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Empirical Study of Growth and Poverty Reduction in Indonesian Farms: The Role of Space, Infrastructure and Human Capital and Impact of the Financial Crisis

Are Schooling and Roads Complementary? Evidence from Rural Indonesia

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Are Schooling and Roads Complementary?
Evidence from Rural Indonesia

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Abstract
This paper examines the impact of spatial connectivity on household income growth and non-agriculture labor supply, combining household panel data and village census in Indonesia during the period of 1995-2007. Empirical results show that the impacts of improved local road quality on income growth and the transition to non-agricultural labor markets depends on household education and distance to economic centers. In particular, post-primary education significantly increases the benefit from the improvement of local spatial connectivity in remote areas, promoting labor transition to non-agricultural sectors. Education and local road quality are complementary, mutually increasing non-agricultural labor supply and income in remote areas.

Keywords: Income growth, Education, Landholding, Spatial connectivity, Rural economy, Indonesia

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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 interest 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 more from better spatial connectivity is not clear. Improved spatial connectivity in the local economy may have heterogeneous impacts on households with different endowments, in particular, their human capital 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.[1]

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

[1] 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 than other regions. Similar pattern can be observed in spatial connectivity where some regions have made significant progress while others were lagging behind.

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.[2]

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). 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 employment choices for rural residents.

Roads can bring changes in labor demand by causing a change in production composition towards non-farm activities. 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 and transportation costs between rural and urban areas, and within rural areas, roads can therefore integrate fragmented markets. In the context of farm market,, Jacoby (2000) adopted the innovative idea of using the value of farm land to capture household-level benefits from a *hypothetical* road project, and showed substantial benefits are attributed to reduced travel time to agricultural markets.[3] We consider that Labor market is also

[2] 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 1980s, 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.

[3] His analysis is based on a cross-sectional inverse relationship between the value of farm land and travel time to agricultural markets. Therefore it is subject to bias that arises from unobserved factors

not an exception.

Our main idea is that inter-village road quality determines the means of transportation and therefore the average speed of resource mobility (including human resources), which affects allocative efficiency in the local economy. Potential gain in allocative efficiency is not only affected by the distance to economic centers at different levels that offer different economic opportunities, but also the household's ability. Conversely, changes in local road quality can be regarded as a disequilibrium factor that induces changes in the optimal resource allocation at the household level. Under such circumstances, we expect agents embodying more human capital to be better able to deal with the disequilibrium (T.W. Schultz 1975). Therefore, returns to schooling may dynamically increase with the improvement of local road quality.[4]

To empirically 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 road infrastructure.[5] In this paper, we capture the actual improvement of spatial connectivity by constructing measures that capture inter-village road quality in a region from the Indonesian village census in different points in time. We combine the above measure and the distance to economic centers: sub-district, district and provincial capitals from the village survey we conducted in 2007.

Road investment can be endogenous at the local level. For example, Foster and Rosenzweig (2001) showed evidence from India that the landless prefer road construction as a

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systematically affecting both travel time and the value of farm land.

4 Yamauchi (2004) provided evidence that supports the complememtarity between schooling and new destination experience among city migrants in Bangkok. Rosenzweig (1995) also showed that a new technology such as high-yielding variety augments returns to schooling; educated farmers are better able to use the technology. In the current context, it is also interesting to see how the improvement of road quality affects the incentive to invest in schooling if returns to schooling are augmented. However, this is beyond the scope of our paper.

5 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. 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).

local public investment choice because it improves the access to labor market, whereas the landed prefer investment in irrigation, which augments returns to land. The connectivity to urban centers benefits laborer households more than farm (landed) households by improving the access to non-agricultural employment opportunities.

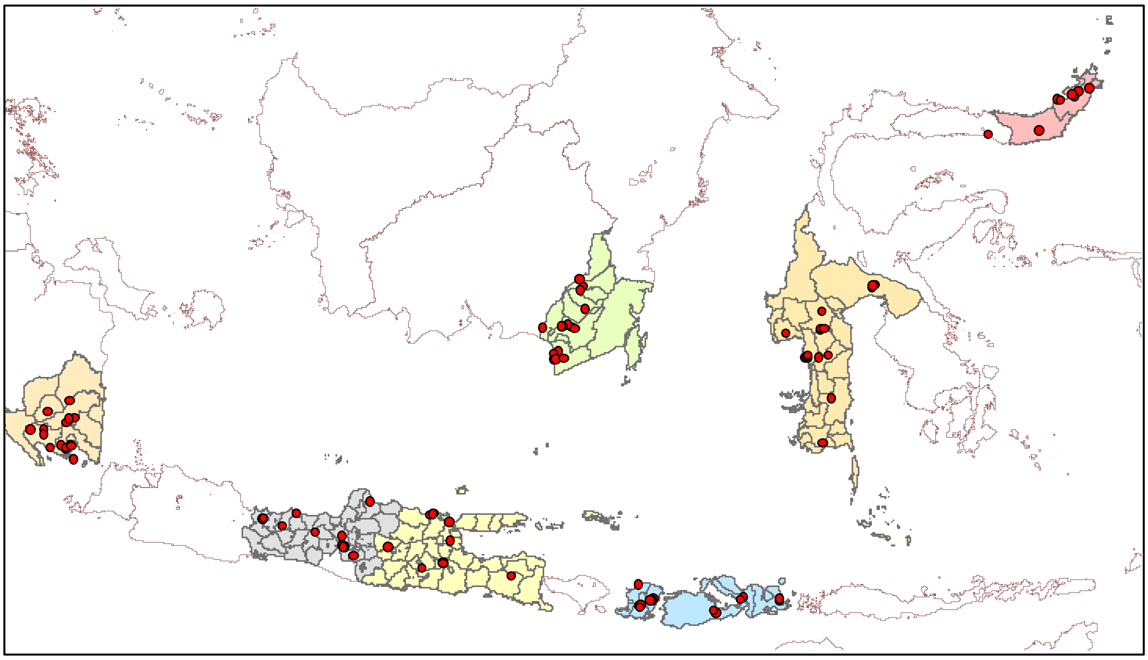
The above perspective gains importance in the context of decentralization where part of infrastructure investments is an endogenous decision at the local level. In the analysis, we include village dummies in the income growth equations (thus, first differenced of log income, and fixed components wiped out) and interact changes in local road quality and the household-level asset variables to highlight the question of how roads alter returns to household assets. The endogeneity issue is therefore dealt with under the assumption that only village-level shocks, not household-level shocks, can affect the change of local road quality.

Our empirical results, summarized in Section 6, 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 depend on household human capital as well as the distance to economic centers. 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. In contrast, the initial landholding size does not significantly affect the benefit from improved road quality. 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 (Lampung, Central Java, East Java, West Nusa Tenggara, South Sulawesi, North Sulawesi, and South Kalimantan) under the JICA'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. Locations of surveyed villages in Indonesia



(Provinces: Lampung, Central Java, East Java, West Nusa Tenggara, South Kalimantan, North Sulawesi, South Sulawesi)

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.

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 Lampung 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 (Lampung, Central Java, East Java, West Nusa Tenggara, South Sulawesi, North Sulawesi) using both the 2007 household and 1994/95 PATANAS surveys.[6]

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. Spatial connectivity: Inter-village road improvement

In this section we describe village census data: PODES with focus on transportation and

[6] 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 education 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.

road quality variables, and characterize changes in local road quality in the period of 1996 to 2006. The data cover all Indonesian 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. In the analysis, the average is taken at the sub-district level in each round.[7] Next, taking difference between the two rounds, we can see improvement and deterioration of road quality in local economies.[8] 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

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

[8] $\Delta\mathbf{z}(j) = \mathbf{z}_1(j) - \mathbf{z}_0(j)$. 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

Java and non-Java regions showed that Java areas had experienced a faster improvement than outside Java.[9]

4 Descriptive statistics: Household income and transition to non-agriculture

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.

[9] Table A1 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. Our preliminary analysis using the PODES data shows tabulations of villages matched between 1996 and 2006 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. Note that our measure of spatial network is constructed from sub-district averages, so this variable is likely to be continuous though village-level information is discrete.

Table1. 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	26,600,000	45,000,000	-13,900,000	813,000,000
Household income 1995	678	2,255,359	3,982,028	-1,658,878	71,200,000
Per-capita income 2007	675	8,740,742	15,400,000	-2,319,559	271,000,000
Per-capita income 1995	677	825,826.2	1,598,886	-1,658,878	28,700,000
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

Panel sample is based on households in 34 villages in 6 provinces.

Table 1 shows descriptive statistics of key variables: number of household members aged 15-64, household incomes, its growth, non-agricultural income shares, and 1995 household head's education in the panel sample. First, non-agricultural employment income shares increased in the period. Second, about 10 percent of the households had heads who completed high school or above. Lastly, growth of nominal household income is about 1.5.[10] However, we have to note that later regression analysis always includes location averages (dummies) which controls for the differences in price variance specific to each location (village).[11]

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 distances to economic centers.

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

[11] 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.

Figure 2a. Per-capita income growth (residuals) and household head's education – road quality improved

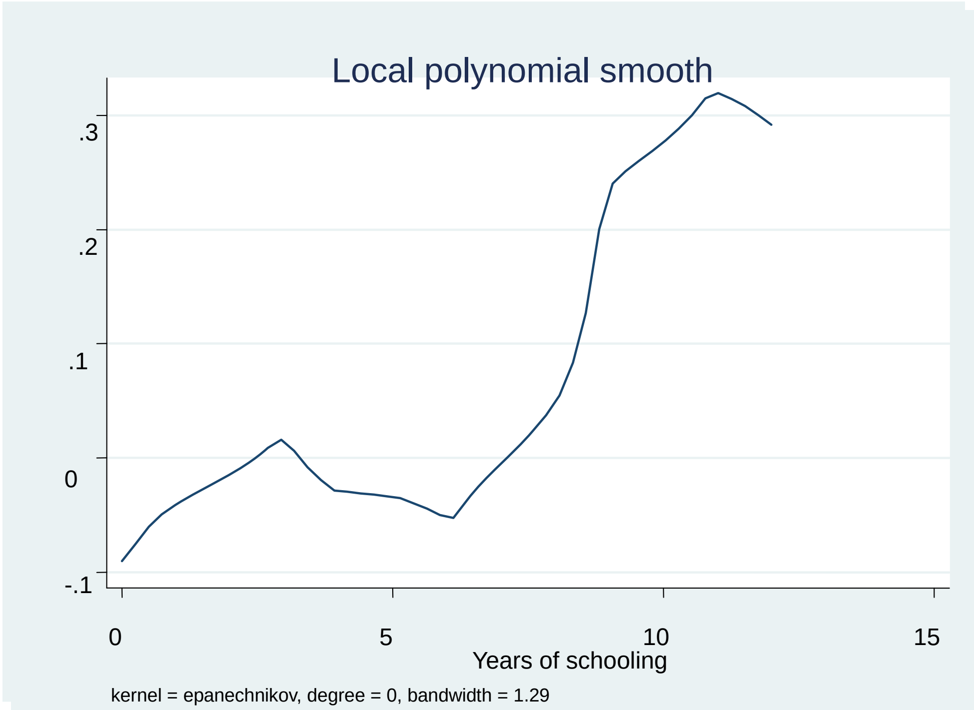
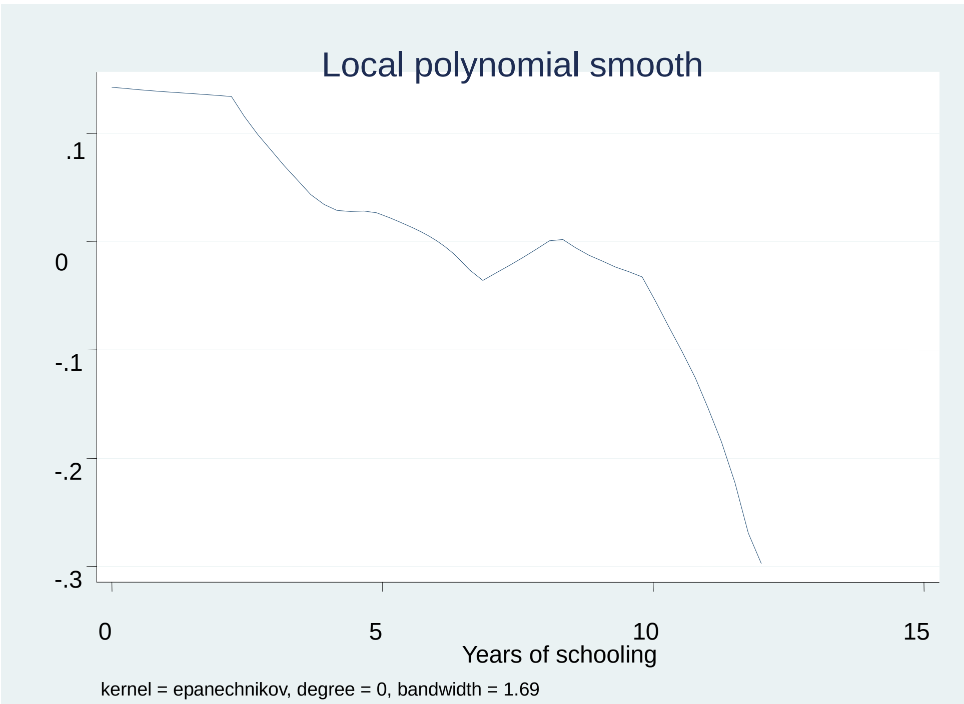


Figure 2b. Per-capita income growth (residuals) and household head's education – road quality deteriorated



Next we investigate the relationship between the 1995 head's years of schooling and income growth. Figure 2a (2b) shows per-capita income growth in villages which experienced a positive (negative) change in the road quality in their sub-districts.[12] Income growth is demeaned by village effects, so we observe intra-village variations using the residuals. Therefore the figures suggest changes in income distribution within a village. Note also that the head's education in the initial period implies their child schooling too since educational attainment is positively correlated between parents and their children, and children's schooling is expected to be above their parents' in our empirical context (see Dewina and Yamauchi 2009). Therefore the maximum level of schooling is expected to be above or equal to the head's. We use the 1995 head's education to represent the initial stock of human capital in the household.

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 among educated households.

[12] Positive change is defined as 20 to 80 percentage point change, whereas negative change is minus 20 to 80 percentage point change. Analyses in Tables 4 and 5 use the range of road quality change in minus 30 to plus 80. We have confirmed that this is a reasonable range for investigating the impacts of road quality change on income dynamics and change in non-agricultural income. In this sense, we have to be careful when interpreting the negative relationship between years of schooling and income changes (residuals) when road quality deteriorates. With a more moderate range of road quality deterioration, we observe no significant relationship.

Figure 3a. Change in non-agricultural income share and average road quality

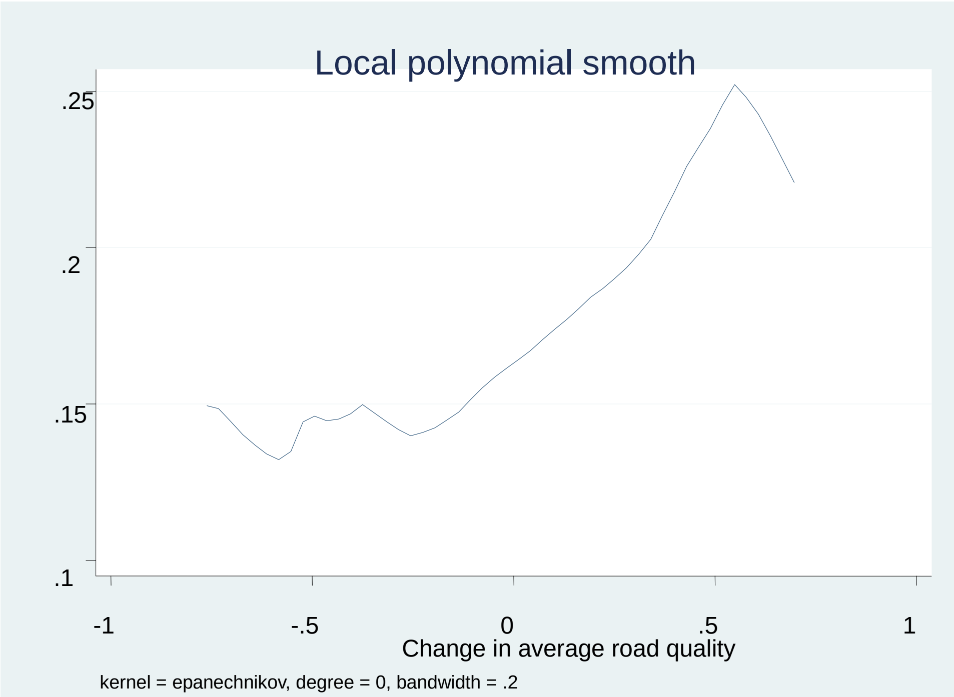
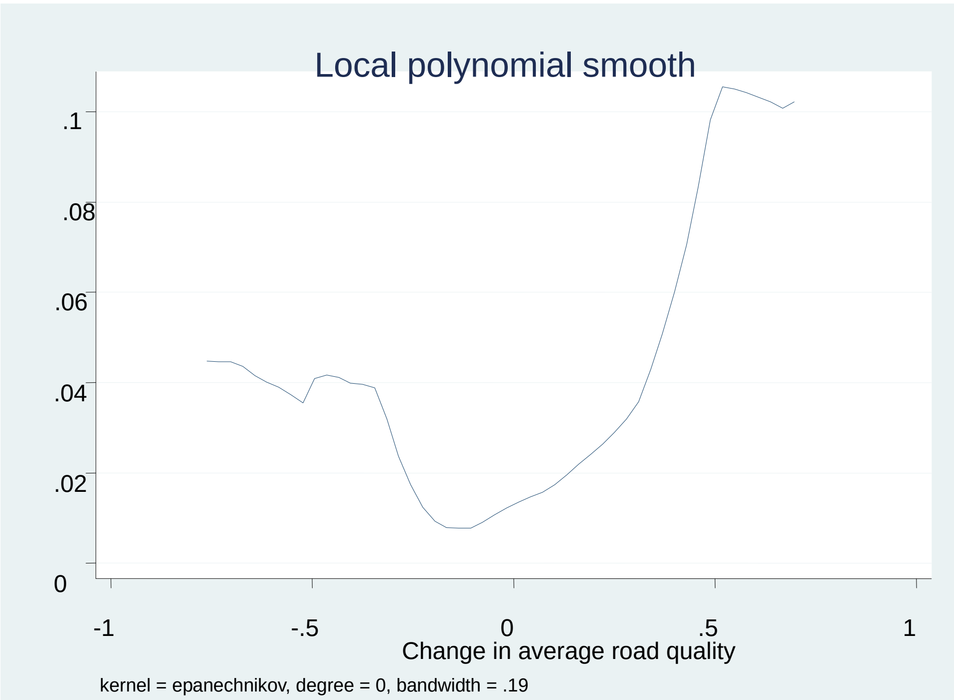


Figure 3b. Change in non-agricultural labor income share and average road quality



Figures 3a and 3b 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 later also confirms the above observation.

Next we show some evidence on the transition of employment structure into non-agricultural sectors, using individual information on the first-job taken after the completion of schooling. Our survey had a special module that captured schooling histories of cohorts aged 20 to 55.

Figure 4. Probability of taking non-agricultural fulltime work

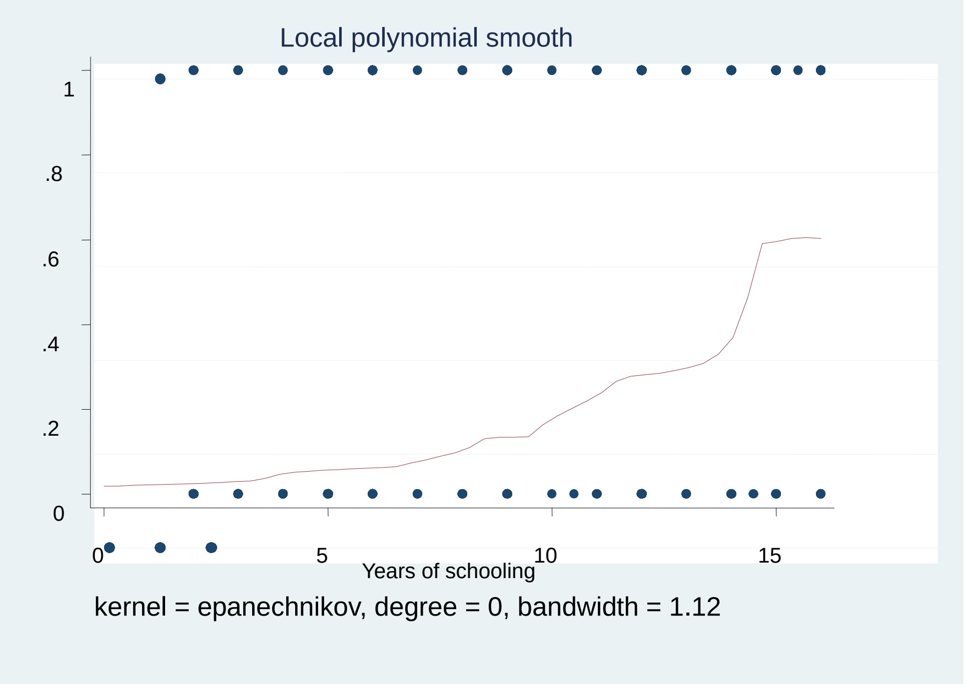


Figure 4 shows non-parametric estimates of the schooling effect on non-agricultural fulltime work. The vertical axis measures the probability (or proportion) of having the first occupation in non-agricultural fulltime work. It shows that primary school stage does not change the proportion but school stages at the secondary or higher level significantly increase the transition to non-agriculture. However, the above observation does not identify any causality.

Table 2. Transition to non-agricultural sector – Vintage effects

Dependent: fulltime work in non-agricultural sector upon the completion of schooling			
Years of schooling		0 0284	
		(10.30)	
Years of schooling in primary			0.0062
			(1.44)
Years of schooling in secondary or higher			0.0359
			(9.95)
Age 45-49	0.0127	0.0005	-0.0022
	(0.57)	(0.02)	(0.10)
Age 40-44	0.365	- 0.0024	-0.0070
	(1.44)	(0.09)	(0.28)
Age 35-39	0.0182	-0.0496	-0.0506
	(0.69)	(1.84)	(1.89)
Age 30-34	0.0401	-0.0377	-0.0353
	(1.55)	(1.42)	(1.33)
Age 25-29	0.1050	0.0036	0.0051
	(4.26)	(0.14)	(0.20)
Age 20-24	0.0804	-0.0400	0.0394
	(3.41)	(1.55)	(1.53)
Female	-0.0362	-0.0190	-0.0181
	(3.69)	(1.94)	(1.86)
Household fixed effects	yes	yes	yes
R squared (within)	0.0192	0.0698	0.0778
Number of observations	4454	4372	4372

Numbers in parenthesis show absolute t values, using robust standard errors with household clusters.

Columns 1 and 2 in Table 2, which look at dynamics of non-agricultural occupation choices without and with years of schooling completed respectively, indicate that the accumulation of human capital led to the transformation of occupational structure from agriculture to non-agriculture. More recent cohorts are likely to be engaged in such occupations, but once years of schooling is included, they become insignificant. Our specifications also control a vintage effect of graduation time. Controlling current age (therefore birth year) and years of schooling means that we control graduation time when he/she completes schooling and enters labor market.

In Column 3, we separate years of schooling at primary and secondary (and higher) stages. For example, if she has completed junior high school (grade 9), years of schooling at the primary stage is 6 and completed years at the secondary stage is also 3. Consistent with our observation in Figure 3, we confirmed that schooling at the secondary or higher level (not primary stage) significantly explains the transition to non-agricultural sectors.

Table 3. Part-time in non-agricultural sector

Dependent: par-time work in non-agricultural sector upon the completion of schooling			
Years of schooling		0.0036	
		(1.54)	
Years of schooling in primary			0.0021
			(0.47)
Years of schooling in secondary or higher			0.0041
			(1.43)
Age 45-49	0.0132	0.0154	0.0152
	(0.62)	(0.71)	(0.70)
Age 40-44	0.0645	0.0627	0.0624
	(3.12)	(2.96)	(2.94)
Age 35-39	0.0343	0.0264	0.0263
	(1.47)	(1.09)	(1.08)
Age 30-34	0.0304	0.0197	0.0199
	(1.38)	(0.84)	(0.85)
Age 25-29	0.0501	0.0369	0.0370
	(2.63)	(1.71)	(1.71)
Age 20-24	0.0622	0.0476	0.0477
	(3.41)	(2.23)	(2.24)
Female	-0.0420	-0.0394	-0.0393
	(4.62)	(4.17)	(4.16)
Household fixed effects	yes	yes	yes
R squared (within)	0.0153	0.0161	0.0161
Number of observations	4454	4372	4372

Numbers in parenthesis show absolute t values, using robust standard errors with household clusters.

We also check the effect of schooling on non-agricultural part-time work (Table 3). Interestingly, schooling does not significantly explain part-time works. Cohorts of age 40-44 and 20s have significantly more proportions of non-agricultural part-time works, but females have significantly less works than males. These cohort and gender effects are robust to schooling. Therefore, the accumulation of human capital though formal education is important to the transition of occupational structure into fulltime - formal works in non-agricultural sectors, but not for part-time - irregular works.[13]

5. 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 common unobservables. Both income growth and non-agricultural income share equations (the level equations being omitted here), after first differenced, are written as:

$$\begin{aligned}\Delta y_{ij} = \alpha &+ \gamma_0 x_{ij}^0 + \gamma_{11}\Delta\mathbf{z}(j) + \gamma_{12} x_{ij}^0 \Delta\mathbf{z}(j) \\ &+ \gamma_{21} d_j \Delta\mathbf{z}(j) + \gamma_{22} x_{ij}^0 d_j \Delta\mathbf{z}(j) \\ &+ \Delta\varepsilon_{ij}\end{aligned} \qquad (1)$$

where Δy_{ji} is income growth (differenced log income, or labor supply change in the labor allocation equation) 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 an economic center (to be discussed below), x_{ij}^0 is household i's education and land owned in the initial period, and ε_{ij} is an error term. For per-capita income, we use the number of household members aged 15-64 to divide household total earnings.[14] The second term checks whether returns to schooling and landholding size changed over 12 years (i.e., growth effect of the initial condition).

We assume that the distance to economic activity center is constant. Economic activity

[14] The earnings do not include remittances. Age range of 15-64 is used here to represent labor force available in the household.

points are defined as sub-district, district and province centers. 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.[15]

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

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

$$\begin{aligned}\Delta y_{ij} &= \alpha + \gamma_0 x_{ij}^0 + \gamma_{12} x_{ij}^0 \Delta\mathbf{z}(j) + \gamma_{22} x_{ij}^0 d_j \Delta\mathbf{z}(j) \\ &\quad + village\ dummies + \Delta\xi_{ij}\end{aligned} \tag{2}$$

where the two terms in Eq (1) are absorbed in village dummies since they are sub-district level changes. Village dummies in the first differenced form control the linear effects of changes in spatial connectivity in the sub-district neighborhood, and their interactions with village-level variables such as distances to various centers.

Note that log transformation of household income separates price effect (log of price) from real income. By first differencing and including village dummies, we can control price changes (inflation rate) under the assumption that both price level and change are village specific. Therefore, income growth equation (2) looks at the effect of changes in spatial connectivity, interacted with location factors and household characteristics, on real income growth.

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[15] Since physical distance is assumed to be constant throughout the period, 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 A2 shows distances to the centers in all 98 villages, using the 2007 village survey.

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. 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.

The inclusion of village dummies in the above estimation also addresses potential omitted variable problems. In reality, many changes could have 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.[16] Household-level variables that are omitted can be correlated with changes in the sub-district spatial connectivity, beyond that is captured by village dummies. However we assume that this is less important than the correlation between changes in village-level factors and the sub-district spatial connectivity. Moreover, with village dummies in the first differenced form, household-level differenced shocks have mean zero centered around the village average, which enables us to ignore potential correlations between changes in neighborhood spatial connectivity (sub-district) and household-level shocks.

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 our sample, we did not observe household migration. Split households are those who separated from the original households, but stayed in the same villages. In the analysis, however, individual migration is not incorporated, which may bias our estimates given that the migration process can differentially affect both the numerator and denominator to calculate per-capita income.

[16] Household-level variables that are omitted can be correlated with changes in the sub-district road networks, beyond that being captured by village dummies. However we assume that this is less important than the correlation between changes in village-level factors and the sub-district road networks.

6. Empirical results

6.1 Income growth and non-agricultural labor income growth

In this section, we summarize the main results from our household analysis, which examines household income growth and changes in non-agricultural labor income. Preliminary analyses show that sub-district-level road quality measures explain income growth and changes in non-agricultural labor income share better than district- and province-level road quality measures, probably due to sub-district-level variations in the sample and the fact that localized spatial connectivity development opens access to wider economic activities (such as district and provincial centers).

Based on preliminary analysis, we decide to restrict the sample to those with changes in the asphalt road proportion being in the range of minus 0.3 to 0.8 (therefore reducing sample size for estimation). Extreme values outside the range create large noise in the estimation.[17] With the above adjustment, the sample sizes in Table 1 slightly differ from what is shown in the following tables.

To capture the potentially heterogeneous effects of the sub-district average road quality improvement on income growth, we introduce some heterogeneity into the analysis by including household head's education level in 1995 (at the household level) and the distances to sub-district, district and provincial centers (at the village level).[18]

[17] Similarly, our estimation excludes two observations that show too large income growth.

[18] 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 changes on household-level outcomes. Therefore, we focus on intra-village distributional effects (with village dummies controlling for price changes and village-level shocks) in our parametric estimation.

Here, the main analytical point is to investigate the role of post-primary education in income growth when spatial connectivity is improving in the local neighborhood, and from there to investigate the relationship with connectivity to larger, more distant economic centers.[19] We include village dummies to control for village-specific shocks and corresponding price changes specific to the village economy.

In preliminary analyses, we detected changes in returns to schooling, which is captured by the 1995 head's education in the income growth equation. Therefore we control the initial human capital in income growth. We use an indicator that takes the value of one if the household head has completed high school or higher, and zero otherwise, and interact this indicator with the 1995 inter-village road quality indicator and the distances to the sub-district, district and provincial centers

[19] Education level can change over time, creating an endogeneity issue. Changes in household income and spatial connectivity can affect changes in household education level. Statistically, the first differencing and the inclusion of village-level fixed effects mitigate the above endogeneity problem, since we are only concerned with the correlation between household-specific shocks and the initial level of household schooling. However, we should consider the direction of the potential bias. Dewina and Yamauchi (2009) show that intergenerational educational growth in the same data set, as measured by the gap between household head's education and the maximum level of educational attainment in the household in 1995, significantly explains income growth. There were significant changes in educational attainment in Indonesia in the 1970-80s. These findings suggest that a higher level of schooling attainment by the household head implies, on average, a lower education gap with the maximum level of educational attainment in the household. If so, the potential bias in the education effect is small. However, if a higher level of educational attainment by the head means higher growth of educational attainment within the household, we may face a potentially large upward bias.

Table 4. Income growth

Dependent:	Per-capita income growth		Per-capita non-agricultural labor income growth	
High school or higher	0.7100	0.7639	2.711	2.576
	(2.58)	(2.92)	(3.41)	(2.98)
Change in average road quality * High school or higher	5.435	4.616	5.655	6.103
	(2.02)	(1.67)	(1.18)	(1.38)
* High school * Distance to sub-district capital	0.1295	0.1321	0.5850	0.4962
	(2.65)	(2.49)	(3.66)	(2.66)
* High school * Distance to district capital	-0.4607	-0.4179	-1.339	-1.312
	(2.79)	(2.48)	(3.00)	(2.97)
* High school * Distance to provincial capital	0.0363	0.0331	0.1214	0.1188
	(3.01)	(2.69)	(3.38)	(3.31)
Land size		-0.0694		0.1965
		(0.90)		(1.14)
Change in average road quality *Land size		-0.3151		0.3983
		(0.53)		(0.32)
* Land size * Distance to sub-district capital		-0.0123		0.0747
		(1.31)		(1.41)
* Land size * Distance to district capital		0.0030		-0.0914
		(0.19)		(1.78)
* Land size * Distance to provincial capital		-0.0024		0.0079
		(2.16)		(1.86)
Village dummies	yes	yes	yes	yes
R squared	0.1465	0.1546	0.1087	0.1157
Number of observations	535	535	535	535

Numbers in parentheses are absolute t values, which we calculate using robust standard errors with village-level clusters. In Columns 3 and 4, we assign 1000 Rupiah to zero values in order to compute income growth. Extreme values of per-capita income growth were excluded.

Table 4 reports estimation results. In Column 1, first, the initial level of household education significantly increases income growth. Second, our results support complementarities between education and road quality. The educated benefited from improvement in road quality in the neighborhood economy. Third, we also find that the distance factors do significantly affect the education-spatial network effects on per-capita income growth.

Column 2 includes land variables and their interactions with changes in road quality.

Interestingly, all the variables are insignificant but the interaction of land size, change in road quality and distance to provincial capital, which shows a negative and significant effect. Therefore, we may conclude that roads are complementary to household human capital, but land endowment does not matter with improvement of road quality.

In Columns 3 and 4, we also attempt to verify the above conjecture by using the growth of non-agricultural labor income from 1995 to 2007. For this analysis, incomes of zero are assigned a value of 1000 Rupea, allowing us to compute income growth. First, the direct effect of education is insignificantly positive. Second, complementarity between education and spatial network becomes insignificant. However, third, location factors, measured by distances from economic centers, significantly alter the complementarity. The distance from the provincial capital significantly increases non-agricultural labor income growth if the household head has attained a high school or higher education and the neighboring road networks improve over time. In contrast, we do not find any significant effects of landholding size interacted with road and distances, except the one interacted with distance to provincial capital.

The marginal benefits from local road quality improvement are expected to be large in remote areas, because there is a low level of capital accumulation. However, our results show that the district center is always important to the local economy, given localized economic interactions at the district level. There seem to be two important dimensions to this economic connectivity: links to the local economy (district capital), and links to the larger economic demand center (provincial capital). In the former, proximity to the center is always beneficial for the educated. However, areas far from the latter (i.e., areas far from the provincial capital) are more likely to benefit from local road quality improvement. Regardless of interactions with distance, however, education always increases the marginal benefits from local road quality improvement.

In our definition, non-agricultural activities only cover those undertaken by current household members, excluding non-members who work/live at a distance from their original villages (i.e. those who do not commute). Therefore, we may be missing migration-linked non-agricultural transitions (see Dewina and Yamauchi 2009). Instead, income growth (as defined herein) includes agriculture-based growth, such as that arising from improved marketing of agricultural products (e.g., vegetables). In this activity, connecting to larger demand centers seems to be a driving force.

In the estimation, we include clustered correlations within the village in order to compute robust standard errors. There may be correlations across shocks outside the village (even after village-level fixed effects are used to control for village-specific shocks), such as when income shocks are positively correlated within a province. In our preliminary analysis, we experimented with district- and province-level clusters, and the results proved the robustness of our results. However, we do not explicitly incorporate any correlation structure that decays with physical or economic distance.

6.2 Labor supply to the non-agricultural sector

This section focuses on the household behavior of labor supply to the non-agricultural sector. In the previous section, we show that income growth does not necessarily match the change of non-agricultural income growth in relation to the improvement of local road network. To resolve this issue, we next examine non-agricultural labor market behavior.

We construct 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 (converted to man-days, assuming that each individual works 250 days a year). Since we note that the 1995 survey undercounted household members, we use the 1995 member list reconstructed from the 2007 survey. For actual man-days worked in non-agricultural activities, we use data from the 1995 and 2007 surveys. For our analysis of labor supply dynamics, we use the change in the share of labor supplied to non-agricultural activities.[20]

[20] Some individuals may work more than 250 days per year. It is also possible that household members

Table 5. Labor allocation

Dependent: Changes in man-days worked in non-agricultural sector				
Sample:	Origin+Split		Plus out-migrants	
High school or higher	0.2289	0.2288	0.1971	0.1946
	(2.93)	(2.82)	(2.49)	(2.38)
Change in average road quality * High school or higher	1.494	1.594	1.533	1.709
	(2.01)	(1.99)	(2.06)	(2.23)
* High school * Distance to sub-district capital	0.0123	0.0054	0.0121	-0.0012
	(0.61)	(0.26)	(0.60)	(0.06)
* High school * Distance to district capital	-0.1370	-0.1401	-0.1267	-0.1313
	(2.02)	(2.05)	(1.90)	(2.00)
* High school * Distance to provincial capital	0.0118	0.0120	0.0106	0.0109
	(2.20)	(2.23)	(2.00)	(2.09)
Land size		-0.0048		-0.0042
		(0.33)		(0.31)
Change in average road quality *Land size		-0.1037		-0.1541
		(0.47)		(0.82)
* Land size * Distance to sub-district capital		0.0043		0.0084
		(2.35)		(4.09)
* Land size * Distance to district capital		-0.0004		-0.0018
		(0.10)		(0.57)
* Land size * Distance to provincial capital		0.0003		0.0005
		(2.14)		(4.85)
Village dummies	yes	yes	yes	yes
R squared	0.0886	0.0905	0.0754	0.0802
Number of observations	565	565	565	565

Numbers in parentheses are absolute t values, which we calculate using robust standard errors with village-level clusters. Origin+split in Columns 1 and 2 add members in the original and split households. In the above, no condition on per-capita income growth is imposed, which creates difference in sample size from Table 4.

Table 5 shows the change in man-days worked in the non-agricultural labor market from 1995 to 2007. Columns 1 and 2 use the sample of household members in the original and split households living in the sample villages in 2007. The results reveal that the signs and

younger than 15 or older than 65 could work in non-agricultural sectors (although it is illegal for children under 15 to work). In some households, our roster may miss some members who contribute to the household income; however their labor supply and incomes are 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 present analysis, however, we take the difference between 1995 and 2007, which minimizes this potential problem.

significance of the parameter estimates are quite similar to those of the income growth equations shown in Table 6. Educational attainment at the secondary or higher level helps households gain more from spatial network development at the local level. Complementarity between education and local road quality is significant. In remote villages (i.e., those distant from the provincial capital), the gain is large. The direct role of initial landholding is not significant, but location factors play a similar role, that is, distance from provincial capital augments the complementarity of landholding size with spatial network.

In Columns 3 and 4, we include out-migrants who left the sample villages between 1995 and 2007. We assume that out-migrants aged 15-64 work full-time in the non-agricultural sector. Thus, man-days take the maximum for these out-migrants.[21] First, the results of this analysis support the observed complementarities between education and road network development, which increase the labor supply and migration to the non-agricultural sector. Second, the initial condition of inter-village roads (asphalt) is significantly important . Third, the results for the interactions with distances to economic centers conform to the above-described findings[22].

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

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

[22] In the above analysis, we focus on transition of the labor supply from agricultural to non-agricultural labor markets. However, the benefits of improvement in spatial connectivity might not be limited to issues of labor transition. Other potential benefits could be seen through changes in the agricultural sector, including increases in output margins due to decreases in traders' bargaining power, transformation of the agricultural output mix from low-value to high-value products, and increased use of modern inputs.

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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Abstract (in Japanese)

要約

本稿では、1995年から2007年の期間の家計パネルデータおよび村データを用い、インドネシア農村部において道路の質の向上が家計所得水準及び非農業部門への労働供給にどのようなインパクトを与えるかを分析する。農村部での道路の質の向上は家計所得水準を上昇させ、非農業部門への労働供給を増加させるが、それは教育水準や、都市部との距離に影響される。すなわち、農村部での道路の質の向上と中等教育以降の教育投資は、特に都市部から遠い地域において、非農業活動への労働供給ひいては所得水準向上に関して補完的な関係にあることが示唆される。

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