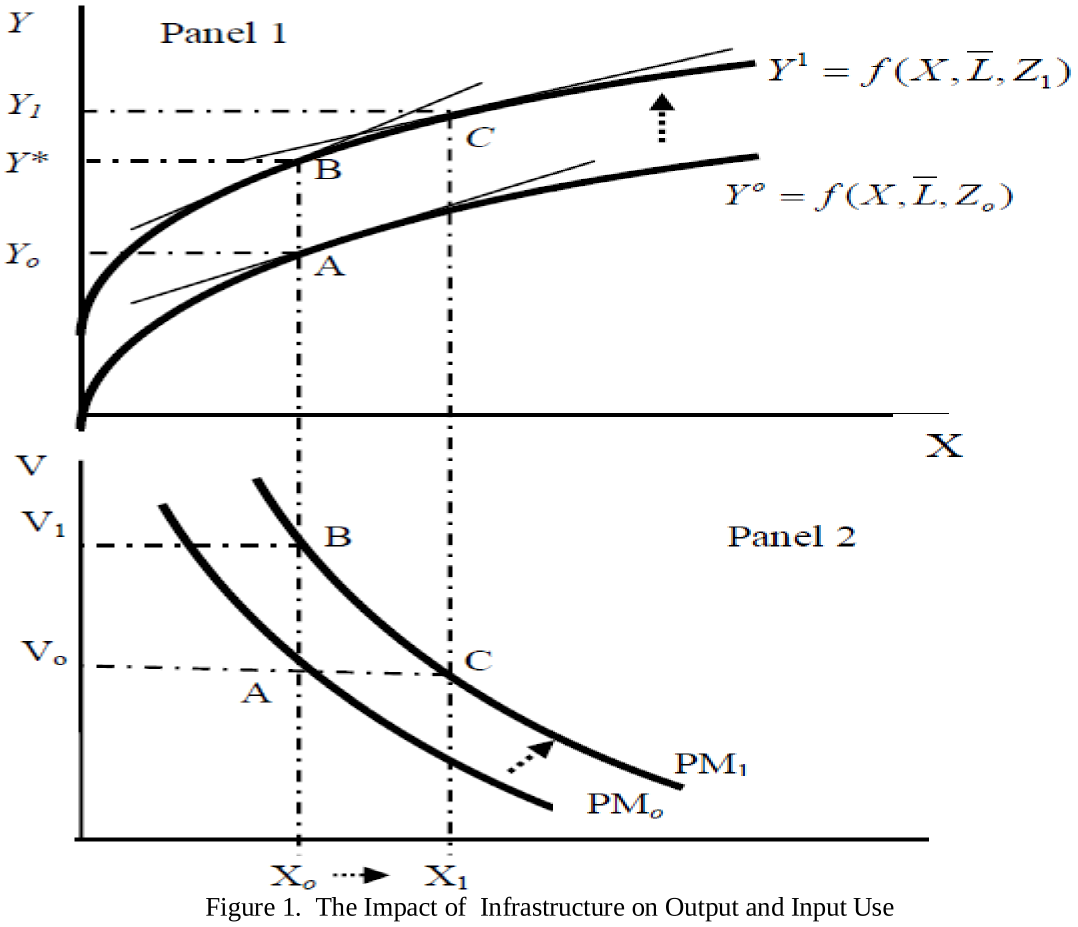

Figure 1. The Impact of Infrastructure on Output and Input Use

The initial condition is reflected in point A, whereby with an input of Xo – with certain technology, the system will produce outputs Y_o. If the quality of infrastructure (for example rural roads) is improved, this will indirectly improve the adoption of technology by farmers as a result of more frequent agricultural extension activities (Dercon, Gilligan, Hoddinott, and Woldehanna, 2007; Hartoyo, 2013). Adoption of new technology in farming will stimulate an increase of farm outputs and productivity. This can be shown in Panel 1, where an improvement of road infrastructure from Z_o to Z_1 will shift the production function from Y^o to Y^1.

Improvement of road infrastructure will also reduce transportation costs, which will eventually affect the input prices (Kiprono and Matsumoto, 2014). Good infrastructure could ease transportation, so as to shorten the delivery time and reduce costs. This will increase the output price received by farmers and at the same time reduce the input price paid by them, which can increase farmers' revenue. Changes in input and output prices will result in the price ratio of input and output.

In general, better infrastructure will lead to an upward shift in the production function from Y^o to Y^1 in Panel 1. The use of the same input will result in higher output, from Y_o to Y*, meaning that the productivity improved from point A to B. As a result of the upward shift in the production function from Y^o to Y^1 (Panel 1) due to increased productivity, the Marginal Productivity curve in Panel 2 will shift to the right from PM_o to PM_1, and the initial condition of point A will shift to point B.

The change in input-output price ratio as a result of the improved infrastructure will stimulate farmers to increase production by adding more inputs from X_o to X_1. Increased inputs will lead to the increase of output from Y^* to Y^1, in other words, point B will shift to point C. Effects of road infrastructue on production in Panel 1 is reflected in the shift of point A to the latest status at point C, thus, the change of output is equal to (Y_1-Y_o) and the change in inputs is equal to (X_1-X_o).

4. Method of Analysis

The study applies a multi input-multi output approach using a translog profit function. The profit function has three advantages, namely: (1) it makes it simpler to generate supply of output and demand for input functions using *Hotteling Lemma principle*; (2) the functions of supply of output and demand for input derived from the profit function will result in the same values as if it were derived from the production function by profit maximization; (3) the application of a profit function makes it possible to avoid bias, because in a profit function all exogenous variables are on the right side of the equation, and all the endogenous ones are on the left side of the equation (Hartoyo, 1994).

The number of outputs to be analyzed include 10 food crop commodities consisting of grains and vegetables. Out of the 10 commodities, rice and corn are reflected in the model, while the price of the other 8 commodities were aggregated as weighted price of output and input price. The number of input variables to be analyzed was six items, namely urea fertilizer, SP-36 fertilizer, NPK fertilizer, irrigation costs, labor, and other inputs (herbicides and pesticides). The fixed variables include land size, irrigation infrastructure, and road infrastructure.

Theoretically, the multi input-multi output approach using a translog function can be used to estimate impacts of infrastructure on the supply of output and the demand for inputs for food crop commodities. Specification of the empirical model of the translog profit function is as follows:

$$\ln \pi = \alpha_0 + \sum_{i=1}^{2}\alpha_i \ln p_i + \sum_{j=1}^{6}\alpha_j \ln r_j + \sum_{k=1}^{3}\alpha_k \ln z_k + 0.5\sum_{i=1}^{2}\sum_{s=1}^{2}\beta_{is}\ln p_i \ln p_s + 0.5\sum_{j=1}^{6}\sum_{g=1}^{6}\beta_{jg}\ln r_j \ln r_g$$
$$+0.5\sum_{k=1}^{3}\sum_{u=1}^{3}\beta_{ku}\ln z_k \ln z_u + \sum_{i=1}^{2}\sum_{j=1}^{6}\beta_{ij}\ln p_i \ln r_j + \sum_{i=1}^{2}\sum_{k=1}^{3}\beta_{ik}\ln p_i \ln z_k + \sum_{j=1}^{6}\sum_{k=1}^{3}\beta_{jk}\ln r_j \ln z_k + \gamma D_m \qquad (1)$$

where :

π = profit (IDR/ha)
p_i and p_s = price of output i^{th} and s^{th}, i=s=1,2
p_1 = price of rice (IDR/kg)
p_2 = price of corn (IDR/kg)
r_j and r_g = price of inputs j^{th} dan g^{th}, j=g=1,2,3,4,5,6
r_1 = price of urea fertilizer (IDR/kg)
r_2 = price of SP-36 fertilizer (IDR/kg)
r_3 = price of NPK fertilizer (IDR/kg)
r_4 = irrigation costs (IDR/ha)
r_5 = wages (IDR/man day)
r_6 = other variable input costs (IDR/ha)
Z_k and Z_u = fixed input k^{th} and u^{th}, for k=u=1,2,3
Z_1 = land size (ha)
Z_2 = Irrigation infrastructure (Rice Planting Index)
Z_3 = Road infrastructure (IDR/km)
D_m= dummy variable m^{th}, for m=1,2
D1 = dummy variable for island (1=Java ; 0=Outer Java)
D2 = dummy variable for year (1=2007 ; 0=2010)
$\alpha_0, \alpha_i, \alpha_j, \alpha_k, \beta_{is}, \beta_{jg}, \beta_{ku}, \beta_{ij}, \beta_{ik}, \beta_{jk}, \gamma$ = estimated parameter

Based on equation (1), using the Hotteling Lemma principle, the following equation of revenue share and cost share of the variable inputs can be formulated as:

$$S_i = \alpha_i + \sum_{s=1}^{2}\beta_{is}\ln p_s + \sum_{j=1}^{6}\beta_{ij}\ln r_j + \sum_{k=1}^{3}\beta_{ik}\ln z_k + \gamma D_m$$
$$-S_j = \alpha_j + \sum_{i=1}^{2}\beta_{ji}\ln p_i + \sum_{g=1}^{6}\beta_{jg}\ln r_g + \sum_{k=1}^{3}\beta_{jk}\ln z_k + \gamma D_m \qquad (2)$$

where :

S_i = revenue share
S_j = cost share of variable input

Some of the requirements for a translog profit function are as follows :

(1) Homogeneous of degree one to output and input price

$$\sum_{i=1}^{2}\alpha_i + \sum_{j=1}^{6}\alpha_j = 1$$
$$\sum_{s=1}^{2}\beta_{is} + \sum_{j=1}^{6}\beta_{ij} = 0$$
$$\sum_{i=1}^{2}\beta_{ji} + \sum_{g=1}^{6}\beta_{jg} = 0$$
$$\sum_{i=1}^{3}\beta_{ki} + \sum_{k=1}^{3}\beta_{jk} = 0 \qquad (3)$$

(2) Symmetry

$\beta_{is} = \beta_{si}$ for $i \neq s$
$\beta_{ij} = \beta_{ji}$ for $i \neq j$
$\beta_{ik} = \beta_{ki}$ for $i \neq k$

$$\begin{aligned} \beta_{jg} &= \beta_{gj} \quad \text{for } j \neq g \\ \beta_{jk} &= \beta_{kj} \quad \text{for } j \neq k \\ \beta_{ku} &= \beta_{uk} \quad \text{for } k \neq u \end{aligned} \qquad (4)$$

(3) Monotonic

A monotonic test was carried out to analyze equation (2), where the estimated revenue share will be positive while the estimated cost share of the variable inputs will be negative.

(4) Convex

A convexity test was conducted by analyzing the values of estimated parameters of the function of variable input costs toward their prices which should be negative.

A coefficient of determination (R^2) was used to gauge the *good of fit* of the model. This coefficient reflects the proportion of data variability which is based on a statistical model. The value of R^2 ranges from 0 to 1, the higher the R^2 the better the model.

Results of the exercise of equation (1) and (2) were used to estimate the elasticity of output supply and elasticity of input demand. The elasticity values were then used to simulate policy formulation as adopted by Fulginiti and Perrin (1990), as follows:

$$\begin{bmatrix} \delta \ln y \\ \delta \ln x \end{bmatrix} = \varepsilon \begin{bmatrix} \delta \ln p \\ \delta \ln r \\ \delta \ln z \end{bmatrix} \qquad (5)$$

where : ε = matrix of elastisity of output supply and elastisity of input demand

$\delta \ln y$ = percentage of output changes

$\delta \ln x$ = percentage of input changes

$\delta \ln p$ = percentage of output price changes

$\delta \ln r$ = percentage of input price changes

$\delta \ln z$ = percentage of infrastructure changes

A number of policy scenarios are analyzed, including: (1) improving the quality of rural roads, (2) a combination of output price and road infrastructure, (3) a combination of input price and road infrastructure, and (4) a combination of output price, input price, and road infrastructure. The output and input prices in the policy analysis scenario is based on the real prices. The real prices were estimated by deflating the the nominal prices of output and input using the Consumer Price Index (CPI) of the 2012 base year.

5. Results and Discussion

5.1. Analysis of Farming System

In general, the average land tenure per household farmer decreased by 20.85 percent during the period 2007-2010 (see Table 1) which happened not only in paddy fields with technical irrigation, but also in those with simple irrigation. The rate of decrease in Java was much faster (32.47%) compared to that outside Java (24.24%). The decrease of average land tenure was due to conversion from paddy areas to non-paddy areas, or even into non-agricultural use in line with the increase in the population and the growth of the industrial sector. According to Lokollo, *et. al.* (2007), during the period 1983-1993 land conversion was predominantly in Java, approximately 79.3%, while for the following decade (1993-2003) land conversion outside Java reached 92.3% of the total areas of converted land. The Central Bureau of Statistics (CBS) reported that land conversion into non-agricultural use reached an average of 56-60 thousand hectares during the period of 2002-2010 (Ministry of Finance, 2014).

Table 1. Land Tenure Size per Household and Rice Planting Index by Province, 2007 and 2010

Province	Land Tenure Size per Household (hectare)			Rice Planting Index		
	2007	2010	Change (%)	2007	2010	Change (%)
Java :	0.317	0.214	-32.47	161	159	-1.24
1. Central Java	0.358	0.230	-35.78	100	154	54.00
2. East Java	0.279	0.199	-28.74	182	163	-10.44
Outside Java :	0.708	0.536	-24.24	145	159	9.66
3. Lampung	0.507	0.408	-19.54	146	202	38.36
4. West Nusa Tenggara	0.722	0.544	-24.55	145	153	5.51
5. South Kalimantan		0.554			115	
6. North Sulawesi		0.651			151	
7. South Sulawesi	0.840	0.562	-33.07	143	197	37.76
Total (Java + Outside Java)	0.609	0.482	-20.85	150	159	5.66

Source : primary data

The Rice Planting Index (RPI) measures the crop intensity within a year, with values ranging from 100 to 300. An RPI with a value of 100 means that rice is planted only once a year, and RPI equal to 300 means that rice is planted three times a year. Table 1 shows that the RPI is between 145 to 161, meaning that the intensity of rice planting was 1 – 2 times per year. During the period 2007-2010, the average RPI in Java decreased by 1.24 percent, while in outside Java it increased by 10 percent. The RPI in East Java decreased with higher rate; this was caused by the decrease in the average size of land tenure and the deterioration of the irrigation infrastructure, which eventually affected the cropping pattern. Generally, rice was planted during the rainy season (MH), and some during the first stage of the dry season (MK-1). During the second stage of the dry season (MK-2), normally farmers grow secondary crops or vegetables such as soybean, peanuts, mung beans, tomato, chili peppers, etc. In areas with a limited water supply, many farmers do not grow any crops, and their land was left fallow. Out of the seven provinces, the RPI in South Kalimantan was the lowest due to the characteristics of paddy fields (which were mostly tidal swamp areas) which can only be planted with rice once a year.

In wetland areas, rice and corn are the major crops cultivated by farmers. To analyze rice and corn farming for two points of time (2007 and 2010), comparison was done based on the real value by eliminating the inflation effect. Real value is computed from the nominal value of input variables divided by the output price. The structure of production costs of each input variable can be seen from its factor share.

During the period 2007-2010, the productivity of rice farming increased by 0.77 percent. Accordingly, the contribution of real profit to the real total revenue increased from 31.5 percent to 37.7 percent (see Table 2). The ratio of real total revenue to real cost (R/C) increased from 1.46 to 1.60. The increase in the farmers's profit was not only caused by the increased productivity but also due to the decrease in input costs from 68.5 percent to 62.3 percent. These were costs of seeds, urea fertilizer, TSP, and other fertilizers. Farmers had to reduce the costs for such inputs because the labor cost increased. The increase in labor cost for agriculture is unavoidable since the supply is diminishing. According to the CBS, the absorption of labor in agricultural sector decreased from 41.9 % in 2007 to 39.5 % in 2010 (CBS, 2015).

Corn is the most dominant secondary crop grown by farmers. Results of the analysis indicate that the farmers's real profit decreased by approximately 25.4 percent during the periode 2007-2010 (see Table 3). The decrease in real profit was caused by increased production costs, especially corn seed and labor. This was due to the increase in the amount of corn seed needed per hectare and its higher price. The increase of labor cost was caused by the increase in the quantity and wages. The wage increased steadily because labor supply in the agricultural sector has continuously diminished over the last decade.

Table 2. Analysis of Rice Farming in Java and Outside of Java, 2007 and 2010

(per hectare per season)

Description	Unit	2007			2010		
		Quantity	Real Value*)	Factor Share**) (%)	Quantity	Real Value*)	Factor Share**) (%)
1. Total Revenue	kg	4 313	4 313	100.00	4 346	4 346	100.00
2. Cost :			2 956	68.53		2 710	62.34
a. Seed	kg	66	120	2.79	54	101	2.31
b. Fertilizer :			751	17.42		410	9.43
- Urea	kg	315	262	6.07	270	201	4.62
- SP-36	kg	189	186	4.32	84	76	1.74
- NPK	kg	79	85	1.97	107	110	2.52
- Others	IDR		218	5.06		24	0.55
c. Labor	MD***)	136	1 160	26.90	140	1 686	38.78
d. Pesticide	IDR		93	2.15		55	1.28
e. Other cost	IDR		80	1.86		48	1.10
3. Profit	IDR		1358	31.47		1 637	37.66
4. R/C			1.46			1.60	

Remarks: *) Real value is the nominal value deflated with rice price per kilogram
**) Factor share is computed from the real value of variable to the real revenues
***) MD (Man days) are the number of working hours of adult men worker (1 MD=8 hours/day)

Table 3. Analysis of Corn Farming in Java and Outside Java, 2007 and 2010

(per hectare per season)

Description	Unit	2007			2010		
		Quantity	Real Value*)	Factor Share**) (%)	Quantity	Real Value *)	Factor Share**) (%)
1. Total Revenue	kg	3 948	3 948	100.00	3 718	3 718	100.00
2. Cost :			1 992	50.46		2 257	60.72
a. Seed	kg	18	237	6.01	42	362	9.73
b. Fertilizer :			547	13.86		208	5.60
- Urea	kg	195	242	6.14	149	126	3.40
- SP-36	kg	88	130	3.30	27	28	0.75
- NPK	kg	6	10	0.26	28	32	0.87
- Others	IDR		164	4.16		22	0.59
c. Labor	MD***)	78	1 070	27.09	118	1 613	43.39
d. Pesticide	IDR		113	2.85		62	1.67
e. Other cost	IDR		26	0.65		12	0.31
3. Profit	IDR		1 956	49.54		1 460	39.28
4. R/C			1.98			1.65	

Remarks: *) Real value is nominal value deflated with corn price per kilogram
**) Factor share is computed from the real value of variable to the real revenues
***) MD (Man days) are the number of working hours of adult men worker (1 MD=8 hours/day)

Although the revenue from rice in nominal terms is higher than that of corn, farmers do not grow rice all the time. Water availability, either from the irrigation schemes or from rainfall is the major consideration in deciding on the cropping pattern. During the dry season when water is limited, farmers usually grow secondary crops which need less water.

5.2. Condition of Rural Road Infrastructure and Change of Transportation Cost

Rural road infrastructure is one of the important factors in supporting the economic development of a community. Empirical evidence shows that the condition of rural roads and infrastructure varies among villages. Connecting roads between villages were generally asphalted; however, only part was in good condition, while the majority was not well maintained. Various transportation modes such as minibuses, trucks, and motorcycles were available in most study locations. People usually use their own motorcycle or use public transport such *angkot*[1] and *ojeg*[2] if they want to go from one place to the other within the village. In addition, for short distance travel, in some places people still use *becak*[3], *delman*[4] and bicycle. The types of public transportation mode vary based on local geographical and cultural conditions.

Even though the local government regulates fares for public transport, in practice, the actual rate is frequently determined by road conditions. This fact is in line with the findings of a study by Usman (2014) in Nigeria that the poor condition of roads triggered higher costs for transportation. Furthermore, Tunde and Adeniyi (2012) stated that rural road and transportation facilities correlate positively with agricultural productivity and farmer's income.

In this study, the fare was defined as the fee to be paid by the consumer from the village office to the center of economic activities which is predominantly located in the capital of the sub-district. This study reveals that the fare of public transport in rural areas outside Java (IDR 1568/km) is in average three times higher than those in Java (IDR 497/km). The study also shows that between 2007 and 2010, the real transport cost per kilogram dried harvested grain decreased significantly (see Table 4). This indicates that a significant improvement of rural roads and transport facilities in the areas of the study had taken place during that period.

Table 4. The Real Transport Cost by Province in Java and Outside Java, 2007 and 2010

Province	The RealTransport Cost *) (kg/km)		Change (%)
	2007	2010	
Java :	0.212	0.165	-22.11
1. Central Java	0.239	0.189	-21.16
2. East Java	0.205	0.158	-23.07
Outside Java :	0.666	0.526	-21.01
3. Lampung	0.157	0.126	-19.69
4. West Nusa Tenggara	1.693	1.326	-21.66
5. South Kalimantan	0.282	0.193	-31.64
6. North Sulawesi	0.437	0.390	-10.59
7. South Sulawesi	0.988	0.802	-18.78
Average	0.540	0.425	-21.33

Note : *) The Real transport cost refers to the nominal cost (IDR/km) deflated by the average price of dried harvested grain in each province (IDR/kg)

5.3. Impacts of Infrastructure on Supply of Output and Demand for Inputs

Rural road infrastructure is an important factor influencing either directly or indirectly the utilization of production inputs for rice, corn, and other crops. The relationship between road infrastructure and production of rice, corn, and other crops can be analyzed through the coefficient (see Table 5). The road infrastructure variable can be estimated through a proxy of transportation cost (IDR/km). In general, road condition has an inverse relationship with transportation cost; the worse the road condition, the higher transportation cost is. This is in line with a study by Usman (2014) in Nigeria, which states that the poor road infrastructure has caused a significant increase in transportation costs.

Table 5 shows that the estimated determinant coefficient (R^2) of the model was 0.5373, which means that about 53.73% of the variation in crop production and demand for input can be explained by variations in the independent variables such as output prices, input prices, and fixed input. Parameter estimates for the supply of rice, corn, and other crops, as well as for the demand for inputs as an impact of road infrastructure (Z3) in general had a positive sign and were statistically significant, except for the rice variable and other inputs. The parameter estimates for supply and prices for 'other crops' were estimated using a homogenous restriction (Equation 3).

The parameter estimates of dummy variable for provinces was in general not significant at a 10% level, except for the use of urea fertilizer and other inputs. It appears that there is no significant difference among provinces with respect to the supply of output and demand for input except for urea fertilizer and other inputs. While the dummy variable for the year has a significant positive impact on corn production and labor, its impact on SP-36 fertilizer is negative.

To understand the impacts of road infrastructure on the production of rice, corn, and other crops, as well as on the demand for inputs, an analysis of the elasticity of supply of output and demand for input was conducted. Table 6 shows

1) *Angkot* is a four wheel public transport (minibus).
2) *Ojeg* is a motorcycle to serve passengers, an informal type of public transport, usually individually owned by the motorist.
3) *Becak* is a type of three-wheeled public transport driven by a person.
4) *Delman* is a type of two-wheeled wagon driven by horse power.

that the supply of rice and demand for inputs were in general elastic to the price of rice with scores between 1.352 and 2.548, and was inelastic to the price of corn with a score 0.499. The supply of outputs and demand for inputs were in general inelastic, except to labor. A negative sign of elasticity of supply toward input price indicates that an increase in input prices will cause a decrease in supply for rice, corn, and other crops. A negative sign for elasticity of input toward its price reflects an inverse relationship, in which an increase in the price of input will decrease its demand, while the demand for other inputs may be constant, increase or decrease.

Table 5. Parameter Estimates Restricted for Symmetry and Homogeneity

Variable	Parameter Estimates								
	Rice	Corn	Other Crops$^{*)}$	Urea Fert.	SP-36 Fert.	NPK Fert.	Irriga-tion	Labor	Other Input
Constanta	-3.555^{b}	1.690^{c}	3.988^{a}	-0.354^{a}	0.197^{b}	0.152^{c}	-0.031	0.035	-1.122^{a}
	0.042$^{**)}$	0.075	(7.983)	0.002	0.049	0.072	0.386	0.492	0.005
Price of :									
1. Rice	1.396^{a}	-0.250	0.199^{b}	-0.059^{b}	-0.021	-0.004	-0.028	-0.959^{b}	-0.274^{a}
	0.017	0.188	(1.387)	0.039	0.277	0.448	0.172	0.025	0.000
2. Corn		0.397^{b}	0.233^{a}	-0.027^{c}	-0.009	-0.018	-0.036^{b}	-0.252	-0.038
		0.046	(3.122)	0.080	0.314	0.156	0.030	0.149	0.214
3. Other Crops$^{*)}$			-0.202^{c}	-0.010	-0.008	-0.002	-0.002	-0.218^{b}	0.010
			(1.408)	(-1.122)	(-0.921)	(-0.253)	(-0.263)	(-1.824)	(0.520)
4. Urea Fertilizer				-0.103^{a}	0.005	0.018^{b}	0.008^{a}	0.155^{a}	0.013^{a}
				0.000	0.243	0.014	0.004	0.000	0.005
5. SP-36 Fertilizer					0.023^{a}	0.014^{b}	0.001	-0.012	0.007^{c}
					0.008	0.020	0.394	0.343	0.067
6. NPK Fertilizer						0.009	0.000	-0.020	0.003
						0.154	0.431	0.228	0.204
7. Irrigation							-0.012^{a}	0.064^{b}	0.005
							0.001	0.011	0.143
8. Labor								1.009^{b}	0.233^{a}
								0.016	0.001
9. Other Input									0.041^{b}
									0.019
Fixed Input :									
1. Land Size	0.101^{c}	-0.166^{a}	0.057^{a}	-0.006^{c}	-0.004	-0.001	0.003	0.022	-0.006
	0.091	0.001	2.991	0.100	0.171	0.360	0.262	0.367	0.375
2. Irrigation	1.646^{a}	0.004	-0.666^{a}	-0.048^{a}	-0.047^{a}	-0.029^{b}	-0.035^{b}	-0.895^{a}	0.070
Infrastructure	0.000	0.492	-8.396	0.006	0.008	0.044	0.026	0.001	0.169
3. Road	-0.160^{b}	0.044	0.042^{b}	0.009^{b}	0.007^{c}	0.001	0.004	0.061	-0.008
Infrastructure	0.032	0.206	1.967	0.022	0.078	0.382	0.173	0.204	0.338
Dummy Variable :									
1. Dummy for	0.016	-0.213	0.282	0.020^{c}	-0.002	-0.014	0.006	0.004	-0.099^{b}
Province	0.475	0.106	4.351	0.086	0.439	0.141	0.339	0.492	0.044
2. Dummy for	-0.436	0.287^{c}	-0.173^{b}	0.003	-0.032^{b}	0.002	-0.003	0.355^{c}	-0.003
Year	0.111	0.081	-2.051	0.442	0.050	0.456	0.426	0.100	0.480

Note : *) Parameter estimates of the other crops to be estimated from homogenous restriction. The number in bracket represent t-value.

$t_{0.01(44)} = 2.414$

$t_{0.05(44)} = 1.680$

$t_{0.10(44)} = 1.301$

**) The numbers below are prob |t| values

a = significant at α = 1 % ; b = significant at α = 5 % ; c = significant at α = 10 %

The impacts of fixed variables (land size, irrigation infrastructure, and road infrastructure) on the supply of outputs and demand for inputs are varied. The impact of land size on the supply of outputs and demand for inputs were generally elastic and statistically significant at a 10% level with the scores between 1.070 and 1.285, except for corn which was inelastic. The rice supply is more elastic than corn because farmers usually prefer to grow rice as it is a staple food. The impact of irrigation on rice supply which was estimated through the rice planting index (RPI) was positive, while its impact on corn and other crops was negative.

Table 6 also shows that all scores of elasticity for the supply of output and demand for inputs toward road infrastructure were negative. In the analysis, the transport cost per kilometer was used as a proxy for the road condition. The better the road quality, the lower the transport cost per kilometer and vice versa, the worse the road condition, the higher the transport cost per kilometer. Therefore, the negative sign of elasticity indicates that if the road is improved the transport cost will decrease, and this will have an impact on the production of rice, corn and other crops. In line with the increase of production, the demand for inputs will increase accordingly. If the government increases its budget allocation for rural infrastructure it could reduce transport cost by 10% and this will have an impact of an increase of the production of rice, corn, and other crops by 6.31%, 3.72% and 4.35%, respectively. Meanwhile, the demand for urea, SP and NPK fertilizer will increase by 6.21%, 6.77%, and 5.35%, respectively, whereas the demand for labor and other inputs such as pesticides will increase by 5.80% and 4.64%, respectively. This finding is in line with the previous study by Inoni and

Omotor (2009), only the elasticity score was different; the previous study revealed that an increase of 10% in road quality resulted in an increase of 12% of agricultural outputs.

Table 6. Estimated Own-Price and Cross-Price Elasticity on Foodcrops Farming in Java and Outside Java

Variable	Quantity of								
	Rice	Corn	Other Crops	Urea Fert.	SP-36 Fert.	NPK Fert.	Irrigation	Labor	Other Inputs
Price of :									
1. Rice	1.367[a]	0.499	1.577[a]	1.992[a]	1.796[b]	1.352[b]	2.285[b]	2.452[a]	2.548[a]
	2.724	0.596	4.450	4.914	1.979	1.776	2.123	4.187	7.241
2. Corn	0.132	0.530	0.712[a]	0.668 [a]	0.569	0.778[b]	1.665[a]	0.647[b]	0.511[b]
	0.596	0.770	3.233	2.864	1.174	1.793	2.443	2.170	2.285
3. Other Crops	0.771[a]	1.313[a]	-0.718[c]	-1.676[a]	-1.178[a]	-0.564[a]	-4.621[a]	-1.405[a]	-2.290[a]
	6.627	5.750	-1.347	-14.862	-5.066	-2.786	-16.394	-9.246	-24.846
4. Urea Fert.	-0.128[a]	-0.162[a]	-0.097[c]	-2.364[a]	0.063[a]	0.384[b]	0.223[b]	0.114[a]	-0.020
	-4.914	-2.864	-1.443	-10.601	0.310	1.908	2.115	3.181	-0.910
5. SP-36 Fert.	-0.054[b]	-0.065	-0.051	0.030	-0.423[b]	0.306[b]	-0.009	-0.053[c]	-0.005
	-1.979	-1.174	-0.887	0.310	-1.775	1.902	-0.081	-1.457	-0.258
6. NPK Fert.	-0.043[b]	-0.093[b]	-0.043	0.189[b]	0.320[b]	-0.809[a]	-0.022	-0.065[b]	-0.024
	-1.776	-1.793	-0.771	1.908	1.902	-3.647	-0.223	-1.943	-1.229
7. Irrigation	-0.050[b]	-0.137[a]	-0.031	0.076[b]	-0.006	-0.015	-1.010[a]	0.052[c]	-0.005
	-2.123	-2.443	-0.943	2.115	-0.081	-0.223	-7.607	1.588	-0.223
8. Labor	-1.564[a]	-1.559[b]	-1.155[a]	1.137[a]	-1.110[c]	-1.305[b]	1.525[c]	-1.824[a]	0.301
	-4.187	-2.170	-3.737	3.181	-1.457	-1.943	1.588	-3.234	0.969
9. Other Inputs	-0.431[a]	-0.326[b]	-0.195[a]	-0.052	-0.030	-0.126	-0.036	0.080	-1.017[a]
	-7.241	-2.285	-3.690	-0.910	-0.258	-1.229	-0.223	0.969	-11.356
Fixed Input :									
1. Land Size	1.254[a]	0.674[a]	1.266[a]	1.243[a]	1.285[a]	1.209[a]	1.070[a]	1.145[a]	1.199[a]
	21.113	4.811	24.515	23.159	11.143	12.207	6.684	13.965	14.808
2. Irrigation	0.349[c]	-0.954[c]	-2.054[a]	-0.363[c]	0.269	-0.230	0.314	0.155	-1.298[a]
Infrastructure	1.418	-1.610	-9.594	-1.613	0.549	-0.549	0.494	0.454	-3.808
3. Road	-0.631[a]	-0.372[a]	-0.435[a]	-0.621[a]	-0.677[a]	-0.535[a]	-0.650[a]	-0.580[a]	-0.464[a]
Infrastructure	-9.470	-2.350	-7.983	-11.132	-5.695	-5.150	-4.248	-6.360	-4.969

Note: The numbers below are t-values.

$t_{0.01(44)} = 2.414$

$t_{0.05(44)} = 1.680$

$t_{0.10(44)} = 1.301$

a = significant at α = 1%; b = significant at α = 5% ; c = significant at α = 10%

The t-value analysis for the elasticity of supply of output and demand for inputs on road infrastucture were mostly significant at a 1% level, and only the elasticity of supply for corn was significant at a 5% level. This implies that improvement of road quality will significantly increase the supply of rice, corn and other crops. In line with the increase of supply of output, the demand for inputs will increase accordingly. This finding suggests that improvement of rural road infrastructure in Indonesia is required if the government wants to achieve its target of food crops production as a means for achieving food self-reliance.

The government has implemented many policies and programs to increase food crop production, but they are frequently focused on setting up input-output price policies. To understand the magnitude of the impacts of a policy on input-output prices, a simulation model was used in this study. For improvement of road quality, the scenario was based on an average expansion of asphalt roads in Indonesia which was 2.69% per year during the period 2000 – 2012 (Ministry of Public Works, 2014). The scenario for the price policy on rice and corn is based on the growth of the real price of dried harvested grain and corn at 4.31 %/year and 3.20 %/year, respectively. The scenario for urea fertilizer's price is based on the growth of its real highest retail price which was 0.51 %/year for the period 2006-2014. The results of the simulation with five scenarios are presented in Table 7.

Table 7 shows that if the road rehabilitation program is implemented without any policies for input-output pricing (Scenario 1), its impact on supply of output and demand for input is less than two percent, except for SP36 fertilizer. In general, a combined program where the government improves rural road infrastructure and at the same time enacts good pricing policies will have greater impacts compared to an isolated program. Out of five scenarios generated, scenario 3 provides the most promising results. A combination of an increased investment for rural road infrastructure by 3% and an increase of pricing standard of rice by 5% in real term provide maximum impacts to the production of rice, corn, and other crops at 8.86%, 2.15%, and 12.04%, respectively. If the government opted to implement an input and output policy simultaneously (scenario 5), its impact on rice supply was relatively similar to scenario 3, but it tends to decrease the supply for corn and other crops. Meanwhile, in scenario 3 and 5, the impacts on input demand tend to be similar. An increase of real price of urea by 1% will not have a significant impact on input demand.

Table 7. Simulation of the Infrastructure and Price Policy on Supply of Output and Demand for Input

(Percent)

Supply of Output/ Demand for Input	Scenario*) (1)	(2)	(3)	(4)	(5)
1. Rice	1.894	8.729	8.861	1.767	8.733
2. Corn	1.117	1.616	2.145	0.955	1.984
3. Other Crops	1.306	9.191	12.041	1.209	11.944
4. Urea Fertilizer	1.864	11.823	14.495	-0.499	12.131
5. SP-36 Fertilizer	2.031	11.011	11.580	2.094	11.643
6. NPK Fertilizer	1.606	8.366	11.476	1.990	11.860
7. Labor	1.741	14.002	16.591	1.855	16.705
8. Other Input	1.393	14.132	16.176	1.373	16.156

*)Scenario :

(1) improving the quality of rural road by 3 %

(2) the real price of rice and the quality of rural road increased by 5% and 3%, respectively.

(3) the real price of rice, corn, and the quality of rural road increased by 5%, 4%, and 3%, respectively.

(4) the real price of urea fertilizer and the quality of rural road increased by 1% & 3%, respectively.

(5) the real price of rice, corn, urea fertilizer, and the quality of rural road increased by 5%, 4%, 1%, and 3%, respectively

6. Conclusion and Policy Implication

Improvements in rural road infrastructure have a positive correlation with the supply of rice, corn, and other food crops. Road quality improvement, as reflected by the reduction of transportation cost by 1 %, will increase the supply of rice, corn, and other crops by 0.63%, 0.37%, and 0.44%, respectively. The increase in the output supply will further stimulate the increased demand for fertilizers and labor force by between 0.46% and 0.68%. A simultaneous government policy in improving road quality and pricing of input-output will have positive impacts on food crops production, particularly rice and corn.

Considering that the role of road infrastructure on agricultural sector is crucial, it would be important for the government to increase its budget allocation to maintain and improve road infrastructure, especially in the centers of food crop production areas. In addition, the government should also formulate appropriate strategies on pricing policies for agricultural inputs and outputs in order to gain maximum benefits.

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