Spatial Networks, Labor Supply and Income Dynamics
Evidence from Indonesian Villages

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Abstract

This paper examines the impact of spatial connectivity development on household income growth and non-agriculture labor supply, combining household panel data and village census in Indonesia. Empirical results show that the impacts of the improvement of local road quality in the area (positively correlated with transportation speed) on income growth and the transition to non-agricultural labor markets depends on the distance to economic centers and household education. In particular, post-primary education significantly increases the benefit from the local spatial connectivity improvement in remote areas and labor transition to non-agricultural sectors. Education and local road quality are complementary, mutually increasing income growth and non-agricultural labor income in remote areas. The gain from improvements in local connectivity (measured by the average road quality) depends on village remoteness and initial household-level endowment.

JEL Classifications: O12, R40

Key words: Income growth, Spatial Connectivity, Rural economy, Education, Indonesia

1. Introduction

Economic growth often accompanies spatial inequality. Spatial connection to high growth centers promises the pathway from poverty in local economies, improving economic returns to investment and reducing costs in transportation and search for both human and physical resources, which alters the household resource allocation. In general, the improvement of spatial connectivity is expected to increase allocative efficiency in the local economy, since therefore the mobility of resources becomes faster and less costly and thus price disparity becomes smaller (e.g., Minten and Kyle, 1999).

Our interests is in identifying household behavior, especially their labor supply, responding to the improvement of spatial connectivity in a dynamic context. How spatial connectivity affects household income and labor allocation and what role it plays in economic transition from a farm-based rural economy to non-farm development are important concerns. Moreover, it is not clear how better spatial connectivity — among neighborhood local areas and/or with distant economic centers — changes income distribution in village economies. In other words, who gain first from better spatial connectivity is not clear. Improved spatial connectivity in the local economy may have heterogeneous impacts on households with different endowments. In this paper, we address these questions with focus on household labor supply in the context of Indonesia combining two unique data sets – household panel data and village census data.[3]

In rural contexts, once a village is connected by a new road to a nearby town where jobs are available, the household allocation of labor is expected to change so that they gain from earning opportunities in the town's labor market. If entry to the labor market is easier for educated agents, the allocation of labor changes among households with educated members. More educated agents may try to capture better employment or urban market opportunities that are available in larger economic centers farther than the local town (without migrating). In this case, road access to the larger economic center is more important. Therefore, the above example implies that the effects could be heterogeneous across different locations and across households with different endowments.[4]

The recent literature provides some studies suggesting that returns to human and physical capital in rural areas critically depend on spatial connectivity, which affects the household resource allocation such as labor supply (e.g., Fafchamps and Shilpi, 2003, 2005; Fafchamps and Wahba, 2006).

[3] In the last three decades, Indonesia has transformed from a predominantly farm economy to one that relies more heavily on its non-farm sector. During this period, the GDP per capita grew at an annual average rate of above 5% starting from 1970 to just before the economic crisis. The relative contribution of agriculture to GDP has declined from a share of around 45% in 1970 to around 16% in 2001 (World Bank, 2003). However, these changes were unevenly distributed with some regions are significantly lagging behind then other regions. Similar pattern can be observed in spatial connectivity where some regions have made significant progress while others were lagging behind.

[4] Development economics has paid enormous emphasis on labor supply and wage determination, beginning from inspiring original contributions of A Lewis (1954), Sen (1966), Stiglitz (1974, 1976). More recently since the 80s, neoclassical labor supply has been supported in empirical studies (e.g., Rosenzweig, 1980; Benjamin, 1992), as summarized in Singh, Squire and Strauss (1986). Fafchamps (1993) introduced a rigorous dynamic analysis in this area. To our knowledge, our work is the first attempt to analyze the role of special network development, measured by change in road quality in the neighborhood area, on household labor supply behavior and incomes in the context of developing countries.

Fafchamps and Shilpi (2003) show that the distance to cities crucially determines wage opportunities and employment structure in Nepal and thus non-farm employment (either wage or self-employment) is concentrated in and around cities. Since road construction improves the access to (non-agricultural) labor markets or urban consumers, it increases wages and employment choices for rural residents. Certain types of employment become available with improved spatial linkages. [5]

The connectivity to urban centers benefits laborer households more than farm (landed) households by improving the access to non-agricultural employment opportunities. Foster and Rosenzweig (2001) recently showed evidence from India that the landless prefer road construction as a local public investment choice because it improves the access to labor market, whereas the landed prefer investment in irrigation, which augments returns to land. Infrastructure can bring changes in both farm and non-farm production. It can bring changes in labor demand due to a change in production composition towards non-farm and tertiary activities. Infrastructure can have both substitution and complementary effects; it can be a cheaper substitute of other inputs and can have positive complementarities with other inputs. This can shift the production composition towards activities that can use infrastructural services. Second, by integrating fragmented markets, infrastructure can cause an outward shift in the production frontier and an increase in labor demand as a result. By reducing time and energy cost of distance and transportation costs between rural and urban areas, and within rural areas, infrastructure can therefore integrate fragmented markets.

Since Aschauer's (1989a, 1989b) pioneering works on the role of public infrastructure on productivity, a diverse body of literature has emerged that looks at the impact of infrastructures at aggregate level. The approach followed in most macroeconomic studies are to augment an aggregated production function to include the public capital stock.[6] There are also sector specific studies that utilized cost function (e.g., Morrison and Schwartz, 1996), and infrastructure specific studies (e.g., Röller and Waverman, 2001) that determined the demand and supply of a specific infrastructure simultaneously. A quite number of studies have estimated returns to infrastructure investment such as road construction under various assumptions but mostly at the aggregate level (Fan, et al, 2004; Binswanger, et al 1993). To analyze the dynamic effects on income growth at the household level, however, we must combine, by household/village locations, both household and spatial panel data over a long span of time with sufficiently large changes in infrastructure.

In this paper, we endeavor to capture the improvement in spatial connectivity by constructing a measure that captures intervillage road quality in a region (from the Indonesian village census). We

[5] The improvement of spatial connectivity also has implications on product markets, reducing transportation margins. Minten and Kyle (1999) showed that price variations are largely due to the transportation cost in the former Zaire. Interestingly, traders gain from bad road conditions with reduced purchase prices (increasing their profit). Therefore, spatial connectivity can potentially increase farmers' incomes by reducing traders' profit margin.

[6] See Gramlich (1994) for a review of such studies. In a Cobb-Douglas production function written in logs would be: $\ln Q = \ln A + a\ln K + b\ln L + c\ln G$, where aggregate output Q is a function of private capital K, labor force L, and public capital stock G. Here A is total factor productivity. Assuming a+b=1 and finding c to be positive is an indication of increasing returns to scale. Alternatively, assuming a+b+c=1 and finding c to be positive is an indication of unpaid public factor and existence of private factor rents.

combine this measure and distance to economic centers: subdistrict, district and provincial capitals (from the village survey we conducted in 2007). Our main idea is that intervillage road quality determines the means of transportation used in the local economy and therefore the average speed of resource mobility (including human), which affects allocative efficiency in the local economy. Potential gain in allocative efficiency is also affected by the distance to economic centers at different levels, as these economic centers offer different economic opportunities.

Previous studies on spatial connectivity of rural households were limited in the sense that they perceived connectivity only as access to local towns or remoteness from growth centers, not being able to discuss the combination of both. But in actual policy choices, public investment planners face decisions on the allocation of resource among trunk roads (that lead to economic centers) and local roads. They also face the policy choice regarding the balance between fiscal spending on education and roads.

Empirical results show that the impacts of the improvement of quality of local road in the local area (positively correlated with an increase in transportation speed) on income growth and transition to non-agricultural activities depends on the distance to economic centers and household education. Education significantly increases the benefit from the spatial connectivity improvement, which is augmented by the distance from provincial center. Especially it increases labor supply to and income growth from non-agricultural labor markets. Education and local road quality are complementary, increasing income growth and labor transition to non-agricultural sector. Therefore, whether the local connectivity improvement (measured by the average road quality) is pro-poor or not depends on village location and the initial household-level human-capital endowment.

2. Data

The data we use come from two sources. First, the main data come from village and household level surveys which we conducted in 2007 for 98 villages in 7 provinces (Lumpong, Central Java, East Java, West Nusa Tenggara, South Sulawesi, North Sulawesi, and South Kalimantan) under the JBIC's Study of Effects of Infrastructure on Millennium Development Goals in Indonesia (IMDG). The 2007 village survey captured the physical distance and time to various economic activity points such as market, station, and capital towns. Figure 1 shows locations of surveyed villages.

Figure 1 to be inserted

The survey was designed to overlap with villages in the 1994/95 PATANAS survey conducted by ICASEPS to build household panel data. The 1994/95 PATANAS survey focused on agricultural production activities in 48 villages chosen from different agro-climatic zones in 7 provinces. In 2007, we revisited those villages to expand the scope of research as a general household survey under the IMDG survey. In the 2007 round, therefore, we added 51 new villages in the 7 provinces.

Table 1 to be inserted

Table 1 summarizes ecological and agricultural characteristics in our sample. As explained above, a subsample of the 2007 survey villages have panel data with the 1995 survey. The table also identifies the panel villages, which we use for the income dynamics analysis. It is worth noting that the sample villages cover a wide range of ecological and agro-climatic conditions. In terms of general development, two provinces in Java are more developed in our sample, followed by Lumpong and two provinces in Sulawesi. The two Sulawesi provinces are largely specialized in estate crop production. South Kalimantan and West Nusa Tenggara are least developed in our sample.

In the revisited villages, we re-sampled 20 households per village from the 1994/95 sample and followed the split households. In the new villages, we sampled 24 households from two main hamlets in each village. Since one of the 48 villages in the 1994/95 PATANAS was not accessible for safety reasons in the 2007 survey (in West Nusa Tenggara province), we have the total of 98 villages that are available for various research objectives. In our panel analysis, we constructed household income panel data from 34 villages in 6 provinces (Lumpong, Central Java, East Java, West Nusa Tenggara, South Sulawesi, North Sulawesi) using both the 2007 household and 1994/95 PATANAS surveys.[7]

Second, 1996 and 2006 PODES data were used to construct road quality data. PODES is a village census conducted by the Republic of Indonesia Central Bureau of Statistic. Details are described in Section 3.

3. Descriptive Analyses

3.1 Spatial Connectivity

(a) Inter-village Road Improvement!

In this section we describe village census data: PODES with focus on transportation and road quality variables, and characterize changes in local road quality in the period of 1996 to 2006. The

[7] 1994/95 PATANAS survey consists of two sub-surveys. Income and production data are available from the second part, which contains 34 villages in 6 provinces excluding South Kalimantan. To merge the household panel data with spatial data on road quality constructed from PODES (1996-2006), we use the information on sub-district, district and province identification. In the analysis, we use sub-district and district-level road quality variables to be interacted with household and village-level variables such as land owned and distance to district center. At this stage, we found that we cannot construct road quality data for 2 sub-districts in North Sulawesi as they have missing information in PODES. When we constructed village panel data from PODES for other studies to analyze village dynamics, we had a problem in linking villages across rounds because of village divisions and merges partly due to the decentralization process in the country. To solve this problem, we linked subdistricts and then linked villages within each subdistrict by their names. In this paper, however, since we only use subdistrict-level information - the average proportion of asphalt roads in inter-village roads, the above problem is less important.

data cover all villages in the census years. For our research, we use 1996 and 2006 rounds as our household panel data were collected in 1995 and 2007. In the panel analysis, we take the difference between 1996 and 2007 to represent changes in the average road quality in the local economies.

The PODES data have the information on major inter-village traffic. If the major traffic is on land, they ask about the type of widest road for this purpose - asphalt/concrete/cone-block, hardened, soil, and others. Another question identifies whether 4-wheel or more vehicles pass the road all year long. From the above information, it is possible to construct indicator variables for (i) major inter-village traffic = land or not, (ii) type of widest road =asphalt/concrete/cone-block or not, (iii) type of widest road = hardened or not, (iv) type of widest road = soil or not, (v) type of widest road = others or not, and (vi) 4-w or more vehicle can pass the road all year long = yes or not.

We choose the measure (ii) to capture transportation speed in the local economy. The average is taken at the sub-district, district and province levels in each round.

$$\mathbf{z}_t(j) \equiv \frac{\sum_{m \in N(j)} z_t^m}{\#N(j)}$$

where z_t^m is the indicator variable which takes the value of one if major inter-village traffic is on land and the road is constructed of asphalt/concrete/cone-block (good quality) and zero otherwise (bad quality), $N(j)$ is a set of villages within the village j 's neighborhood, and $\#N(j)$ is the number of villages in $N(j)$. Therefore, $\mathbf{z}_t(j)$ is the probability of having good-quality transportation, which is assumed to be positively correlated with the average transportation speed in the local economy.

Table 2 to be inserted

Table 2 shows the province-wise averages of asphalt road indicators in 1996 and 2006. To have comparability between the two years, we use 1996 provinces for villages which have changed province/district from 1996 to 2006. First, in both years, we observe inter-provincial disparities in the average road quality. Second, the average proportion of asphalt inter-village roads has improved in many provinces.

Table 3 to be inserted

Table 3 shows tabulations of villages matched between 1996 and 2007 based on changes in inter-village road quality (asphalt or not). In many provinces, more villages have improved inter-village road quality rather than deteriorated although a large number of villages have no change in quality and there are a non-negligible number of villages where road quality has been deteriorated. The reason for deterioration of road quality is not obvious from the data. Yet, it may be related to inadequate road maintenance or construction of new road with poor quality.

Next, taking difference between the two rounds, we can see improvement and deterioration of road quality in local economies:

$$\Delta \mathbf{z}(j) = \mathbf{z}_1(j) - \mathbf{z}_0(j)$$

Interestingly, we found that, in all regions, the changes are symmetrically distributed with either improvement or deterioration though the majority shows relatively small changes around zero (see Figures 2).

Figure 2 to be inserted

At the sub-district level, improvement and deterioration coexist over the ten years in Indonesia, by which we can examine the impact of inter-village quality change on household income dynamics. Comparison of the road quality change (at the sub-district level) between Java and non-Java regions showed that Java areas had experienced a faster improvement than outside Java.

(b) Distance to Economic Centers

We assume that the physical distance has been constant throughout the period, so it is taken as predetermined. This information is important because we think the impact of spatial connectivity development on village economies is not even, depending on the distance to main economic activity points. Table 4 shows distances to the centers in all 98 villages, using the 2007 village survey.

Table 4 to be inserted

3.2 Household Income

In the analysis of household income dynamics, we use household panel data from two rounds conducted in 1995 and 2007 in 6 provinces as mentioned above. In both surveys, we collected detailed information on income generating activities. From each activity, we aggregated incomes to construct household-level income measure.

To merge the income data with that of 1995, we aggregated incomes from original and split households using the 1995 household units. Some households split from the 1995 households (called original households), but it is important to aggregate incomes from both original and split households in 2007 to be comparable with the 1995 original households. The results were quite similar, which implies attrition (split) bias in our panel analysis was not large.

Table 5 to be inserted

Table 5a shows descriptive statistics of key variables: number of household members aged 15-64, household incomes, its growth, non-agricultural income shares, non-farm self-employment income shares, landholding size and 1995 household head's education in the panel sample. First, both non-agricultural and non-farm self-employment income shares increased in the period. Second, about 10 percept of the households had heads who completed high school or above. Lastly, growth of nominal household income is about 1.5.[8] However, we have to note that regression analysis always includes location averages (dummies) which controls price changes specific to each location (village).[9]

To merge the household panel data with spatial data on road quality constructed from PODES (1996-2006), we use the information on sub-district, district and province identification. In the analysis, we use sub-district and district-level road quality variables to be interacted with household and village-level variables such as education, and owned and distance to district center.

Figures 3 to be inserted

Next we investigate the relationship between head's years of schooling and income growth. In this exercise, villages are grouped in two use observations (villages) which experienced a positive change in the road quality in their sub-districts. Figure 3a (3b) shows per-capita income growth in villages which experienced a positive (negative) change in the road quality in their sub-districts. Income growth is demeaned by village effects, so we observe intra-village variations using the residuals. Interestingly, when the road quality improves, as head's years of schooling increases, income growth stays intact up to around junior high-school completion, but it substantially increases from senior high-school completion or higher. There seems to be a threshold in schooling level, beyond which local road quality change and education jointly increases the impact on income growth. In villages that experienced the deterioration of road quality, the negative impact on income growth is large

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[8] The number is the average of income logarithm differences from 1995 to 2007.

[9] We also compared province-wise averages. First, non-agricultural income and non-farm self-employment income shares are higher in Java provinces than outside Java. Second, this does not necessarily imply higher income (or growth) in Java provinces. Third, landholding size is smaller in Java provinces than outside Java. It is easy to link diminishing roles of land and increase in non-agricultural activities in rural areas, but this does not mean higher income or its growth in our sample. Relationships to changes in local road quality are described in graphs below.

among educated households.

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Figures 4 to be inserted

Figures 4 show the relationship between change in average road quality and non-agricultural income share. Both graphs imply that the improvement of inter-village roads in sub-district causes an increase in non-agricultural income share. This is particularly strong for non-agricultural labor income. Our econometric analysis also confirms the above observation.

4. Empirical Framework

In the analysis we estimate the following equations on income growth and change in non-agricultural income share, both first differenced between 1995 and 2007 to eliminate fixed effects. Both income growth and non-agricultural income share equations, after first differenced, are written as:

$$\begin{aligned}\Delta y_{ij} &= \alpha + \gamma_{11}\Delta\mathbf{z}(j) + \gamma_{12}x_{ij}^{0}\Delta\mathbf{z}(j) \\ &+\gamma_{21}d_j\Delta\mathbf{z}(j) + \gamma_{22}x_{ij}^{0}d_j\Delta\mathbf{z}(j) \\ &+\Delta\varepsilon_{ij}\end{aligned}$$

where Δy_{ji} is income growth (or change in non-agricultural income share, labor supply change) for household i in village j, $\Delta\mathbf{z}(j)$ is change in the average road quality in the neighborhood of village j, d_j is the distance to a center (to be discussed below), x_{ij}^{0} is household i 's land owned and education in the initial period, and ε_{ij} is an error term. As mentioned, fixed effects are differenced out.

We assume that the distance to economic activity center is predetermined, so taken as exogenous. Economic activity point can be sub-district, district or province center. The interaction of $\Delta\mathbf{z}(j)$ and d_j captures how the benefit from the spatial connectivity improvement varies with village location and distance from economic activity points.

In the above specification, we also attempt to capture heterogeneous effects of the spatial development by the household initial-stage asset-holding and endowment. We use the information on landholding size and household head's education in 1995.

The error term potentially consists of aggregate and household-specific shocks: $\varepsilon_{ij} = v_j + \xi_i$. To control province-specific shocks, we can include province dummies. However, village-specific shocks are correlated with local economic development, which is again correlated with dynamic change in the average road quality. Thus, $E\left[\Delta v_j \Delta \mathbf{z}(j)\right] \neq 0$. In the estimation below, therefore, we control village-level dynamic shocks in the first differenced specification.

$$\Delta y_{ij} = \alpha + \gamma_{12} x_{ij}^0 \Delta \mathbf{z}(j) + \gamma_{22} x_{ij}^0 d_j \Delta \mathbf{z}(j) \\ + village\ dummies + \Delta \xi_{ij}$$

This specification enables us to see intra-village variations in the response to the spatial connectivity development (as the village average is controlled). Village-specific income shocks (affecting growth) are controlled by village dummies. We assume that the correlation between household-specific shocks and the area-wide spatial development is not important.

The inclusion of village fixed effects in the above estimation also addresses potential omitted variable problems. In reality, many changes occurred over time, and the estimation cannot control for all of them. We assume that changes experienced by sample households are common within the village. In the above framework, the improvement of spatial connectivity, specific to sub-districts, can only alter the returns to household characteristics such as household head's education and land holding since we include village fixed effects.

Note that we use income aggregated from both original and split households in 2007. Therefore, our results will be robust to attrition bias potentially arising from endogenous household split dynamics. In the analysis, however, individual migration process is taken as exogenous, which may bias our estimates given that the migration process defines the denominator to calculate per-capita income.

5. Empirical Results

5.1 Income Growth and Non-agricultural Share

In this section we summarize main results from the household analysis. In this analysis, we examine household income growth, changes in non-agriculture income share, and non-farm self-employment income share. In preliminary analyses, we found that sub-district level road quality measure explains them better than district-level and province-level road quality measures, probably because it has enough variations in the sample and localized spatial connectivity development is important to opening access to wider economic activities (such as district and province center).

To capture potential heterogeneous effects of the sub-district average road quality improvement on income growth, we introduce some heterogeneity in the analysis: household head's education level and landownership in 1995 at household-level and distance to sub-district, district and provincial centers at the village level.[10]

Table 6 to be inserted

The main analytical point is to investigate the role of post-primary education and initial landholding in income growth when spatial connectivity is improving in the local neighborhood, and then to investigate the relationship with the connectivity to farther economic centers.[11] We include village dummies to control village-specific shocks containing price change specific to village economy.

In Table 6, Column 1 uses the indicator which takes the value of one if head has completed high school or higher, and zero otherwise, being interacted with the 1995 inter-village road quality indicator, and distances to sub-district, district and province centers. Distance factors do not significantly affect the education-spatial network effects on per-capita income growth, though the initial condition on village road significantly increases the above effect. The improvement of spatial network does not influence household income growth.

Columns 2 and 3 examine changes in non-agricultural total income share and non-agricultural labor income share respectively. The results are comparable. First, education effect is significantly negative in both cases. Second, however, in the former case, distance to sub-district capital significantly increases the marginal effect of education. With a little more than 10 kilometers from the sub-district capital, the total effect of being educated at high school level or higher turn out to be positive. Third, more interestingly, change in non-agricultural labor income share increases significantly with distance from provincial capital. Combining the above findings, we can conclude that the impact of improved local spatial network on transition to non-agricultural income sources (especially, labor income) tends to be positive in remote villages.

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[10] In our empirical setting with a small number of villages in each sub-district, we cannot identify the effect of sub-district level road quality change on household-level outcomes. Therefore, we focus on intra-village distributional effects (with village dummies controlling price change and village-level shocks) in our parametric estimation.

[11] Educational level can also change over time, which creates the endogeneity issue. Changes in household income as well as spatial connectivity affect changes in the household education level. Statistically, the first differencing and the inclusion of village fixed effects mitigate the above endogeneity problem since we should be only concerned about the correlation between household-specific shocks and the initial level of household schooling. On this point, we need to be careful about the direction of potential bias. Dewina and Yamauchi (2009) show that intergeneration educational growth, measured by the gap between household head's education and the maximum level in the household in 1995 significantly explains income growth. Yamauchi and Yuki (2009) also demonstrate significant changes in educational attainment in the 1970-80s. These findings suggest that a higher level of schooling attained by the household head implies, on average, a lower education gap with the maximum level in the household. If so, potential bias in the education effect is small. However, if a higher level of education attained by the head means higher growth of educational attainment within the household, we may face potentially large upward bias.

In Column 4, we use growth of non-agricultural labor income from 1995 to 2007. For zero incomes from this source, we assigned 1000 Rupea in order to compute income growth. The previous results were basically confirmed in this estimation. First, the direct effect of education is insignificant now. Second, the initial condition on village road quality augments the education-spatial network effect. That is, given the improvement of the average spatial network in neighborhood, villages with better road conditions have advantage of accessing non-agricultural employment. Third, as found before, distance from provincial capital significantly increases non-agricultural labor income growth, if household head attained high school or higher and the neighboring road networks improves over time. The above findings are consistent with Figures 4a and 4b.

The above results suggest that local center in remote area is key. Marginal benefit from local road quality improvement is large in remote areas, probably because capital accumulation is at low level. However, our results show that district center is always important in local economy given localized economic interactions at district level. There seems to be two important dimensions in their economic connectivity: links to local economy (district capital) and larger economic demand center (province capital). In the former, proximity to the center is always beneficial for the educated, but areas far from the latter (thus, districts far from province capital) are more likely to benefit from local road quality improvement. Regardless of interactions with distance, education always increases marginal benefits from local road quality improvement.

The result also confirms that the initial openness (inter-village road quality in 1995) and the improvement of the average road quality in the local network (sub-district) are complementary for the educated agents (households). The educated experienced a higher income growth when the initial condition on inter-village road quality was favorable, and the local economy has improved the average road quality.

In our definition, non-agricultural activities only cover those undertaken by current household members. This excludes non-members who work in locations distant from their villages (those who do not commute from their villages). Therefore, it is still possible that we are missing migration-linked non-agricultural transition.[12] Instead, income growth includes agriculture-based growth, which for example includes improved marketing of agricultural products (e.g., vegetables). In this activity, connecting to larger demand centers seems to be a driving force. The next section shows

[12] We had a negative effect of schooling on change in non-agricultural income share (all through the interaction term with change in road quality). First, the educated are more likely to have the non-agriculture income opportunities than the less educated at the initial stage, and therefore the local road quality improvement has a smaller marginal effect on the transition to the non-agriculture sector among the educated. Second, the more educated households also have more assets for agriculture production and thus the road quality improvement increases the productivity of their farm activities. Third, individual-level selectivity may cause the above result. At the individual level, the educated are more likely to move out of the households over time to get higher income opportunities in non-agricultural sectors. The comparison of completed schooling between current members and non-members shows higher average schooling among non-members. In the household with educated head, other members were also likely to be educated too. Therefore, if the above mentioned migration selection is important in the period of 1995-2007, an inverse correlation between schooling (at the household level) and observed non-agricultural transition is feasible. This is because educated agents go out, and stayers are relatively less educated in the households.

some findings on the above issues.

In the estimation, we included clustered correlations within the village to compute robust standard errors. Potentially there can be correlations across shocks outside the village (even after village fixed effects control for village-specific shocks). For example, income shocks can be positively correlated within province. In the preliminary analysis, we experimented with district or province-level clusters, which proved the robustness of our results. However, we have not explicitly incorporated any correlation structure that exhibits a decaying degree with physical or economic distance.

5.2 Labor Supply to Non-agricultural Sector

This section focuses on the household behavior of labor supply to non-agricultural sector, and its income growth. In the previous section, we found income growth and share change of non-agricultural income sources do not necessarily match. To resolve this issue, we will look into the non-agricultural labor market behavior.

We constructed the share of labor supplied to non-agricultural activities in 1995 and 2007. The number of household members aged 15 to 64 defines the household labor endowment, once converted in man-days. We assume that each individual works 250 days a year. Since we noted that the 1995 survey undercounted household members, we used the 1995 member list reconstructed from the 2007 survey. For actual man-days worked in non-agricultural activities, we use the data from the 1995 and 2007 surveys. In the analysis of labor supply dynamics, we use change in the share of labor supplied in non-agricultural activities. [13]

Table 7 to be inserted

Table 7 shows the change in man-days worked in non-agricultural labor market from 1995 to 2007. Columns 1 and 2 use the sample of household members in the original and split households, that is, those who live in the sample villages in 2007. With the same specifications used in Tables 5, we can investigate what factors contributed to changes in the household labor supply.

The results confirm that signs and significance of parameter estimates are quite similar to those of income growth equations in Table 6. Openness to outside economy, combined with the development of spatial network surrounding the village, increases labor supply to non-agricultural activities. Education attainment at the secondary or higher level helps gain more from the spatial network development. In remote villages distant from provincial capital, the gain is large. The role of landholding is not significant except the distance to sub-district town, but it is hard to provide an

[13] Some individuals may work more than 250 days in the past year. It is also possible that household members of age less than 15 or above 65 work in non-agricultural sectors (though age less than 15 is not legal). In some households, we may still miss some members in the roster who contributed to the household income but their labor supply and incomes were captured. For all these possible reasons, the estimated share of labor can be above one. In this case, we adjust the values to one. In the analysis, however, we take difference between 1995 and 2007, which minimizes the potential problem.

interpretation solely from this parameter.

In Columns 3 and 4, we include out-migrants who moved out of the sample villages before 2007. We assume that out-migrants aged 15-64 work fulltime in non-agricultural sector. Thus, man-days take the maximum for those out-migrants.[14] First, the results support complementarities between education and road network development, which increases labor supply and migration to non-agricultural sector. Second, the initial condition on inter-village road condition (asphalt) is significantly important in this case. Third, results on the interactions with distances to economic centers conform to the previous findings.

Land factors show some interesting results once we include out-migrants. First, the initial road quality in inter-village roads in 1995 seems to stop labor transition. More landholding, combined with the initial road condition, probably means advantage in input purchase and produce marketing, which decreases the transition to non-agricultural labor market. Second, however, distance from economic centers seems to promote out-migration and labor supply to non-agricultural sector.

In the above analysis, we focused on transition in labor supply from agriculture to non-agricultural labor markets. In general, the benefits of improvement in spatial connectivity might not be limited to the labor transition. Another potential benefits could be changes in the agricultural sector, including increased output margins due to decreased traders' bargaining power, transformation of the agricultural output mix from low-value to high-value products, and increased use of modern inputs. Yamauchi et al. (2008) analyzed some of these issues.

6. Policy Discussion

In this paper, we intend to bridge the gap between academic studies and infrastructure planning. Previous academic studies on spatial connectivity of rural households were limited in the sense that they perceived connectivity only as access to local towns or remoteness from growth centers, not being able to discuss the combination of both. But in actual policy choices, public investment planners face decisions on the allocation of resource among trunk roads (that lead to economic centers) and local roads. Public investment planners also face the policy choice regarding the balance between spending on education and on roads.

The analyses described above suggest that the more educated households can increase income with better spatial connectivity at local level. Better local road quality may also improve the access for remote villages to trunk roads and thus help the more educated engage in better job/business opportunities at district capital (local economy) or province capital (larger economic center).

However, the effect on income growth is larger when the village is close to district center, and/or distant from provincial center. Although we cannot include in the empirical analysis due to data

[14] We take this as the upper bound on labor supplied in non-agricultural sectors. In the share, we add to both the numerator and denominator 250 times the number of out-migrants aged 15-64.

limitation, this difference may be due to the market space as well as the value added of different income generating activities. First, there exists income generating activities focusing on the market with district capital as the local economic center. These may include activities such as food processing with low value added (such as dried fish or chips/crackers) and marketing staple food. In this case, proximity to the economic center is a key as it reduces transport related transaction cost. However, there are other types of activities with wider market area, especially catering to urban economic centers such as provincial center. These may include higher value added goods sold in large urban markets such as bamboo or wood products. Another example can be high quality vegetables for the urban market. In such case, the added value can cover the transaction cost due to transportation and thus distance from provincial center is not an obstacle, as provided that it is connected to economic centers. Better road connectivity to provincial center due to local road improvement may give remote villages the chance to market such value added products.

In the former case, it can be suggested that improving the trunk roads connecting to closer district centers is important alongside with the improvement of local roads that provide access to such trunk roads. In the latter, it is important to develop the network of the trunk roads to secure connectivity to distant economic centers, such as provincial capital, alongside with the improvement of local roads.

Poverty Reduction Strategies (PRSs) adopted by low income countries especially those in Africa are entering a second stage, becoming more growth oriented. Compared to the previous generation of PRSs emphasizing budget allocation to primary education and health, the current generation focuses on growth strategies. Yet, little is known on the type of public investment combination that induces growth. The analyses of this paper suggest that investing simultaneously in spatial connection of local neighborhoods as well as in connecting to distant economic centers pays off. This paper also suggests that investing in both higher education (high school and above) and roads is important. Although the actual PRSs should be country driven and country specific, such findings can add value to the next generation of growth oriented PRSs.

7. Conclusion

This paper examined the impact of spatial connectivity development on household income growth and transition to non-agriculture, combining household panel data and village census in Indonesia. Empirical results show that the impacts of the improvement of road quality in the local area (positively correlated with an increase in transportation speed) on income growth and transition to non-agricultural activities depends on the distance to economic centers and household education and landholding size. In particular, post-primary education significantly increases the benefit from the local connectivity improvement in remote areas and the transition to non-agricultural labor markets. Post-primary education and local road quality are complementary, increasing income growth and labor supply to non-agricultural sector.

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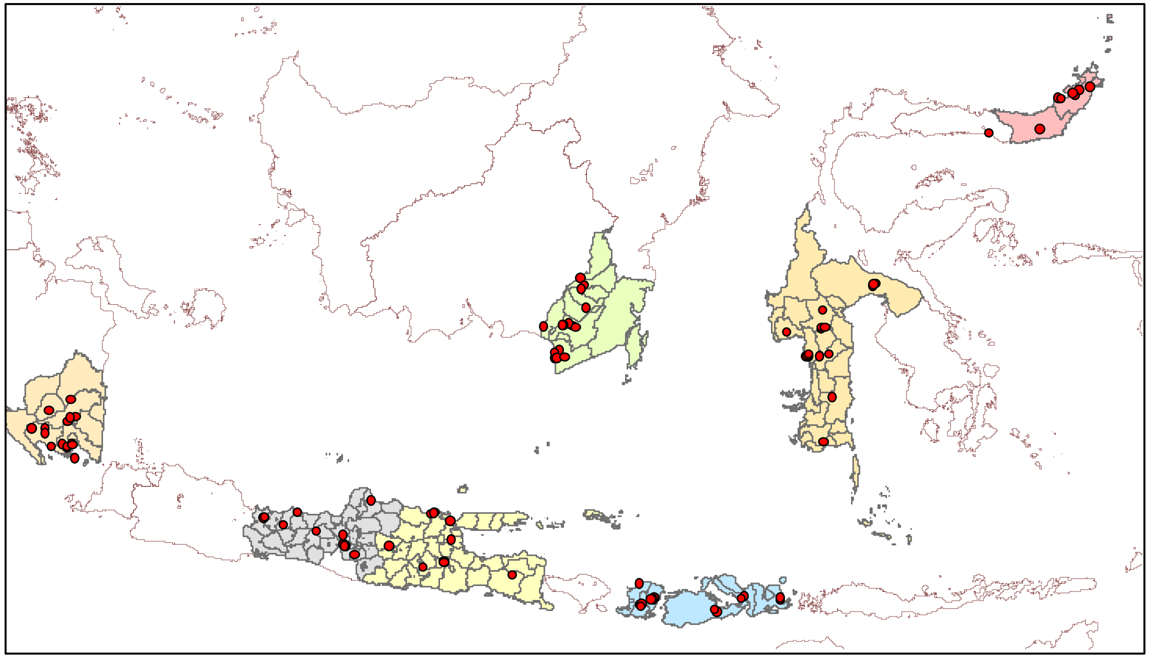
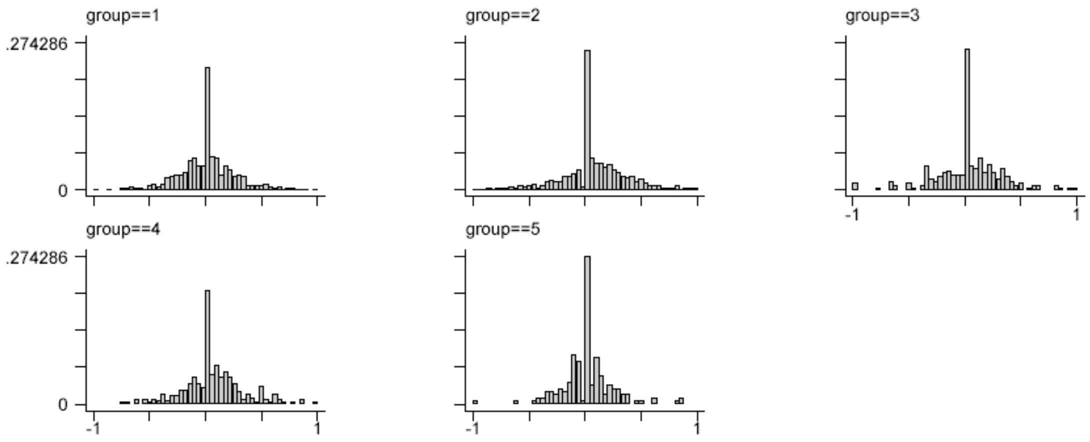
Figure 1. Locations of surveyed villages



Figures 2 Change in the average inter-village road quality (asphalt road proportion)



Group 1: Sumatra, Group2: Java (excluding Jakarta), Group 3: Kalimantan, Group 4: Sulawesi, Group 5: Others (excluding Bali)

Figure 3a Per-income income growth and household head's education – road quality improved

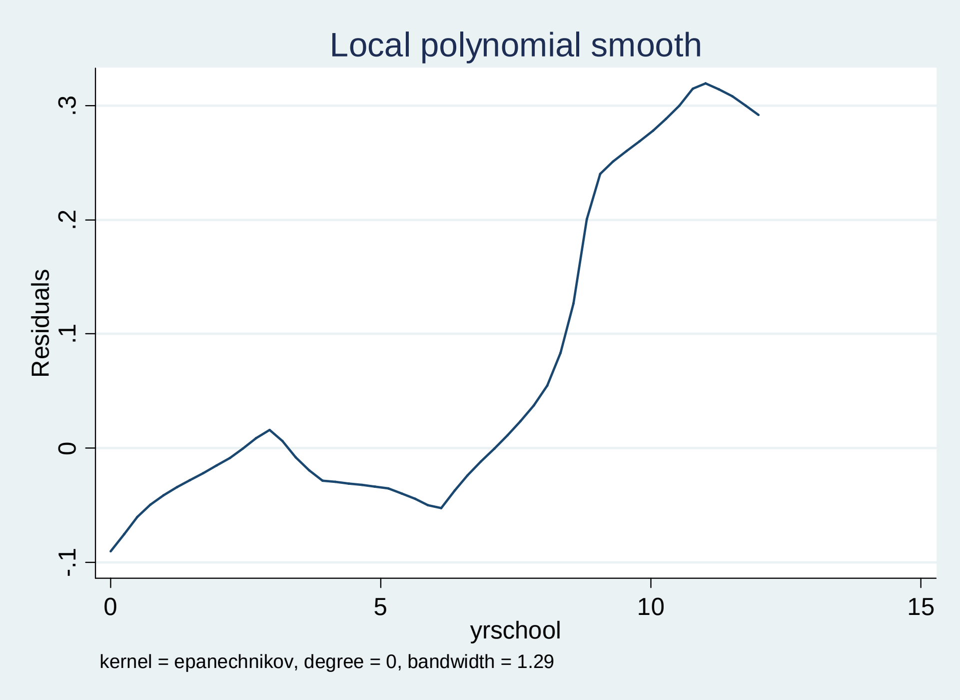


Figure 3b -income income growth and household head's education – road quality deteriorated

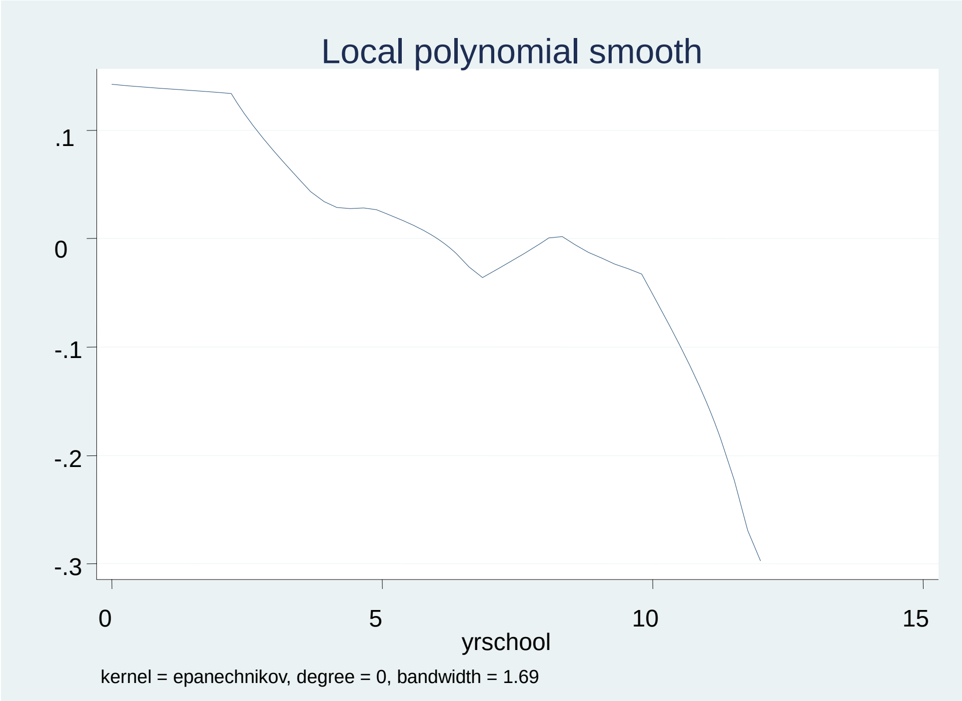


Figure 4a –Change in non-agricultural income share and average road quality

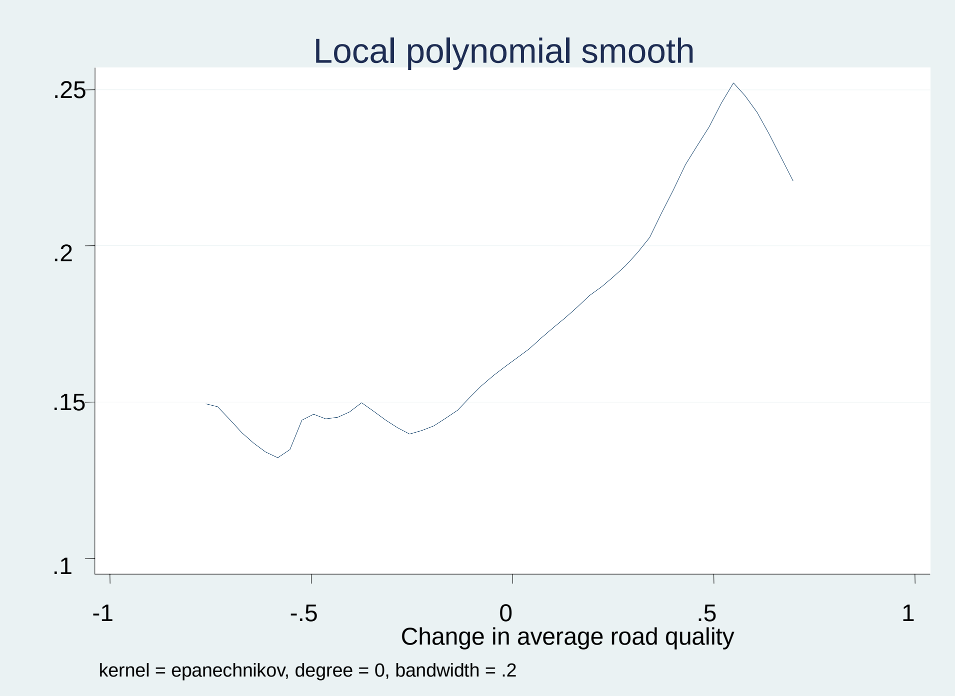


Figure 4b –Change in non-agricultural labor income share and average road quality

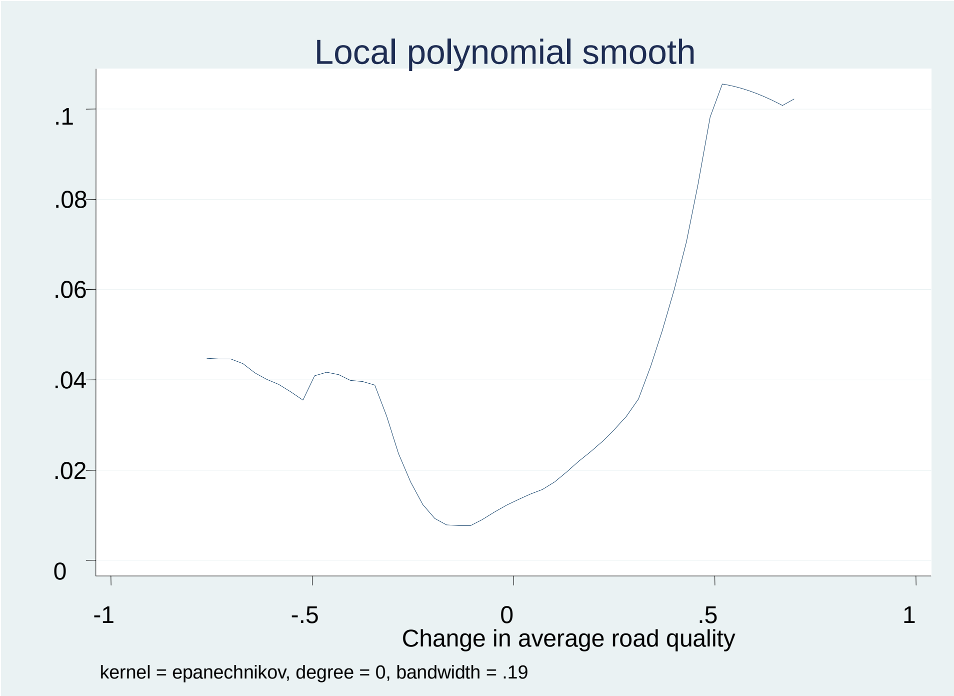


Table 1 Sample village econlogical and agricultural chanracteristics

No.	ID	Name of the Province	Panel 95	Eco-system	Main commodity/farming
1	1	Lampung	yes	mountain	cocoa, banana, bean
2	2	Lampung	yes	mountain	coffee, pepper
3	3	Lampung	yes	Irrigated area	paddy
4	4	Lampung	yes	dry land	cassava, paddy
5	5	Lampung	yes	rainfed	pepper, cofee
6	6	Lampung	yes	dry land	sugar cane
7	7	Lampung	no	mountain	paddy, secondary crops, coffee
8	8	Lampung	no	mountain	paddy, secondary crops, coffee
9	9	Lampung	no	mountain/close to the sea	secondary crops, cocoa, banana
10	10	Lampung	no	mountain/close to the sea	secondary crops, cocoa, banana
11	11	Lampung	no	small island	fishery
12	12	Lampung	no	low land	paddy, cassava
13	13	Lampung	no	low land	paddy, cassava
14	14	Lampung	no	Mountain	coffe, upland rice
15	15	Lampung	no	Mountain	coffee
16	16	Lampung	no	mountain	coffee, pepper
17	1	Central Java	yes	mountain, up land	vegetables, livestock
18	2	Central Java	yes	low land (irrigated area)	paddy, secondary crops
19	3	Central Java	yes	mountain, upland	tobacco
20	4	Central Java	yes	mountain	potato
21	5	Central Java	yes	Irrigated area	paddy
22	6	Central Java	yes	up land	paddy, secondary crops
23	7	Central Java	no	coastal	fish pond, fishery
24	8	Central Java	yes	dry land	cassava, sugar cane
25	9	Central Java	no	mountain	secondary crops, livestock
26	10	Central Java	no	low land	paddy, secondary crops
27	11	Central Java	no	Irrigated area	paddy
28	12	Central Java	no	Irrigated area	paddy
29	1	East Java	yes	low land (irrigated area)	paddy, sugar cane
30	2	East Java	yes	low land (irrigated area)	paddy, corn
31	3	East Java	yes	low land (irrigated area)	paddy, sugar cane
32	4	East Java	yes	coastal	fish pond (milk fish, shrimp)
33	5	East Java	yes	coastal	fishery
34	6	East Java	yes	mountain	horticulture, dairy
35	7	East Java	no	mountain	paddy, tobacco
36	8	East Java	no	low land	paddy, corn, fish pond (milk fish)
37	9	East Java	no	coastal + irrigated area	paddy, corn, fish pond (milk fish)
38	10	East Java	no	mountain	horticulture, dairy
39	11	East Java	no	mountain	horticulture, dairy
40	1	North Sulawesi	yes	low land	paddy, tobacco, garden
41	3	West Nusa Tenggara	yes	mountain	paddy, corn, tobacco, vegetables
42	4	West Nusa Tenggara	yes	low land	paddy, tobacco, garden
43	5	West Nusa Tenggara	yes	mountain	cashew nut, paddy
44	6	West Nusa Tenggara	no	coastal	fishery
45	7	West Nusa Tenggara	no	mountain	paddy, corn, tobacco, vegetables
46	8	West Nusa Tenggara	no	mountain	paddy, corn, tobacco, vegetables
47	9	West Nusa Tenggara	no	low land	paddy, secondary crops, garden
48	10	West Nusa Tenggara	no	low land (coastal)	paddy, cashew nut
49	11	West Nusa Tenggara	no	low land	paddy, tobacco, beans
50	12	West Nusa Tenggara	no	low land (dry land)	paddy, soy bean
51	13	West Nusa Tenggara	no	low land	Paddy, corn
52	14	West Nusa Tenggara	no	low land	paddy, tobacco, beans
53	1	South Kalimantan	no	tidal/swamp area	local paddy
54	2	South Kalimantan	no	estate plantataion	rubber
55	3	South Kalimantan	no	tidal	paddy, coconut
56	4	South Kalimantan	no	tidal/swamp area	local paddy
57	5	South Kalimantan	no	tidal/swamp area	local paddy
58	6	South Kalimantan	no	coastal	fishery, paddy
59	7	South Kalimantan	no	mountain	paddy, horticulture
60	8	South Kalimantan	no	estate plantataion	rubber

61	9	**South Kalimantan**	no	estate plantataion	rubber
62	10	**South Kalimantan**	no	tidal/swamp area	local paddy
63	11	**South Kalimantan**	no	coastal	fishery, paddy
64	12	**South Kalimantan**	no	low land	paddy, secondary crops
65	13	**South Kalimantan**	no	mountain	paddy, corn
66	14	**South Kalimantan**	no	tidal/swamp area	local paddy
67	15	**South Kalimantan**	no	tidal	coconut palm
68	16	**South Kalimantan**	no	tidal/swamp area	local paddy
69	1	**North Sulawesi**	yes	mountain	coconut, clove, paddy
70	2	**North Sulawesi**	yes	irrigated area + plantation	paddy, clove, coconut
71	3	**North Sulawesi**	yes	up land	horticulture
72	4	**North Sulawesi**	yes	plain, rainfed	coconut, nutmeg
73	5	**North Sulawesi**	yes	low land	paddy, coconut
74	6	**North Sulawesi**	no	coastal	fishery
75	7	**North Sulawesi**	no	mountain	paddy, coconut
76	8	**North Sulawesi**	no	coastal-irrigated area	coconut, paddy, secondary crops
77	9	**North Sulawesi**	no	coastal-irrigated area	coconut, paddy, secondary crops
78	10	**North Sulawesi**	no	mountain	coconut, vanilla, clove, woods
79	11	**North Sulawesi**	no	mountain	coconut, corn, native palm
80	12	**North Sulawesi**	no	mountain	coconut, cocoa
81	1	**South Sulawesi**	yes	low land	paddy, cocoa, coconut
82	2	**South Sulawesi**	yes	irrigated area	paddy
83	3	**South Sulawesi**	no	irrigated area	paddy
84	4	**South Sulawesi**	yes	iigated area	paddy
85	5	**South Sulawesi**	yes	mountain	coffee
86	6	**South Sulawesi**	yes	mountain (dry land)	upland rice, corn
87	7	**South Sulawesi**	yes	dry land, plantation	cocoa
88	8	**South Sulawesi**	no	low land (coastal)	paddy, fish pond
89	9	**South Sulawesi**	no	low land (coastal)	paddy, fish pond
90	10	**South Sulawesi**	no	low land (coastal)	paddy, fish pond
91	11	**South Sulawesi**	no	irrigated area	paddy
92	12	**South Sulawesi**	no	irrigated area	paddy
93	13	**South Sulawesi**	no	coastal	fishery, fish pond
94	14	**South Sulawesi**	no	low land	paddy, cocoa, coconut
95	15	**South Sulawesi**	no	low land	paddy, cocoa, coconut
96	16	**South Sulawesi**	no	low land	paddy, cocoa, coconut
97	17	**South Sulawesi**	no	irrigated land and fish pond	paddy, milk fish
98	18	**South Sulawesi**	no	coastal	milkfish, shrimp

Note: NTB No.2 was dropped due to the fact that access to the village was unsafe in 2007, and we added a new village in the province.

Table 2 Asphalt road proportion in inter-village roads (province-wise average)

province	1996	2006
11	0.45562672	0.394104
12	0.48859242	0.527837
13	0.69230769	0.926199
14	0.39776952	0.481432
15	0.61111111	0.736089
16	0.63424867	0.685742
17	0.74492498	0.727365
18	0.52244898	0.470416
31	0.98850575	1
32	0.68730866	0.657614
33	0.64077898	0.740671
34	0.80593607	0.791569
35	0.55911418	0.67632
51	0.98452012	0.987988
52	0.81891026	0.783646
53	0.44480171	0.403344
61	0.41470588	0.467368
62	0.36184211	0.435606
63	0.63270504	0.665449
64	0.32412791	0.493113
71	0.75829726	0.755102
72	0.57568627	0.633303
73	0.49590893	0.603246
74	0.5215783	0.552339
81	0.56921488	0.642105
82	0.24639671	0.441704

Unit of observations is village

Table 3 Villages based on changes in inter-village road quality (Asphalt/concrete/cone block or Not) between 1996-2006

Province name	Number of villages					Proportion of villages in each province				
	No change		Deteriorated	Improved	Total	No change		Deteriorated	Improved	Difference (Improved)-(Deterorated)
	Remain good	Remain bad				Remain good	Remain bad			
Jawa Barat	516	546	230	128	1,420	36.3%	38.5%	16.2%	9.0%	-7.2%
Lampung	373	60	53	35	521	71.6%	11.5%	10.2%	6.7%	-3.5%
Maluku	249	349	91	70	759	32.8%	46.0%	12.0%	9.2%	-2.8%
Jambi	586	154	101	77	918	63.8%	16.8%	11.0%	8.4%	-2.6%
South Kalimantan	303	47	42	35	427	71.0%	11.0%	9.8%	8.2%	-1.6%
East Java	1,067	438	279	250	2,034	52.5%	21.5%	13.7%	12.3%	-1.4%
Aceh	989	1,907	689	649	4,234	23.4%	45.0%	16.3%	15.3%	-0.9%
Kalimantan Timur	602	3	8	10	623	96.6%	0.5%	1.3%	1.6%	0.3%
Bali	1,277	1,277	385	424	3,363	38.0%	38.0%	11.4%	12.6%	1.2%
Sulawesi Tengah	349	125	71	82	627	55.7%	19.9%	11.3%	13.1%	1.8%
Central Java	258	0	0	7	265	97.4%	0.0%	0.0%	2.6%	2.6%
Riau	860	599	139	189	1,787	48.1%	33.5%	7.8%	10.6%	2.8%
West Nusa Tenggara	188	378	56	78	700	26.9%	54.0%	8.0%	11.1%	3.1%
Sumatra Barat	261	207	56	78	602	43.4%	34.4%	9.3%	13.0%	3.7%
Sumatra Selatan	190	357	12	36	595	31.9%	60.0%	2.0%	6.1%	4.0%
Irian Jaya	1,162	646	157	261	2,226	52.2%	29.0%	7.1%	11.7%	4.7%
Nusa Tenggara Timur	101	759	25	81	966	10.5%	78.6%	2.6%	8.4%	5.8%
North Sulawesi	968	695	179	314	2,156	44.9%	32.2%	8.3%	14.6%	6.3%
Sumatera Utra	152	251	17	49	469	32.4%	53.5%	3.6%	10.4%	6.8%
Bengkulu	215	37	8	28	288	74.7%	12.8%	2.8%	9.7%	6.9%
Sulawesi Tenggara	561	423	73	159	1,216	46.1%	34.8%	6.0%	13.1%	7.1%
South Sulawesi	139	502	18	73	732	19.0%	68.6%	2.5%	10.0%	7.5%
DKI Jakarta	378	137	64	123	702	53.8%	19.5%	9.1%	17.5%	8.4%
Kalimantan Barat	4,379	1,361	684	1,441	7,865	55.7%	17.3%	8.7%	18.3%	9.6%
DI Yogyakarta	268	536	61	171	1,036	25.9%	51.7%	5.9%	16.5%	10.6%
Kalimantan Tengah	3,653	1,756	807	1,746	7,962	45.9%	22.1%	10.1%	21.9%	11.8%
Total	20,044	13,550	4,305	6,594	44,493	45.0%	30.5%	9.7%	14.8%	5.1%

Table 4 Distance to sub-district, district and provincial capital

		Distance (km)		
Province	**Village**	**sub-district**	**district**	**province**
Lampung	1	9	37	53
	2	13	56	120
	3	5	14	75
	4	7	7	67
	5	3	15	125
	6	3.5	42	145
	7	12	85	55
	8	38	104	12
	9	7	85	37
	10	37	95	14
	11	35	95	14
	12	1	10	45
	13	5	5	50
	14	4	45	82
	15	20	80	120
	16	15	60	150
Central Java	1	3	13	110
	2	3	15	50
	3	3	30	93
	4	10	60	120
	5	0.05	30	250
	6	2	60	225
	7	0.1	8	114
	8	4	14	90
	9	6	5	93
	10	6	15	60
	11	7	15	270
	12	5	8	250
East Java	1	3	15	190
	2	5	20	137
	3	5	14	35
	4	4	20	38
	5	0.7	27	90
	6	5	14	115
	7	6	20	218
	8	4	17	80
	9	2	25	93
	10	1	8	145
	11	2	27	145
West Nusa Tenggara	1	5	5	50
	3	5	25	60
	4	0.1	62	300
	5	6	25	500
	6	2.5	44	640
	7	2	19	57
	8	5	12	50
	9	8	54	250
	10	3	4	22
	11	0.3	44	45
	12	0.1	30	500
	13	7	49	650
	14	12	13	39

		Distance (km)		
Province	**Village**	**sub-district**	**district**	**province**
South Kalimantan	1	0.5	4	102
	2	4	12	124
	3	3.5	37	40
	4	3	10	180
	5	0.1	22	170
	6	4	22	90
	7	18	18	61
	8	17	20	67
	9	0.1	29	79
	10	0.05	17	86
	11	15	32	45
	12	1.5	16	81
	13	3.5	10	93
	14	21	45	60
	15	50	40	50
	16	50	20	50
North Sulawesi	1	0.3	27	54
	2	0.7	18	100
	3	1	5	25
	4	4	6	27
	5	4	40	335
	6	6	5	5
	7	0.5	18	60
	8	6	25	105
	9	3.5	16	97
	10	1	30	60
	11	4	23	59
	12	13	20	50
South Sulawesi	1	3	60	600
	2	5	42	279
	3	2	7	258
	4	3	48	126
	5	9	33	352
	6	0.5	28	114
	7	1	30	140
	8	3	17	189
	9	3	16	186
	10	3.5	13	183
	11	8	45	282
	12	16	51	280
	13	2	16	185
	14	1	60	600
	15	2	60	530
	16	7	70	570
	17	7	17	197
	18	7	24	250
mean		6.9	32.7	141.1

Table 5 Summary statistics

Variable	N Obs.	Mean	Std. Dev.	Min	Max
Age 15 to 64 2007	677	3.283604	1.646921	0	11
Age 15 to 64 1995	677	3.574594	1.887942	0	11
Household income 2007	676	2.66e+07	4.50e+07	-1.39e+07	8.13e+08
Household income 1995	678	2255359	3982028	-1658878	7.12e+07
Per-capita income 2007	675	8740742	1.54e+07	-2319559	2.71e+08
Per-capita income 1995	677	825826.2	1598886	-1658878	2.87e+07
Per-capita income growth	632	2.373005	1.477035	-3.183594	10.31219
Head 1995 primary or more	661	.4220877	.4942664	0	1
Head 9595 high school or more	661	.1089259	.3117821	0	1
Non-agriculture income share 2007	676	.4853472	.4355295	0	1
Non-agricultural labor income share 2007	676	.2505172	.3587893	0	1
Non-agricultural income share 1995	678	.3110805	.402232	0	1
Non-agricultural labor income share 1995	678	.2184026	.3626179	0	1

Table 6 Change in non-agricultural income

Dependent:	Per-capita income growth	Change in non-agricultural income share	Change in non-agricultural labor income share	Per-capita non-agricultural labor income growth
Change in average road quality				
* High school or higher	0.145	-0.577	-0.520	-2.932
	(0.28)	(1.96)	(2.91)	(1.22)
* High school * asphalt 95	2.058	0.129	0.3264	6.630
	(2.55)	(0.29)	(1.19)	(2.07)
* High school * distance to sub-district capital	-0.0337	0.0522	0.0415	0.0314
	(2.67)	(4.51)	(5.04)	(0.68)
* High school * distance to district capital	-0.0335	0.0042	-0.0157	-0.2494
	(0.85)	(0.22)	(1.45)	(1.35)
* High school * distance to provincial capital	0.0009	-0.0005	0.0023	0.0232
	(0.39)	(0.32)	(2.25)	(2.05)
Village dummies	yes	yes	yes	yes
R squared	0.1152	0.1249	0.1345	0.1035
Number of observations	605	646	646	644

Numbers in parentheses are absolute t values, using robust standard errors with village-level clusters. In Column 4, we assigned 1000 Rupea to zero values to compute income growth.

Table 7 Change in labor supply to non-agricultural sector

Dependent: Change in man-days worked in non-agricultural sector				
Sample:	Origin+Split		Plus out-migrants	
Change in average road quality				
* High school or higher	0.6929	0.7923	0.8820	1.0300
	(2.33)	(2.67)	(3.21)	(4.10)
* High school * asphalt 95	0.5151	0.6307	0.6554	0.7990
	(1.21)	(1.45)	(1.88)	(2.44)
* High school * Distance to sub-district capital	-0.0254	-0.0296	-0.0210	-0.0316
	(5.11)	(4.07)	(2.65)	(2.80)
* High school * Distance to district capital	-0.0555	-0.0619	-0.0657	-0.0740
	(2.54)	(2.81)	(3.53)	(4.30)
* High school * Distance to provincial capital	0.0047	0.0050	0.0048	0.0053
	(3.80)	(4.12)	(3.70)	(4.30)
* Land size		0.0024		0.0294
		(0.03)		(0.28)
* Land size * asphalt 95		-0.2184		-0.2907
		(1.34)		(1.86)
* Land size * Distance to sub-district capital		0.0035		0.0077
		(2.17)		(3.85)
* Land size * Distance to district capital		0.0018		0.0004
		(0.41)		(0.10)
* Land size * Distance to provincial capital		0.0002		0.0004
		(1.57)		(4.00)
Village dummies	yes	yes	yes	yes
R squared	0.0639	0.0685	0.0652	0.0738
Number of observations	639	639	639	639

Numbers in parentheses are absolute t values, using robust standard errors with village-level clusters.