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Roads, Labor Markets, and Human Capital

Evidence from Rural Indonesia

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Abstract

This paper uses household panel data from rural Indonesia to examine the impact of road quality on labor supply and wages. First, road projects are found to increase transportation speed. Second, the empirical results from intra-village variations of household endowments and labor market behavior show that an increase in transportation speed raised wages in nonagricultural and agricultural employment, and was associated with a decline in working time in agricultural employment, for households whose members are relatively educated. The findings support potential complementarity between road quality and education.

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Roads, Labor Markets, and Human Capital

Evidence from Rural Indonesia[1]

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1. Introduction

It has been increasingly recognized that transportation infrastructures critically determine the allocative efficiency of economic activities, and therefore influence household resource allocation and outcomes (e.g., Binswanger et al. (1993) and Fan et al. (2004)).[3] The improvement of road quality expands the geographic area individuals can reach. Resources can move faster. For instance, households can reach employment opportunities that, before the change, were too distant to capture. Improved transportation networks can also invite new capital investments, which alter the spatial distribution of economic activities and demands for skills. New market opportunities can alter returns to household resources, and thus, their initial endowments affect how effectively they can benefit from the new roads.

Household endowments potentially matter in the improved road impact on household outcomes. For example, when the demand for skilled labor is concentrated in urban labor markets, the educated in rural areas will benefit more from the improved spatial connectivity to urban areas (e.g., Fafchamps and Shilpi, 2003, 2005). Another example is linked to new opportunities, which improved spatial connectivity can create. To utilize these new opportunities, knowledge and/or experience are important since the process involves learning as well as risk taking.[4]

In this paper, I examine the effects of improved roads on labor supply and earnings using household panel data from Indonesia by focusing on potential heterogeneity in the impacts related to initial household endowments such as educational attainment. The analysis also compares agricultural and nonagricultural labor markets to investigate possible differences in household labor supply and

[3] Using aggregate data, the previous studies such as estimated the returns to road constructions. To identify the impact of road infrastructure, however, it is necessary to use household-level data with a sufficiently long span of period in which road conditions change or explicit information on new road projects. This study takes the latter approach.

[4] This is similar to the availability of a new technology (Schultz, 1975), which increases returns to schooling. The hypothesis that the educated have an advantage in learning has been tested by Foster and Rosenzweig (1995) and others.

wage responses to road improvements. The impact on wages (returns to labor) could be different between agriculture and nonagriculture since the improvement of roads potentially opens faster access to urban labor markets. Accordingly, labor can be reallocated between agriculture and nonagriculture if wages change differentially between the two sectors and sector-specific skill requirements do not significantly constrain the household decision.

The following three points are important in the analysis. First, as mentioned, this paper examines how the distribution of labor earnings across households within a village alters in response to village-level changes in transportation speed. Thus, changes in the intra-village distribution of household labor earnings are compared across villages with and without changes in transportation speed.[5] By focusing on the intra-village distributional issues, I will minimize the effect of endogenous placement of road projects. Second, I use an important characteristic of road projects to endogenize changes in transportation speed. That is, during the project, the local demand for construction workers will certainly increase, but the effect ceases when the project is completed, whereas the impact of road improvement on transportation speed will remain as long as the road quality is maintained.

Third, Indonesia, at least in the survey sites, had established key road networks before 2007 so most village road projects aimed to improve and rehabilitate existing roads, rather than opening new road paths[6] Therefore, changes in the estimated transportation speed (for agricultural and nonagricultural employment) are due to improvements in road quality. To measure road quality, I estimated transportation speed by dividing distance in kilometers to an employment site by the required number of hours.

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[5] This procedure therefore uses triple differencing. In addition, instrumentation is adopted to wipe out potential bias.

[6] After decentralization introduced in 2000, road projects can be implemented at the district (kebupaten) or sub-district (kecamatan) level, The hierarchy under province follows district, sub-district and finally village (desa).

In the literature, Yamauchi et al. (2011) showed from Indonesia that improvements in road quality in neighboring areas increased incomes of relatively educated households and promoted their transition to nonagriculture between 1995 and 2007. The findings of the current study are also consistent with their work. In contrast with agriculture, nonagricultural economic activities require more advanced skills and knowledge to handle more complicated technologies (e.g., Yamauchi, 2004; Fafchamps and Shilpi, 2005). To realize larger returns to human capital in the context of rural labor markets, it seems critically important to have access to nonagricultural labor markets (Fafchamps and Shilpi, 2003).[7]

In the context of Indonesian road networks, three papers in particular are close to the current study: Gertler et al. (2014), Gibson and Olivia (2010) and Yamauchi et al. (2011). Gibson and Olivia (2010) used the Indonesian Family Life Surveys to confirm a positive linkage between nonfarm employment and infrastructure developments such as roads and electricity. The above study is, however, a cross sectional analysis, not taking advantage of the panel surveys, so it did not identify a causal relationship from roads to nonfarm employment. On the other hand, Gertler, at al. (2014) used the same data set to conduct a panel analysis by combining it with road quality panel data. Their analysis used the International Roughness Index and computed roughness-induced travel time. Yamauchi et al. (2011) used the proportion of inter-village roads using asphalt computed from village census data (PODES), and showed a positive effect of changes in road quality on nonagricultural labor supply. As confirmed in Gibson and Olivia (2010) citing Parikesit (2006), the quality of existing roads substantially varies across regions.

Table 1 shows the proportion of inter-village roads using asphalt in 1996 and 2006.[8] The table demonstrates that, in addition to variations in the quality at a given point in time (e.g., 100% in Jakarta

[7] In agricultural commodity markets, Jacoby (2000) and Jacoby and Minten (2009) showed evidence that farmers who transport their produces to local markets can potentially increase their profits (reflected in the value of their farm land).

[8] The village census, PODES, reports materials used in inter-village roads for each village.

to 40% in Nusa Tenggara Timor), the changes also substantially vary across provinces. The average trend is, however, clearly upward in the country. Changes in percentage point of the proportion of inter-village roads made of asphalt in the 7 sample provinces from 1995 to 2006 are: +5% (Lampung), +10% (Central Java), +8% (East java), -4% (NTB), +4% (South Kalimantan), no change (North Sulawesi) and +10% (South Sulawesi). In 2006, one year prior to the initial survey round, the least developed province is Lampung (47% asphalt), while the most developed ones are North Sulawesi (76%) and Central Java (74%). In general, Java is the most developed area in terms of rural road conditions.

In sum, the contribution of this paper is threefold. First, the data enable me to directly compute the average transportation speed and the impacts on household labor supply and income are estimated. Second, agricultural and nonagricultural labor markets are distinguished. Third, the analysis shows distributional effects across households within a village, rendering direct implications for local income distributions. The next section describes the empirical strategy.

2. Empirical Strategy

This section describes the specification and estimation strategy used, and discusses identification issues. The analysis uses household-level panel data to analyze labor supply and wages that potentially respond to changes in road quality.

To mitigate potential endogeneity problems related to the placement of road projects in villages, the focus is on the heterogeneous impacts of road quality improvement (measured by changes in transportation speed) associated with household endowments such as education, gender and age (i.e., interaction terms of change in transportation speed and the initial household characteristics). The number of road projects during the period is used as an instrument for changes in transportation speed to wipe out potential bias that comes from a possible correlation between changes in transportation speed and household-level labor supply or wage shocks.[9]

The following first-differenced equation is estimated,

$$\Delta y_{ij(0,1)} = \alpha + \beta_1 \Delta s_{j(0,1)} + \beta_2 \Delta s_{j(0,1)} x_{ij0} + x_{ij0}'\gamma + \Delta v_{j(0,1)} + \Delta \varepsilon_{ij(0,1)} \qquad (1)$$

where $\Delta y_{ij(0,1)}$ is change in the number of working days (or months) or wages for household i in village j, from time 0 to 1, $\Delta s_{j(0,1)}$ is change in the average transportation speed between 2007 and 2010, x_{ij0} is a vector of initial household characteristics, $\Delta v_{j(0,1)}$ is a village-level shock, and $\Delta \varepsilon_{ij(0,1)}$ is the difference in shocks in the number of working days (or months) or wages (assume that ε_{ijt} is an ex-post shock after household decisions are made). Note that β_1 is the effect of change in the average transportation speed on the dependent variable, and β_2 captures how the initial household characteristics affect the impact of change in the average transportation speed. The estimated village-level average mobility speed is interacted with household characteristics x_{ij0}: the average years of schooling, the average age and number of household members, all defined relative to a baseline of 20-55 in $t=0$.

Since $\Delta s_{j(0,1)}$ is correlated with village-level shocks in the labor market conditions (e.g., an increase in income enabling households to purchase motorbikes), $\Delta v_{j(0,1)}$ is controlled for using village fixed effects. The focus of estimation is on identifying β_2, rather than β_1. That is,

$$\Delta y_{ij(0,1)} = \alpha + \beta_2 \Delta s_{j(0,1)} x_{ij0} + x_{ij0}'\gamma + FE_j + \Delta \varepsilon_{ij(0,1)} \qquad (2)$$

[9] I assume that these shocks are ex-post in the sense that shocks are realized after household decisions are made. An unanticipated change in wages after labor decisions are made is a good example. Similarly, labor hours can change unexpectedly after an individual agrees to his/her employment conditions.

where FE_j is the village fixed effects, which capture both $\beta_1 \Delta s_{j(0,1)}$ and $\Delta v_{j(0,1)}$. With the inclusion of FE_j, the inference is based on *intra-village* variations in the above estimation.

The estimation uses instruments to remove potential bias due to correlations between initial period wage shocks and changes in the average transportation speed. For example, a positive income shock in the initial period enables the household to choose a more expensive but speedy transportation mode (e.g., purchasing a motorbike), which increases the average speed prevailing in *t=1*. To wipe out potential bias due to the correlation between $\Delta s_{j(0,1)}$ and ε_{ij0}, the number of road projects at the village level ($\Delta R_{j(0,1)}$) is used as an instrument for $\Delta s_{j(0,1)}$. However, since the village fixed effects are included in Eqn (2), the actual instruments are also the interactions between $\Delta R_{j(0,1)}$ and x_{ij0}.

Two features of road projects deserve special attention. First, since road projects are mostly public investments and their preparation normally requires some time (say, a few years), their installation is unlikely to be correlated with individual decisions influenced by the initial period labor market shocks (ε_{ij0}).[10] Second, the direct impact of road projects on labor demand is temporary, so the direct effect ceases after project completion. However, the impact of road improvements on transportation speed lasts as long as the quality of the road is maintained. Section 4 shows some evidence supporting this point (Table A1). For the above two reasons, $E\left[\Delta R_{j(0,1)} x_{ij0}{}' \varepsilon_{ij0}\right] = 0$. The next section describes the panel data used in the analysis.

3. Data

In this section, I describe the survey data from Indonesia used in this analysis in detail. The data come from two rounds of household surveys conducted in Indonesia (Indonesian Center for

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[10] Note that villages with a relatively better endowment, e.g., in educational attainment, could be possibly in a good position to plan road projects (since they know potential returns to such a project are high in their villages). However, these potential village-specific effects are all controlled by village fixed effects.

Agricultural Socio Economic and Policy Studies and International Food Policy Research Institute). First, the primary source of our data is the village and household surveys 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 Japan Bank for International Cooperation (JBIC; currently JICA) Study of Effects of Infrastructure on Millennium Development Goals in Indonesia (IMDG). Figure 1 shows locations of surveyed villages. In 2010, the survey team revisited all the 98 sample villages to re-interview sample households and their splits. Out-migrants were also tracked through either direct or phone interviews.

The survey was designed to overlap with villages covered 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 seven provinces. The sample was representative for major agro-climatic zones in Indonesia. In 2007, the team visited those villages to expand the scope of research as a general household survey under the IMDG survey.

The 2007 round added 51 new villages. These new villages were selected with the following criteria. First, the same districts (kebupaten) where PATANAS villages are located were chosen. Second, villages that had received relatively large amounts of government infrastructure projects during the period of 1995 to 2005 were listed (mainly funded by either the Japan Bank for International Cooperation or the World Bank). Finally, the new villages were randomly sampled from the list.

In the revisited original-sample villages in 2007, 20 households were resampled per village from the 1994/95 sample and the split households (defined below) were included. In the new villages, 24 households were sampled in each village. We have a total of 98 villages that are available for various research objectives. The 2010 survey followed sample households in all 98 villages.[11]

Between the surveys, some household members separated from the 2007 original households to start their own new households or to join other households. In the survey, a split household is defined as a new household in which (i) a member of the original household became the *head* of a new household, and (ii) the household resides in the same village. The above two conditions define split households in this study; household members who moved out of the original village or simply joined other households within the village are not called splits in the survey. From 2007 to 2010, 9.25% of the 2010 households were split households under the above definition. 12.97% of the sample individuals recorded as household members in 2007 migrated out, i.e., either moved out of their village or joined other households. The proportion is 11.82% once the group is restricted to those aged 20-55 in 2007.

The omission of out-migrants could potentially downwardly bias the estimated transportation speed impacts on labor supply and earnings if improved spatial connectivity is likely to make able individuals migrate to look for outside employment opportunities. However the opposite could hold if more able individuals can commute when roads are improved. Though out-migrants are most likely to be engaged in nonagricultural works in the current empirical context, this will also lead to an underestimation of the impacts on labor supply in nonagricultural sectors.

On the mechanism of household splits (in the above definition), the incidence of splits is regressed on the explanatory variables used in the main outcome equations (Table 2).[12] Column 1 uses province dummies, and Column 2 uses village dummies. The results show that changes in the average transportation speed, and its interactions with the initial household characteristics are all

11 See also Yamauchi (2012) that used the same survey data from 2007 and 2010 to analyze determinants of birthweight seasonality and its impacts on child human capital formation.

12 The sample size is 1904 since 6 villages were omitted due to collinearity.

insignificant, which indicates that transportation factors are not driving household splits (specifically defined in Section 3). Second, among the household characteristics, only the average age and the number of household members, both defined only over the age range 20 to 55, are significantly related to the incidence of splits. Namely, older households tend not to split, while larger households tend to be split. Based on the above results, I aggregate split households and their original household in 2010 (both residing in the same village) to match with the original household in 2007. Though the decision to start a new household in the same village could be potentially affected by changes in inter-village road quality, the magnitude of any such influence seems to be substantially smaller than that of migration decisions since the major factor affecting split decisions (rather than migration) remains demographic, such as marriage (see Table 2).[13]

4. Road Infrastructure and Transportation Speed

This section shows some descriptive evidence for the relationship between road projects and transportation speed. The rate of change in speed (i.e., change in the log of speed) is related to the number of road projects completed in the period from 2007 to 2010. Table 3 tabulates the number of road projects by village. More than 61 percent of the sample villages had some road projects completed during the period.

Both the 2007 and 2010 surveys have employment modules that capture the nature of employment, such as wages (both cash and in-kind), duration, contract types for each employment case in the past year (therefore, an individual can have multiple records of employment experience). An important feature of the IMDG surveys is that they captured details of commuting in each case, e.g.,

[13] In a preliminary analysis, Eq(2) was estimated without including households who split (i.e., both main and split households). The results remain qualitatively similar, which confirms that in this particular period, potential bias due to the split process is small (consistent with the results in Table 2).

distance, time, cost and main mode of transportation. Some cases include temporary migration--such as living and working in a distant location for some months and returning to the original household-- since our definition of household membership uses 6 months of residence in the past one year. However even in this case, it is useful to compute the speed to capture road and transportation quality in the surrounding areas.

Figure 2a shows the distributions of speed estimates from individual nonagricultural employment cases in 2007 and 2010. The distributions are skewed in both 2007 and 2010. The distribution has slightly shifted rightward. Figure 2b displays the distributions in agricultural employment. Changes in the distribution are quite small. Though both distributions are skewed, the speed in accessing agricultural employment is much lower than that of nonagricultural employment. Next, Figures 3a and 3b show the relationship between the estimated speed and distance for nonagriculture and agriculture, respectively. It is found that the speed has increased evenly in a large range of distance in nonagriculture, but the change is not clear in agriculture. Therefore, Figures 2 and 3 point to the asymmetry between the two sectors: transportation speed has increased more in accessing nonagricultural employment.

Figures 4 shows the relationship between the speed for nonagricultural employment (village-average) in 2007 and (a) the proportion of asphalt/concrete/cone-blocked and (b) the proportion of 4-wheel passable roads in inter-village roads at sub-district (kecamatan) in 2006 (both constructed from the 2006 PODES village census).[14] The graphs show that they are positively correlated, which implies that the overall quality of inter-village roads in the neighboring areas seems to explain speed in accessing nonagricultural employment. The above observation is reasonable since the

[14] One village in North Sulawesi (currently in Gorontalo) could not be identified in the 2006 PODES, so this village is not included when we use the 2006 PODES (Figure 4 and Table 1). However, since we do not use the 2006 PODES in the analysis, this does not affect the main results.

actual speed available to villagers is determined by both their own inter-village roads as well as those in their neighboring areas. Figure 5 shows the distribution of change in log village mean speed (averaging nonagricultural and agricultural employment). The change is symmetrically distributed across villages.

Next, the change of log speed is regressed on the number of road projects completed in 2007-2010, the village-mean log speed in 2007, and their interactions (Table 4, Columns 1 and 2). The access speed for either nonagricultural or agricultural employment could not be calculated for 6 villages, thus not enabling to compute the mean village-level speed, which renders 92 villages in the regressions. It is found that the number of completed road projects significantly has increased the village-mean speed. The initial level of speed is negatively associated with the subsequent change of speed, and the interaction term of the initial speed and the number of road projects has a significant negative effect on the change in speed, which implies that a potential gain from improved roads is larger if the initial level of speed is low (i.e., road conditions are bad in the initial period).

In Column 3, the number of road projects is regressed on the initial village-level speed and the proportions of asphalt roads and four-wheel transportable roads in the sub-district. The incidence of road constructions/rehabilitations is not correlated with the mobility speed in the initial period,[15] but is positively related to the proportion of asphalt roads within the sub-district, implying that potential benefits of the road improvement could be greater if the village is surrounded by relatively better roads (this is consistent with Figures 4).

Note that road projects could have increased labor demands during the project period (e.g., construction period) but, by definition, such a temporary increase in employment in road constructions does not sustain after the project completion. Though working time and wages in 2010 could reflect some parts of the recent road project impacts, the major portion of the impacts is not directly related to

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[15] As the next section shows, nonagricultural wages are positively related to the mobility speed in 2007.

the dependent variables. Table A1 shows the effect of road projects on the change in working time, measured in months for nonagricultural and days in agricultural employment, respectively. The number of road projects does not affect the change in working time in both cases due to the fact that road construction can only temporarily alter labor demands during the project period and the effect ceases upon the completion.

Finally, as mentioned, the main focus of analysis is to examine changes in the intra-village income distribution in response to changes in transportation speed. Before showing the estimation results, the intra-village schooling distributions are compared between villages with and without road projects. Figure 6 uses the residuals of the average years of schooling completed after controlling village dummies. The two distributions are strikingly similar, which indicates that the intra-village schooling distributions are not different between road project and non-project villages, though the placement of projects could be biased to a certain group of villages.

5. Empirical Results

This section summarizes the estimation results. Tables 5 and 6 show estimates from the household-level panel analysis. Table 5 shows the effects of transportation speed change on working time. The estimation includes village dummies to absorb village-level shocks (especially, general price changes). Village average change in speed is interacted with household-level average years of schooling completed, average age (age 20-55) and the number of household members aged 20-55, all measured in 2007. Instruments are: indicators for the number of road projects completed interacted with years of schooling, average age and the number of household members aged 20-55 in 2007, and other exogenous variables. The test of exogeneity supports non-instrument cases.

Columns 1 and 2 show the results on nonagricultural employment. In both the no-instrument and instrument cases, changes in the speed have no significant effect (via schooling, age and household size). Columns 3 and 4 show the results on agricultural employment working time. Working time in nonagricultural employment decreased if the average educational attainment is high (Column 3, no instrument). The above results point out that there is a tendency that the household decreases their labor supply to agricultural work, especially among the educated members, but the effect on nonagricultural work was not clear. There is a possibility that agricultural producers allocate more of their time to their production activities, by reducing labor supply to agricultural labor work on their farms.

Table 6 summarizes estimation results for wages. Monthly and daily incomes are used as dependent variables for nonagricultural and agricultural employment, respectively. Columns 1 and 2 show results for the monthly wage received in nonagricultural employment with and without instruments, respectively. First, in both cases, an increase in the village-average speed significantly raises returns to schooling at the household level. In other words, relatively more educated households experience increased wages (and total income) from nonagricultural employment when road and transportation quality improve in the neighboring areas. The effect is larger in the instrumental variable estimation than the OLS estimation. The effect of the average age becomes smaller (negative effect). Household size (age 20-55) does not have the above effect. The test of exogeneity shows that the IV estimates significantly differ from the OLS estimates ($p = 0.015$).

Columns 3 and 4 show the results from agricultural employment daily wages with and without instruments, respectively. Interestingly, it is found that the interaction term of changes in village-average speed and household schooling is significantly positive (in contrast to the cross-sectional wage regressions). The estimate of the speed-schooling complementarity is larger in the instrumental variable estimation than that of the OLS estimation, though the test of exogeneity favors the non-instrument case.

In contrast to the previous studies (e.g., Yamauchi et al., 2011) that showed that the income sources of the educated tend to shift from agriculture to nonagriculture by increasing labor supply to nonagricultural employment when road quality improves in the local economy, the current study showed that increased transportation speeds significantly augmented returns to schooling in both nonagricultural and agricultural labor markets. However, labor supply to agricultural work has simultaneously decreased.

6. Conclusions

This paper examined the impact of road quality on labor supply and wages using household panel data from rural Indonesia. The findings are twofold. First, an increase in average transport speed increased labor market wages in both nonagricultural and agricultural employment, while decreasing working time in agricultural employment, especially for the households whose members are relatively educated. The findings support complementarity between road quality and education. However, the question of whether better roads attract new investments, creating more job opportunities in the same place, remains unanswered, beyond the scope of the current analysis.

Second, the current study has also demonstrated that road projects significantly increased the average transportation speed around villages. The average speed also depends on spatial connectivity in the neighboring areas, measured by the proportion of asphalt (or 4-wheel car passable) inter-village roads within the sub-district.

The complementarities between education and roads have several implications. First, public investments in rural road construction can generate greater returns if the rural population is more educated. Second, better spatial connectivity could augment returns to educational investments (e.g., school construction). Finally, due to the above complementarities, the government should incorporate such cross-augmenting effects when designing public investments for rural development.

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Figure 1 Locations of surveyed villages

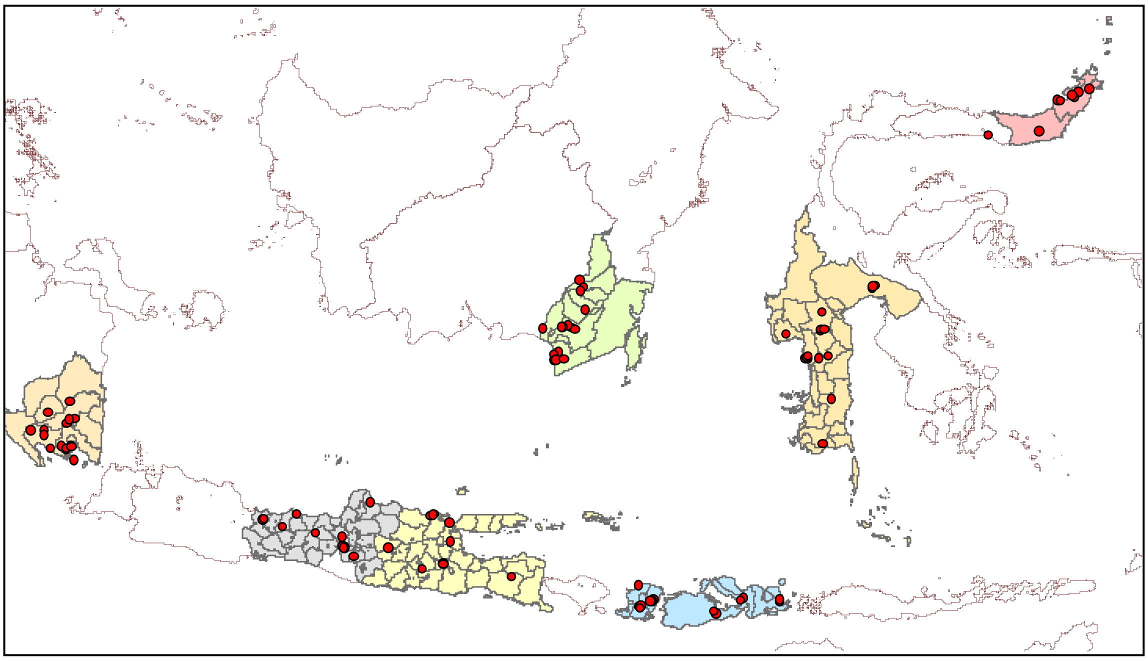


Figure 2a Speed for nonagricultural employment

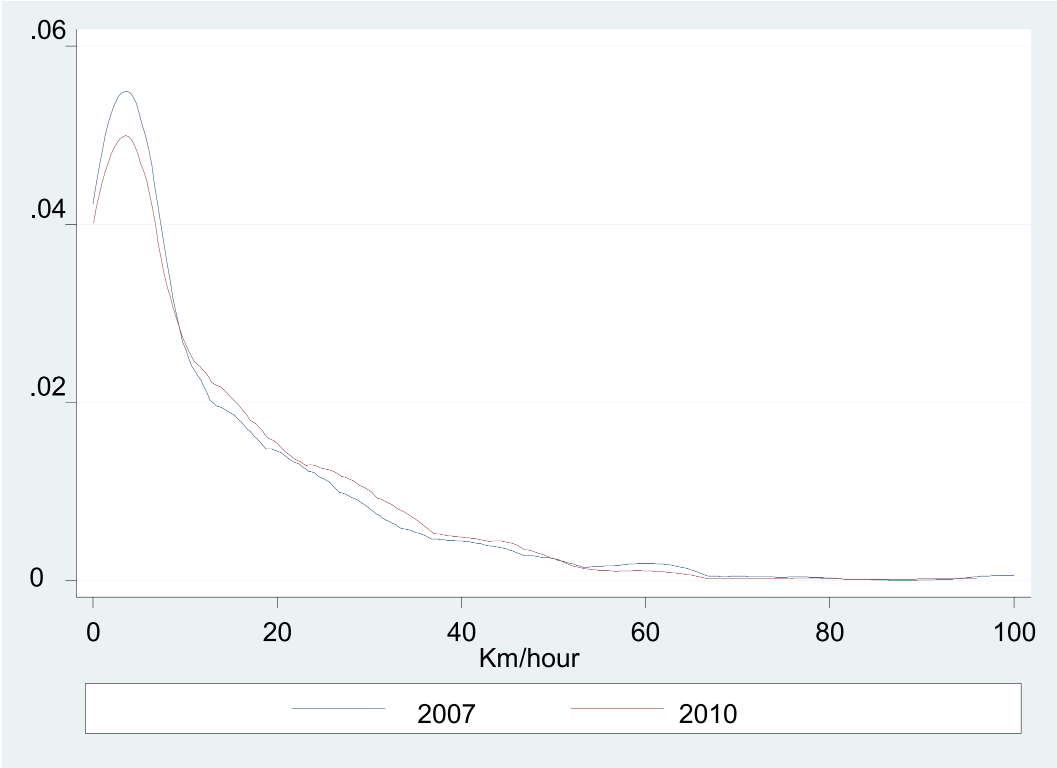


Figure 2b Speed for agricultural employment

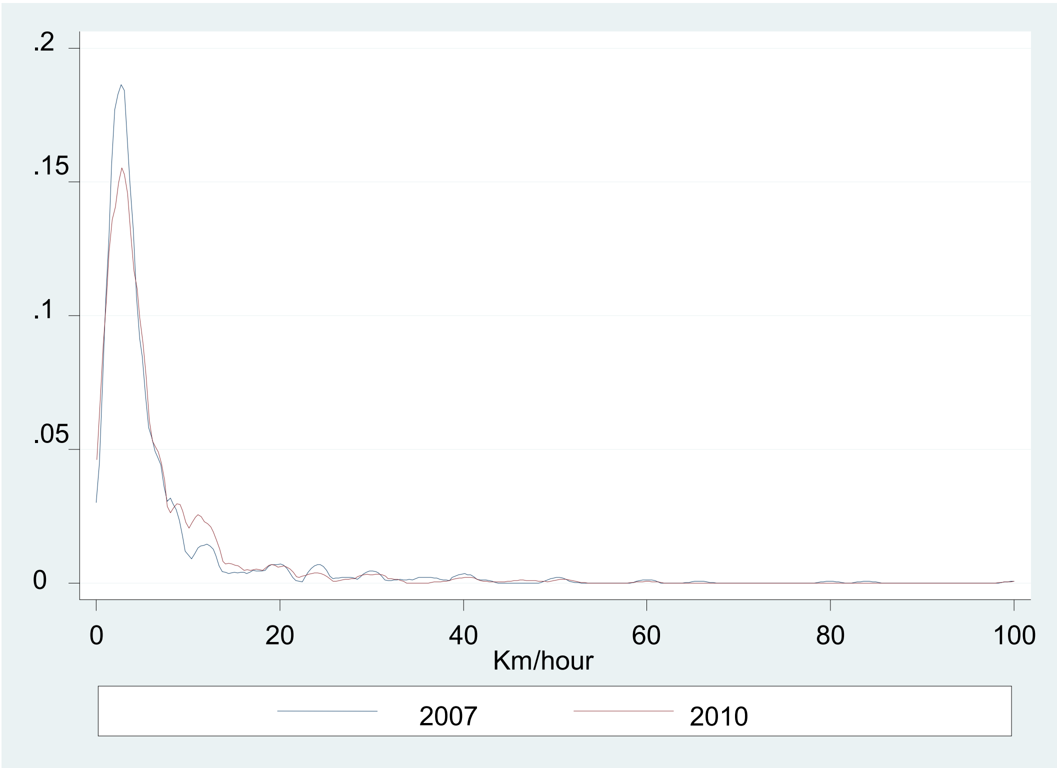


Figure 3a Speed (km/hour) vs distance (km) for nonagricultural employment

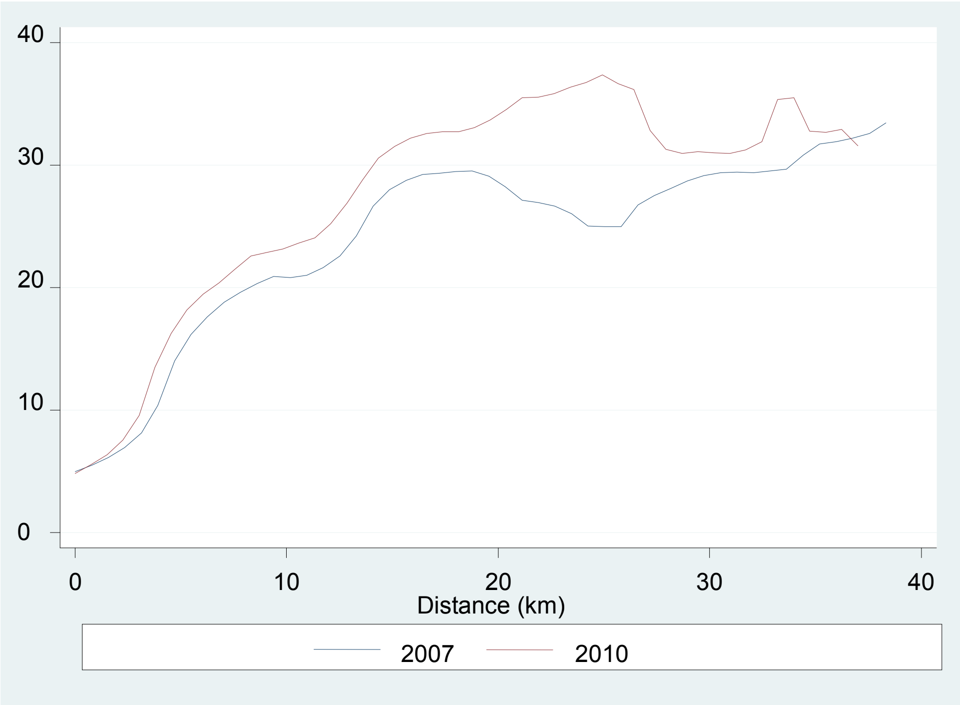


Figure 3b Speed (km/hour) vs distance (km) for agricultural employment

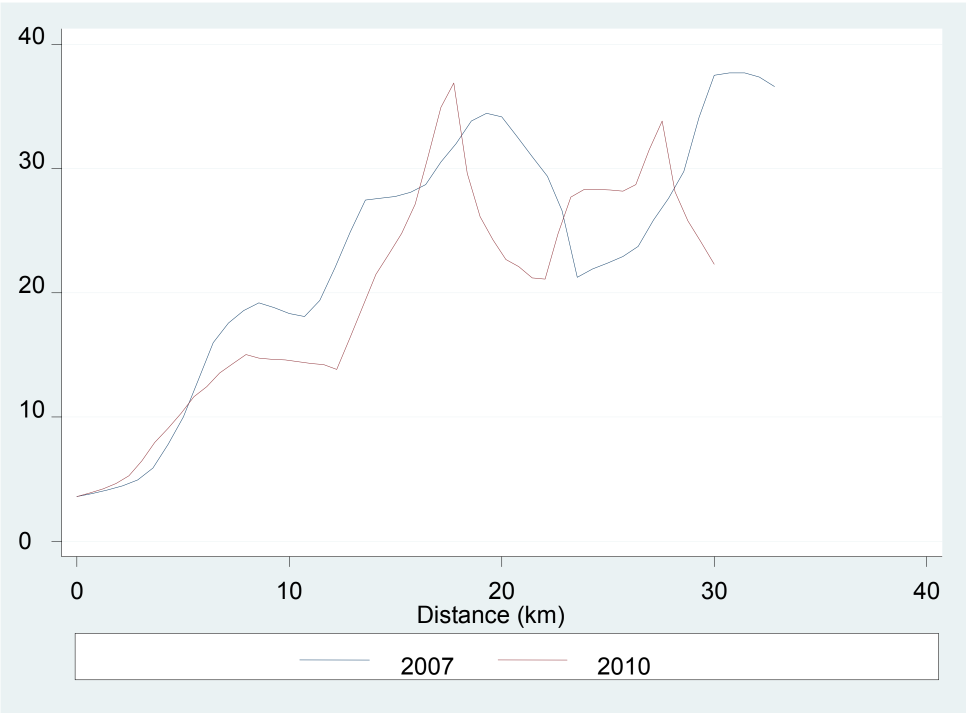
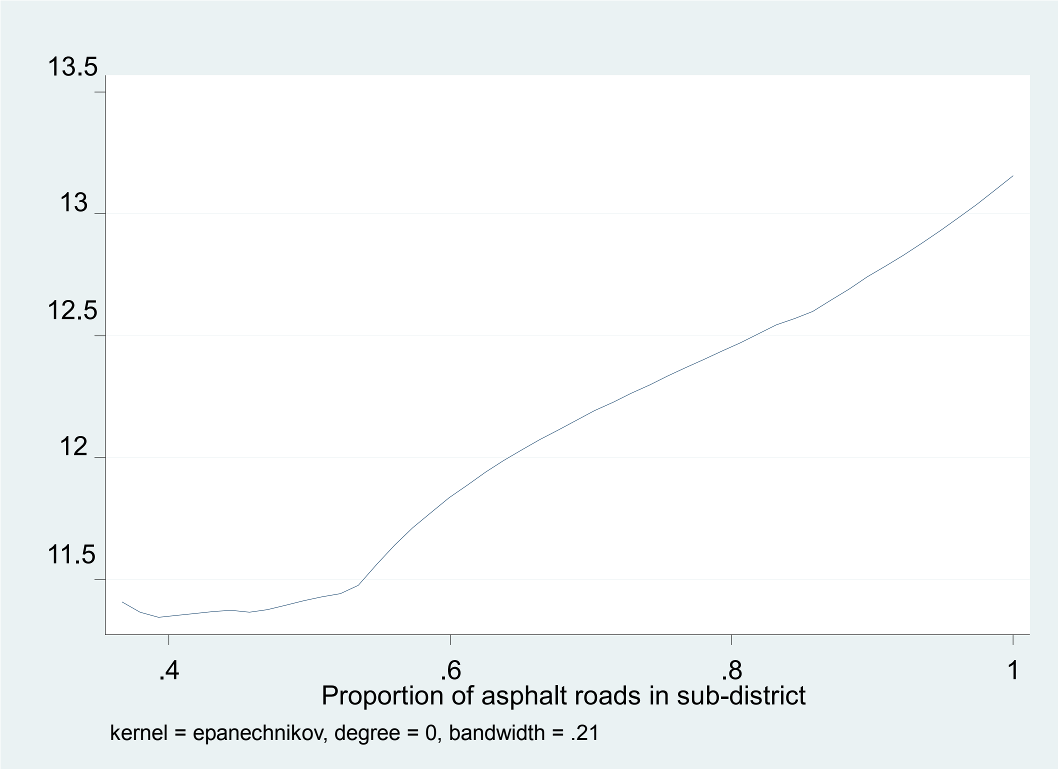


Figure 4 Relationship between nonagriculture speed (km/hour) in 2007 and (a) the proportions of asphalt used in inter-village roads and (b) the proportion of 4-wheel passable in inter-village roads within sub-district (PODES 2006)



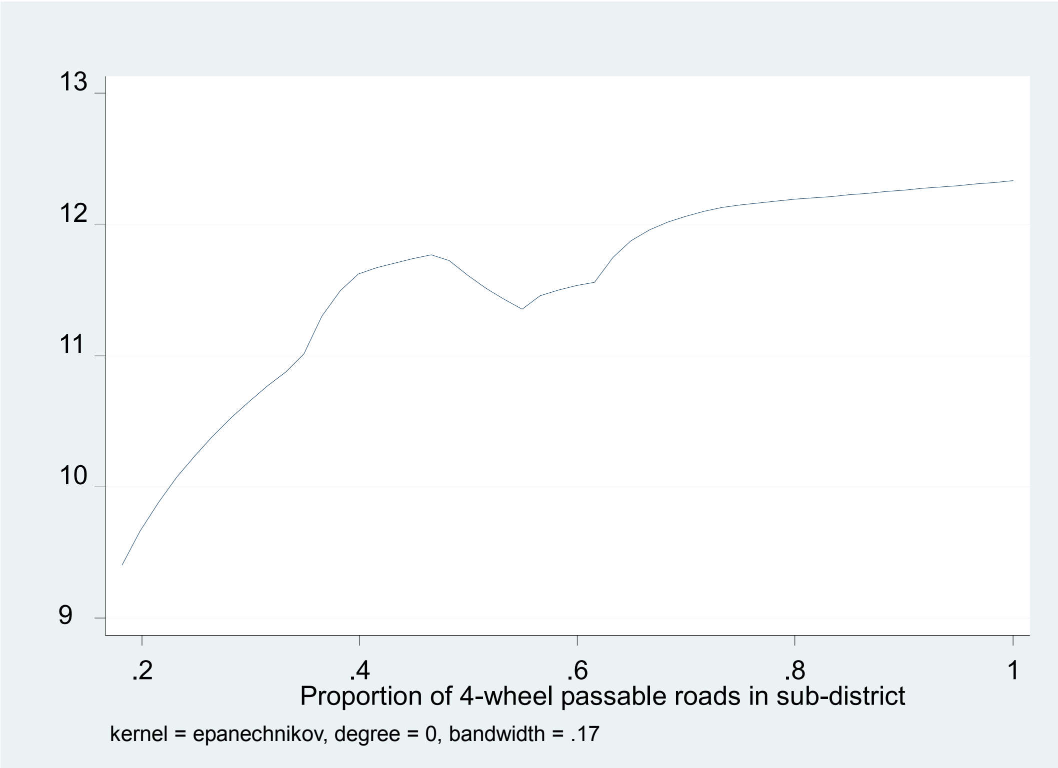


Figure 5 Change in (log) mean village speed (km/hour)

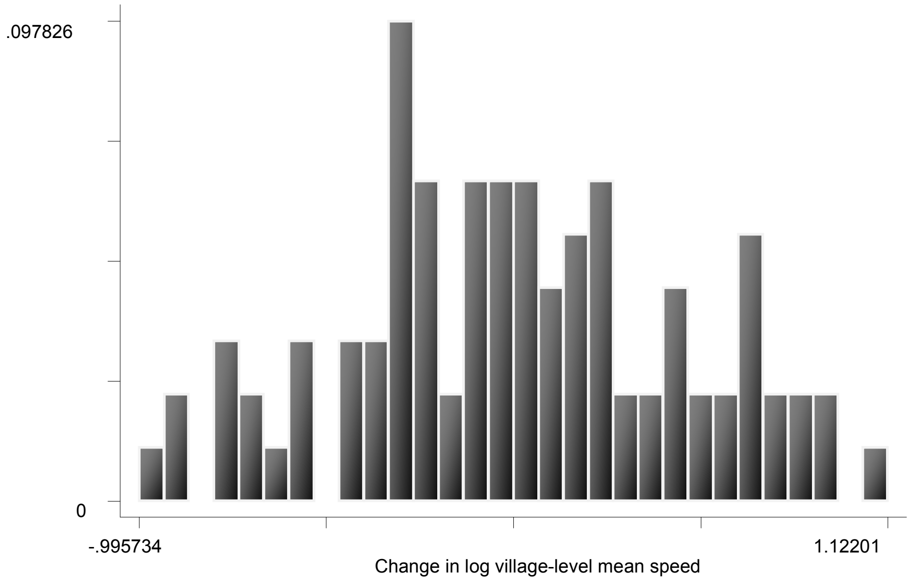


Figure 6 Intra-village schooling distributions with and without road projects

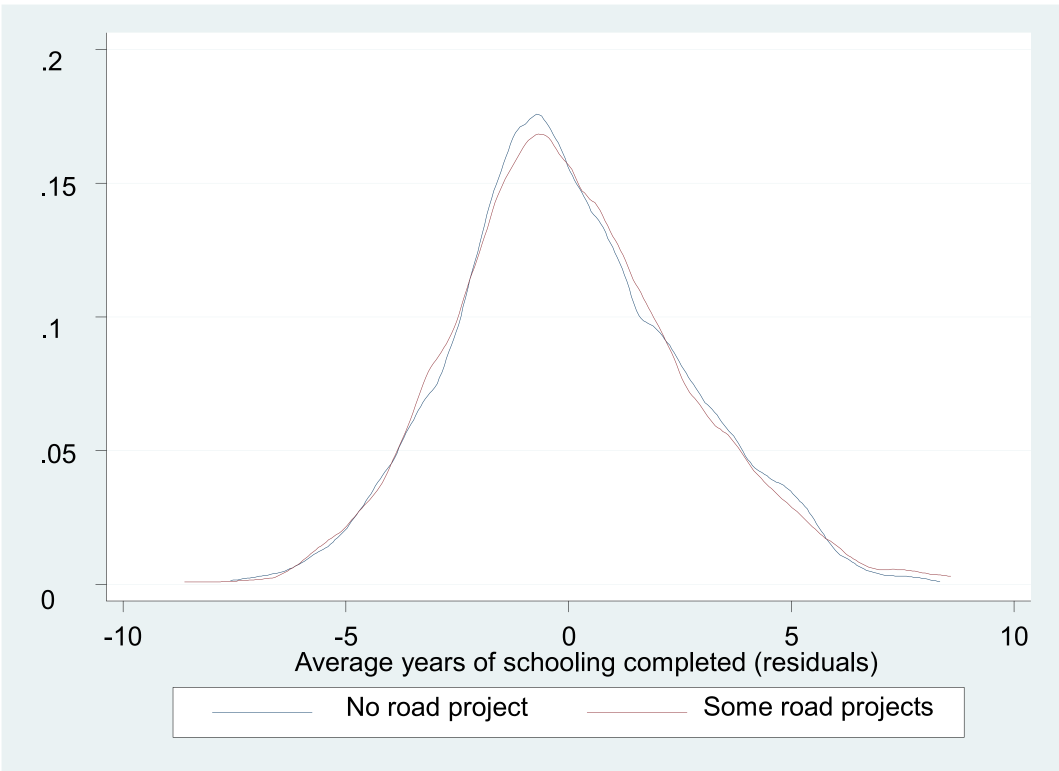


Table 1 Asphalt road proportion in inter-village roads (province-wise average)

Province code	1996	2006
Aceh	0.46	0.39
Sumatera Utara	0.49	0.53
Sumatera Barat	0.69	0.93
Riau	0.40	0.48
Jambi	0.61	0.74
Sumatera Selatan	0.63	0.69
Bengkulu	0.74	0.73
Lampung *	0.52	0.47
Jakarta Raya	0.99	1.00
Jawa Barat	0.69	0.66
Jawa Tengah *	0.64	0.74
Yogyakarta	0.81	0.79
Jawa Timur *	0.56	0.68
Bali	0.98	0.99
Nusa Tenggara Barat*	0.82	0.78
Nusa Tenggara Timur	0.44	0.40
Kalimantan Barat	0.41	0.47
Kalimantan Tengah	0.36	0.44
Kalimantan Selatan *	0.63	0.67
Kalimantan Timur	0.32	0.49
Sulawesi Utara *	0.76	0.76
Sulawesi Tengah	0.58	0.63
Sulawesi Selatan *	0.50	0.60
Sulawesi Tenggara	0.52	0.55
Maluku	0.57	0.64
Maluku Utara	0.25	0.44

Sources: PODES 1996 and 2006 (Yamauchi, et al. 2011, Table 7). * marks the sample provinces.

Table 2 Split decision

Dependent: = 1 if split, and 0 otherwise		
Change in log speed (vlg)	0.1470	
	(1.09)	
Change in log speed (vlg) * average yrs of schooling	-0.0067	-0.0049
	(1.49)	(1.08)
Change in log speed (vlg) * average age (age 20-55)	-0.0033	-0.0015
	(1.24)	(0.57)
Change in log speed (vlg) * household size (age 20-55)	0.0096	0.0100
	(0.53)	(0.49)
Average years of schooling	-0.0074	-0.0085
	(0.98)	(0.97)
Years of schooling squared	0.0001	0.0003
	(0.24)	(0.67)
Average age (age 20-55)	-0.0049	-0.0041
	(3.96)	(3.67)
Household size (age20-55)	0.0643	0.0677
	(4.88)	(6.16)
Province dummies	yes	
Village dummies		yes
Number of observations	1904	1904
R squared	0.0778	0.1443

Numbers in parentheses are absolute t values using robust standard errors using province clusters (Column 1) or village clusters (Column 2).

Table 3 Road projects in 2007 - 2010

Number of road projects completed	Villages	Frequency
0	38	38.78
1	35	35.71
2	16	16.33
3	4	4.08
4	4	4.08
6	1	1.02

Table 4 Road projects and change in log speed: village-level data

Dependent:	Change in log mean village-level speed		Number of road projects
Number of road projects completed	0.2525	0.2729	
	(2.29)	(2.69)	
Log speed in 2007	-0.3139	-0.3260	-0.1269
	(3.07)	(3.20)	(0.56)
Road projects * log speed 2007	-0.1033	-0.1117	
	(1.76)	(2.02)	
Sub-district proportion asphalt		-0.2193	0.7541
		(1.08)	(1.80)
Sub-district proportion 4 wheel		0.6457	-0.0778
		(2.32)	(1.10)
Constant	0.6448	0.2187	0.8424
	(3.16)	(0.88)	(1.20)
R squared	0.2423	0.2744	0.0397
F stat	12.22	9.47	1.29
Prob > F	0.0000	0.0000	0.2817
Number of observations	92	92	92

Numbers in parentheses are absolute t values using robust standard errors. The access speed for either nonagricultural or agricultural employment could not be calculated for 6 villages, thus not enabling to compute the mean village-level speed.

Table 5 Change in working time				
Dependent:	Nonagricultural Change in total months		Agricultural Change in total days	
	No IV	IV	No IV	IV
Change in log speed (vlg) * average yrs of schooling	0.2918	-0.1319	-6.1628	-11.031
	(1.50)	(0.23)	(2.64)	(1.16)
Change in log speed (vlg) * average age (age 20-55)	0.0912	-0.0265	-1.6961	1.2959
	(1.35)	(0.09)	(1.61)	(0.42)
Change in log speed (vlg) * household size (age 20-55)	-0.6118	-1.9355	-3.0854	-14.780
	(1.29)	(1.51)	(0.33)	(1.07)
Average years of schooling	-0.2791	-0.2511	5.2784	6.1037
	(0.92)	(0.80)	(1.13)	(1.25)
Schooling squared	0.0222	0.0218	-0.1741	-0.2075
	(1.17)	(1.11)	(0.72)	(0.83)
Average age	-0.0056	0.0025	1.3305	1.2364
	(0.17)	(0.07)	(2.57)	(2.21)
Household size	0.1653	0.3054	0.5806	1.4742
	(0.68)	(0.09)	(1.11)	(0.29)
Village dummies	yes	yes	yes	yes
Durbin-Wu-Hausman: Chi-sq (3) [p-value]		1.219 [0.748]		1.186 [0.756]
Number of observations	1943	1943	1943	1943
R squared	0.0770	0.0704	0.1136	0.1063

Numbers in parentheses are absolute t values using robust standard errors using village clusters. Instruments are: indicators for the number of road projects completed interacted with years of schooling, average age and the number of household members aged 20-55 in 2007, and other exogenous variables.

Table 6 Change in monthly/daily income

	Nonagricultural employment Monthly wage		Agricultural employment Daily wage	
	No IV	IV	No IV	IV
Change in log speed (vlg) * average yrs of schooling	30509.71	100304.9	3626.14	8086.12
	(1.97)	(1.91)	(2.30)	(1.91)
Change in log speed (vlg) * average age (age 20-55)	-5667.51	-94143.59	-109.93	-155.62
	(0.62)	(2.21)	(0.23)	(0.19)
Change in log speed (vlg) * household size (age 20-55)	-21347.45	-176045.5	-2563.98	-975.01
	(0.39)	(0.88)	(1.02)	(0.17)
Average years of schooling	-28959.77	-49664.92	-583.56	-1170.06
	(1.0)	(1.38)	(0.32)	(0.58)
Schooling squared	3134.57	4217.41	-47.31	-22.93
	(1.75)	(2.01)	(0.39)	(0.19)
Average age	3226.41	7297.64	-76.62	-75.94
	(0.50)	(1.01)	(0.48)	(0.42)
Household size	6845.74	28235.47	-1131.18	-1337.00
	(0.27)	(0.86)	(1.00)	(0.86)
Village dummies	yes	yes	yes	yes
Durbin-Wu-Hausman: Chi-sq (3) [p-value]		10.428 [0.015]		1.586 [0.663]
Number of observations	1943	1943	1943	1943
R squared	0.0641	n.a	0.070	0.0619

Numbers in parentheses are absolute t values using robust standard errors using village clusters. Instruments are: indicators for the number of road projects completed interacted with years of schooling, average age and the number of household members aged 20-55 in 2007, and other exogenous variables.

Table A1 Road projects and working time

Dependent:	Change in months Nonagricultural	Change in days Agricultural
The number of road projects	-0.0295	-1.7147
	(0.12)	(0.42)
Average years of schooling	-0.4627	4.2634
	(1.57)	(1.99)
Years of schooling squared	0.0289	-0.2003
	(1.58)	(1.20)
Average age (age 20-55)	-0.0068	1.1178
	(0.13)	(2.67)
Household size (age20-55)	0.1281	0.1002
	(0.87)	(0.03)
Province dummies	yes	yes
Number of observations	2080	2080
R squared	0.0102	0.0193

Numbers in parentheses are absolute t values using robust standard errors using province clusters.