ESTIMATION OF THE IMPACT OF RURAL ROADS ON HOUSEHOLD WELFARE IN VIET NAM

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There is a consensus on the importance of rural roads when increasing economic growth and household welfare. However, little is known regarding the positive effect these roads will have on the welfare of households in Viet Nam. This paper aims to measure that effect. It is known that rural roads help households increase per capita income and working hours. The estimated impact of these roads on expenditure, the share of non-farm income, and children's schooling rate is not statistically significant.

JEL Classification: O12, O22, R20.

Key words: Rural roads, impact evaluation, household welfare, household survey, Viet Nam.

I. INTRODUCTION

Rural roads play a crucial role in the socio-economic development of rural areas (WB, 1994; Gannon and Liu, 1997; Lipton and Ravallion, 1995; Jalan and Ravallion, 2001). Jalan and Ravallion (2001) pointed out that rural roads are a necessary element for fostering rural income growth and reducing poverty. Rural roads can increase household income, including both farm and non-farm income. They increase agricultural productivity by reducing transportation costs, increasing access to advanced technology, increasing capital and enabling the employment of labour from outside local areas. Farmers also have better access to a greater number of markets, which facilitates the selling of goods. In addition, rural roads can also increase non-farm production and non-farm employment opportunities for local

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people. Increased income leads to an increase in consumption expenditure and a reduction in poverty. Additionally, rural roads result in an increased education level for children as the availability of a reliable road system reduces education costs and improves travel to and from schools.

There are several studies that measure the impact of roads on household welfare. Most find a positive connection between rural roads and non-farm income. Kwon (2000) found that in Indonesia economic growth has a larger effect on poverty reduction in areas with good roads. Roads are also found to have a positive effect on wage and employment. According to Balisacan and others (2002), roads have a remarkable direct and indirect effect on the welfare of the poor in the Philippines. Fan and others (2002) examined the effect of a variety of infrastructure projects on poverty reduction in China. They found that the effect of rural roads on poverty reduction is larger than the effect of other infrastructures. Other positive effects of roads on household income are found in Nicaragua and Peru (Corral and Reardon, 2001; Escobal, 2001).[1]

Viet Nam is a developing country with more than two-thirds of the population living in rural areas. Although Viet Nam is very successful in promoting economic growth and reducing poverty, poverty remains very high in rural areas, especially in the mountain regions. In 2006, 20 per cent of the poverty stricken population of Viet Nam lived in rural areas, while 36 per cent resided in the Northern mountainous regions (Viet Nam, 2006). State and international agencies work continuously to improve and maintain infrastructures, including roads. According to Donnges and others (2007), Viet Nam had a rural road network consisting of approximately 175,000 kilometres in 2007. Around 80 per cent of the population has access to an all-weather road (according to Viet Nam Household Living Standard Survey in 2006). This all-weather road can reach about 84 per cent of all rural cities and villages. In addition, nearly 54 per cent of provincial roads and 21 per cent of district roads are paved (Donnges and others, 2007).

The importance of rural roads in economic growth and household welfare is clear. However, there is little specific information regarding their impact upon household welfare in Viet Nam. Their impact on living standards is often mentioned in qualitative studies. Perhaps the two exceptions are Van de Walle and Cratty (2002) and Mu and Van de Walle (2007), who examined the effect of rural road rehabilitation projects on household welfares using data collected from the projects. They found that rural roads improve transportation to and from local markets in Viet Nam.

[1] A review on empirical studies of the impact of rural roads can be found in Ali and Pernia (2003).

This paper particularly investigates the impact of rural roads on household welfare in Viet Nam. Welfare indicators include household income and consumption expenditure, working effort, non-farm income and the education rate and level of children. Unlike Van de Walle and Cratty (2002) and Mu and Van de Walle (2007), who measured the effect of specific road projects, this paper examines the effect of roads in rural Viet Nam using nationally representative data from Viet Nam Household Living Standard Surveys (VHLSSs) of 2004 and 2006. Therefore, estimates can be representative for the rural areas. In addition, the data sets used in this study are more recent than those used by Van de Walle and Cratty (2002) and by Mu and Van de Walle (2007) (who used data surveys before 2000). The condition and effect of a road system can change remarkably over time. Therefore, more recent data are required for capturing the current effect of rural roads. Two estimation methods employed in this study include fixed-effect regressions and difference-in-differences with propensity score matching, using panel data from VHLSSs 2004 and 2006.

The paper is structured into six sections. Section II introduces the data sets that were used in this analysis. Section III presents the definition of rural roads and discusses their availability in Viet Nam. Section IV presents estimation methods. Estimation results are presented in section V, showing the impact assessment of rural roads on household welfare. Finally, section VI provides the paper's conclusion.

II. DATA SOURCE

This study relies on data from the Viet Nam Household Living Standard Surveys (VHLSSs) conducted in 2004 and 2006 by the General Statistics Office (GSO) of Viet Nam. The surveys contain household data which include basic demography, employment and labour force participation, education, health, income, expenditure, housing, fixed assets and durable goods, participation of households in poverty alleviation programs, and especially information on access to different sources of water for drinking and daily use. The surveys also contain commune data, which consist of demography and general situation of communes, general economic conditions and aid programs, non-farm employment, agriculture production, local infrastructure and transportation, education, health, and social affairs. Commune data can be merged with household data.

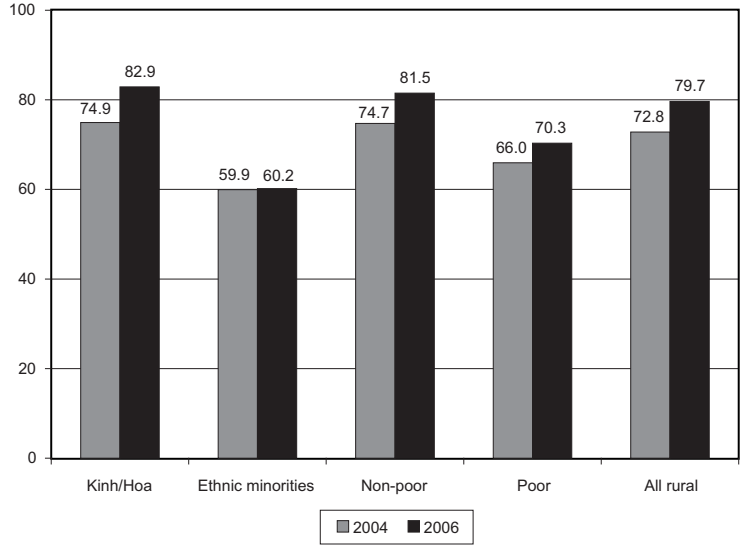
The samples of the 2004 and 2006 VHLSSs covered 9,188 and 9,189 households respectively. Information on commune characteristics was collected from 2,181 rural communes and was representative of the urban and rural areas of eight regions. The two surveys set up a panel data set of 4,216 households. This paper focuses on 3,204 of those households, which belong to 1,068 communes. It should be noted that in VHLSS, each village is sampled from each commune.

Therefore, the number of villages in this sample is also 1,068, and there are 3 households per village.

III. RURAL ROADS IN VIET NAM

Viet Nam has a highly dense population. The country is approximately 331,688 square kilometres in size, but had a population of nearly 86 million in 2009. Currently, Viet Nam is divided into 63 provinces, with each province further divided into districts. Smaller administrative units are called communes and villages. In 2009, there were 685 districts, 10,987 communes, and 125,710 villages. The average population of a village is around 685. In 2006, 97 per cent of rural communes contained an internal road that was passable by cars. However, the proportion of villages that could be reached by cars, in other words, having a connecting road that was passable by cars was lower. The proportion of households living in rural villages with a road which could be driven year round was 72.8 per cent in 2004 and 79.7 per cent in 2006 (see figure 1).[2]

Figure 1. Percentage of households living in villages with a good road



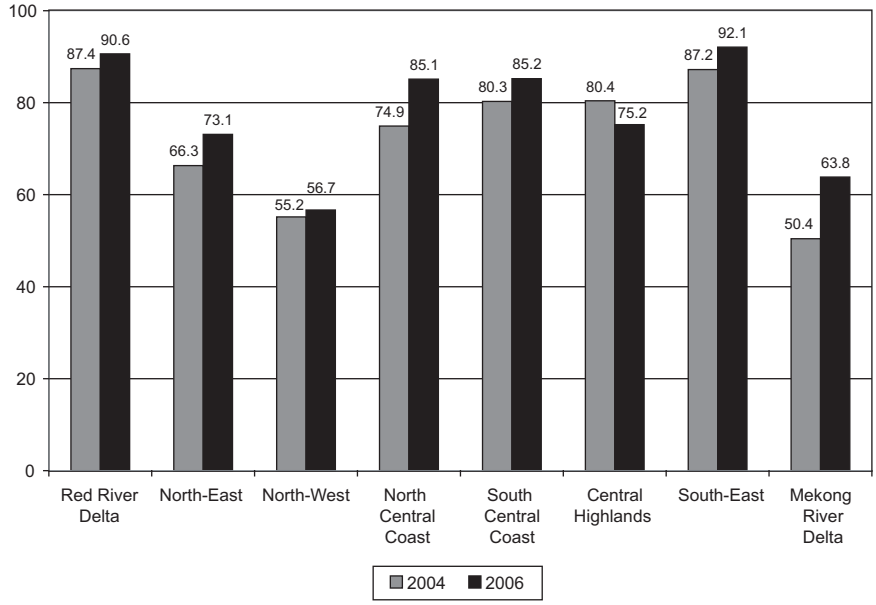
Source: Author's estimation from VHLSSs 2004 and 2006.

[2] In the VHLSSs, there is a question: 'For how many months during the past year was the road passable by cars?' The answers are coded from 1 month to 12 months. In this study, we define a village having a good road if the road is passable for 12 months.

Although the proportion of people living in a village with a good road increased between 2004-2006, there was still a large disparity in accessing a road between different groups (figure 1). In 2006, the proportion of households living in a village with access to a good road was 82.9 per cent for Kinh and Hoa and 60.2 per cent for ethnic minorities. The figure for the non-poor and the poor was 81.5 per cent and 70.3 per cent respectively. It should be noted that while the percentage of people accessing a road in villages increases for all household groups, the difference between the poor and the non-poor as well as the Kinh/Hoa and ethnic minority households tended to be larger between 2004 and 2006.

The proportion of households living in villages with roads varies spatially (figure 2), and the percentage of households living in a village with a passable road is much lower in the mountainous regions such as the North-East and the North-West than in delta regions such as the Red River Delta and the South-East.

Figure 2. Percentage of households living in villages with a good road by regions



Source: Author's estimation from VHLSSs 2004 and 2006.

IV. ESTIMATION METHOD

In this study, we use two methods to estimate the effect of rural roads on household welfare. This section describes these methods.

Fixed-effects regression

We use a similar specification for estimating the effect of rural roads on per capita income, per capita expenditure, work efforts, the share of non-farm income, and on children's education enrollment:

$$Y_{ijt} = \beta_0 + X_{ijt}\beta_1 + D_{jt}\beta_2 + C_{jt}\beta_3 + u_{ij} + v_j + \varepsilon_{ijt}, \qquad t = 1, 2 \tag{1}$$

Where Y is a vector including income per capita, expenditure per capita, and other household welfare indicators, the subscripts i, j and t refer to household i in village j at time t respectively. X is a vector of household variables. D is a dummy variable indicating whether a village has a good road. C is a vector of control variables with village characteristics. u_{ij} and v_j are unobserved time-invariant household and village characteristics respectively. ε_{ijt} is an error term. The summary statistics of dependent and independent variables is presented in annex tables A.1 and A.2. The impact of availability of a rural road in a village on household welfare is measured by β_2.

A common problem during an impact evaluation of rural households is the endogeneity of roads (Van de Walle, 2002). Households in an area with a large number of roads obviously have better conditions. It is more difficult to separate the effect of rural roads from the effect of other unobserved simultaneous factors at work. Technically, unobserved variables in regressions are correlated with rural roads. A standard method to deal with the endogeneity is instrumental variables regression. However, finding a valid instrument which is correlated with rural roads but not household welfare is a difficult task. We tried a variable of historic road network as the instrument for current rural roads, but this instrument does not work. Therefore, in this study we use fixed-effects regressions to estimate equation number 1. In fixed-effects regressions, the time invariant household and commune characteristics, including u_{ij} and v_j which are correlated with the rural road, are dropped from the model. It is expected that unobserved variables which are time-variant are not correlated with rural roads in the household welfare equation.

Time-invariant observed variables, like regional dummies, are also removed in fixed-effects regressions. To control time-invariant variables, we can interact these time-invariant observed variables with other time-variant observed variables and control these interactions in the fixed-effects regression.

Difference-in-differences with propensity score matching

In addition to the fixed-effects regrssions, we also used the difference-in-differences with propensity score matching. This method is ideally applied to evaluate the impact of a program when we have data on the treatment and control before and after the program implementation. For the impact of rural roads, the 2004 VHLSS was not clean baseline data since there were many households living in villages with a good road in 2004. In addition, there were a number of households in a village in which there was a good road in 2004 but not in 2006 due to the deterioration of road quality. To apply the difference-in-differences estimator, we limited our sample to households who lived in a village without a good road in 2004. This sample consisted of 686 households, of these households there were 281 households living in villages with a good road in 2006 and 405 households living in villages without a good road in 2006. The 281 households set up the treatment group, while the 405 households set up the control group.

These control and treatment groups can be used to measure the effect of rural roads. The difference-in-differences estimator can be expressed as follows:

$$\hat{ATT} = \left(\bar{Y}_T^{2006} - \bar{Y}_C^{2006}\right) - \left(\bar{Y}_T^{2004} - \bar{Y}_C^{2004}\right), \quad (2)$$

where $\bar{Y}_T^{2004}$ and $\bar{Y}_C^{2004}$ is the mean of a welfare indicator of interest of the treatment group (households living in villages with a good road in 2006) and the control group (households living in villages without a good road in 2006) in the year 2004 respectively. $\bar{Y}_T^{2006}$ and $\bar{Y}_C^{2006}$ are the welfare means of the treatment group and the control group in 2006 respectively.

The above parameter of the program impact is Average Treatment Effect on the Treated, which is most popular parameter in impact evaluation (Heckman and others, 1999). This is the expected impact of the rural roads on the treatment group. To remove the difference in welfare between the treatment and control groups, due to observed variables, we combined the difference-in-differences estimator with propensity score matching. The control group was constructed in a way so that it is similar to the treatment group. In order to construct a comparison group that was similar to the treatment group in observed characteristics, matched each household in the treatment group (participants) with households in the control group (non-participants) based on the similarity of observed characteristics. There were a large number of characteristic variables and finding “close” non-participants to match with a participant was not straightforward. A widely-used way to find the matched sample is the propensity score matching, which is the probability of being assigned into the program (Rosenbaum and Rubin, 1983). In this study, the matching based on the

propensity score is proposed to be employed.[3] The propensity score is often estimated using a probit or logit regression. Once the scores are estimated, participants are matched with non-participants according to the closeness of estimated scores. Standard errors of the estimator given by equation (2) can be estimated using bootstrap.

Compared with the fixed-effects regressions, the difference-in-differences with propensity score matching has an advantage in that it does not rely on the assumption of the functional form of welfare outcomes. However, in this study since we restricted our sample when using the difference-in-differences with propensity score matching, estimates from this method should be interpreted for this restricted sample, not for the entire population.

V. ESTIMATION RESULTS

Table 1 presents the coefficient of rural roads in regressions of different household welfare indicators. Four models were used: ordinary least squares (OLS), random-effects, fixed-effects without and fixed-effects with interactions between regional dummies and household demographic variables. OLS and random-effects models are presented for comparison and examination of potential biases caused by unobserved time-invariant variables. For income and expenditure, in addition to linear models presented by equation number 1, we also use semi-log functions. Table 1 reports only the estimates of rural roads, and the full regressions are reported in annex tables A.3 to A.9.

It shows that rural roads have a positive effect on household income. The estimates of the impact on income are quite similar in different models. According to fixed-effect linear regression with interactions, rural roads increase per capita income by around VND[4] 858,000. The fixed-effect regressions log of per capita income indicates an increase of approximately 8.8 per cent. It should be noted that income and expenditure of 2004 are adjusted to reflect those of 2006.

The impact on per capita expenditure is positive, but not statistically significant in fixed-effect regressions. The point estimate of the impact on expenditure is much lower than the estimate on income. It implies that rural roads have positive effects on households' investment and saving. In addition, expenditure is less fluctuated than income. Houeseholds with low income still have to keep

[3] Other matching methods can be subclassification (see, e.g., Cochran and Chambers, 1965; Cochran, 1968) and covariate matching (Rubin, 1978; 1979).

4 Viet Nam Dong.

consumption expenditure at a sufficient level. Thus, rural roads can have a minimal impact on expenditure.

Households in a village with a good road are more likely to have higher working hours per person than those without one. Although the effect estimated at around 37 hour per person per year is small, it implies the importance of rural roads in increasing employment. The effect of rural roads on the share of non-farm income in total household income and the schooling rate of children between the ages of 6 and 17 is not statistically significant.

Table 1. The estimates of the impact of rural using regressions

Dependent variables (outcome variables)	Regression models			
	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Per capita income (thousand VND)	527.6***	666.3***	867.2***	858.0***
	[189.4]	[183.7]	[273.8]	[278.4]
Log of per capita income (thousand VND)	0.091***	0.100***	0.091***	0.088***
	[0.019]	[0.017]	[0.021]	[0.021]
Per capita expenditure (thousand VND)	227.3***	228.9***	205.4	214.4
	[86.6]	[82.9]	[144.0]	[146.8]
Log of per capita expenditure (thousand VND)	0.056***	0.042***	0.014	0.014
	[0.016]	[0.014]	[0.019]	[0.019]
Annual working hours per capita	40.28***	38.02***	34.34*	37.13**
	[14.02]	[13.76]	[18.69]	[18.84]
The share of non-farm income	0.040***	0.023***	0.004	0.002
	[0.010]	[0.009]	[0.010]	[0.010]
Proportion of children attending school	0.010	0.001	0.002	-0.025
	[0.011]	[0.011]	[0.020]	[0.020]

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: In fixed-effects models with interactions, we interacted regional dummies with three demographic variables of households, including size, proportion of members under 16 and proportion of members over 60. There are 21 interaction terms controlled in the fixed-effects models.

Income and expenditure data of the 2004 VHLSS are deflated to the 2006 price for comparison.

Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

As mentioned in section III, most communes have a road which leads to the commune center. The impact of a village road can depend on the closeness of a village to its commune road. In the VHLSS, we did not have data on the distance. Although the distance between village and commune road can increase or mitigate the actual effect of the road, it does not make our estimate biased as the distance from village to commune road is assumed to be fixed during the time of the study, 2004 to 2006, and can therefore be eliminated by the fixed-effects regressions.

The second method to measure the impact of rural roads is the difference-in-differences with propensity score matching. The first step is to predict a propensity score using a probit regression. Annex table A.10 presents this regression. The dependent variable is a binary one indicating whether or not a household lived in a village with a good road in 2006. The explanatory variables are the characteristics of households in 2004. The estimated propensity score is presented in annex figure A.1, which indicates a large common support between the treatment and control groups. It means that we were able to select similar households from the control group to match households in the treatment group.

The second step is to construct the control group. Depending on the number of non-participants matched with participants, there can be nearest-neighbours matching and kernel matching. Since standard errors computed by bootstrap can be invalid for the nearest-neighbours macthing (Abadie and Imbens, 2006), we used kernel matching with a bandwidth of 0.05. Kernel matching, using other bandwidths such as 0.01 and 0.03, produces similar estimates, but they are not represented here. Table 2 presents the estimates from the difference-in-differences with propensity score matching. It shows very similar estimates as the fixed-effects regressions. Living in a village with a good road can increase household income and working hours. The effect on consumption and child education is positive, but not statistically significant.

VI. CONCLUSIONS

Viet Nam has achieved remarkable economic growth and poverty reduction over the past 20 years, with the average annual rate of economic growth of approximately 7 per cent. The poverty rate decreased from 58 per cent in 1993 to 37 per cent in 1998 and then to 16 per cent in 2006. Household living standards have been also steadily improved. Infrastructures, especially roads, have been playing important roles in increasing household welfare in Viet Nam. Using VHLSS data, this paper makes an effort to estimate the impact of rural roads on household welfare and shows that they have a positive effect on household income. Rural roads increase per capita income by around VND 858,000, or equivalently 8.8 per cent of mean

Table 2. The estimates of the impact of rural using diffference-in-differences with propensity score matching (kernel matching with bandwidth of 0.05)

Dependent variables (outcome variables)	2004			2006			Diff-in-diff
	Treatment	Control	Diff	Treatment	Control	Diff	
	(1)	(2)	(3)=(1)-(2)	(4)	(5)	(6)=(4)-(5)	(7)=(6)-(3)
Per capita income (thousand VND)	5 619.0*** [306.9]	4 758.4*** [176.4]	860.6** [347.8]	7 454.0*** [552.6]	5 739.5*** [210.0]	1 714.6*** [568.4]	854.0** [422.6]
Per capita expenditure (thousand VND)	4 032.9*** [169.5]	3 327.3*** [112.8]	705.6*** [211.4]	4 770.1*** [214.8]	3 862.9*** [104.1]	907.1*** [364.4]	201.5 [140.6]
Annual working hours per capita	865.4*** [26.7]	946.0*** [30.7]	-80.6* [43.1]	912.3*** [30.3]	919.6*** [29.7]	-7.3 [45.2]	73.3* [42.1]
The share of non-farm income	0.316*** [0.019]	0.326*** [0.019]	-0.010 [0.023]	0.321*** [0.018]	0.333*** [0.019]	-0.011 [0.021]	-0.001 [0.019]
Proportion of children attending school	0.484*** [0.030]	0.475*** [0.029]	0.010 [0.020]	0.451*** [0.029]	0.439*** [0.029]	0.011 [0.022]	0.002 [0.014]

Notes: (i) Income and expenditure data of the 2004 VHLSS are deflated to the 2006 price for comparison.
(ii) Standard errors are indicated by brackets and are calculated using bootstrap with 500 replications.
* significant at 10%; ** significant at 5%; *** significant at 1%.

income. However, the impact on per capita expenditure is much lower. The estimated amount is positive, but not statistically significant in fixed-effect regressions. It implies that rural roads have positive effects on households' investment and saving. It is interesting that households living in a village with a good road are more likely to have longer working hours per person than households living in a village without a rural road. The effects of rural roads on the percentage of non-farm income or level of education in total household income are not statistically significant.

The findings suggest several policy implications for Viet Nam. As noted, rural roads are an important factor for economic growth. At the household level they increase employment and income. Thus, policies geared towards improving household access to these roads are important. However, at least in the short-term a rural road policy is not effective in reducing poverty if said poverty is measured based on a consumption indicator. Finally, roads are not effective at increasing the share of non-farm income and the level of education. The implication is that improving rural roads simply increases access of people to public services and markets. Improving rural roads alone is not enough as other infrastructres, such as markets and schools, need to be upgraded.

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APPENDIX

Annex table A.1. Summary statistics of variables in 2004

Variable	Type	Households living in a village with good road		Households living in a village without good road	
		Mean	Std. Dev.	Mean	Std. Dev.
Per capita income (thousand VND)	Continuous	5 892.3	4 983.9	5 382.4	4 744.3
Per capita expenditure (thousand VND)	Continuous	4 231.8	2 709.8	3 846.0	2 756.8
Annual working hours per capita	Continuous	923.1	507.3	868.5	462.6
Proportion of non-farm income	Continuous	0.3859	0.3197	0.3120	0.3200
Proportion of children attending school	Continuous	0.5246	0.4920	0.5395	0.4850
Household size	Continuous	4.3487	1.6931	4.6653	1.8194
Proportion of members under 16	Continuous	0.2553	0.2192	0.2688	0.2147
Proportion of members over 60	Continuous	0.1262	0.2578	0.1083	0.2285
Proportion of members having technical diploma	Continuous	0.0524	0.1386	0.0312	0.1146
Proportion of members having post-secondary diploma	Continuous	0.0157	0.0785	0.0080	0.0553
Annual crop land (10 000m^2)	Continuous	0.3581	0.6324	0.5416	0.8524
Perennial crop land (10 000m^2)	Continuous	0.1281	0.6440	0.1159	0.5298
Forestry crop land (10 000m^2)	Continuous	0.0955	0.6055	0.2776	2.0903
Water surface (10 000m^2)	Continuous	0.0134	0.1255	0.0717	0.3794
Living in a village with market	Dummy	2.5283	4.4057	4.3043	8.7499
Red River Delta	Dummy	0.2700	0.4441	0.0903	0.2868
North-East	Dummy	0.1441	0.3512	0.1817	0.3858
North-West	Dummy	0.0354	0.1847	0.0850	0.2791
North Central Coast	Dummy	0.1233	0.3288	0.1360	0.3430
South Central Coast	Dummy	0.0990	0.2987	0.0584	0.2347
Central Highlands	Dummy	0.0645	0.2457	0.0393	0.1945
South-East	Dummy	0.1140	0.3179	0.0436	0.2042
Mekong River Delta	Dummy	0.1498	0.3570	0.3656	0.4818
Number of observations		2 263		941	

Source: Author's estimation from VHLSSs 2004 and 2006.

Note: Income and expenditure data of the 2004 VHLSS are deflated to the 2006 price for comparison.

Annex table A.2. Summary statistics of variables in 2006

Variable	Type	Households living in a village with good road		Households living in a village without good road	
		Mean	Std. Dev.	Mean	Std. Dev.
Per capita income (thousand VND)	Continuous	7 383.2	7 209.3	6 407.9	5 461.9
Per capita expenditure (thousand VND)	Continuous	4 917.9	3 042.9	4 268.3	2 652.0
Annual working hours per capita	Continuous	947.2	530.5	894.6	517.8
Proportion of non-farm income	Continuous	0.4048	0.3326	0.2959	0.3072
Proportion of children attending school	Continuous	0.4841	0.4946	0.4770	0.4868
Household size	Continuous	4.2343	1.6534	4.6657	1.9128
Proportion of members under 16	Continuous	0.2237	0.2106	0.2459	0.2150
Proportion of members over 60	Continuous	0.1346	0.2666	0.1208	0.2417
Proportion of members having technical diploma	Continuous	0.0561	0.1438	0.0333	0.1150
Proportion of members having post-secondary diploma	Continuous	0.0160	0.0802	0.0107	0.0719
Annual crop land (10 000m^2)	Continuous	0.3765	0.7608	0.6339	0.9231
Perennial crop land (10 000m^2)	Continuous	0.1322	0.5624	0.1588	0.6150
Forestry crop land (10 000m^2)	Continuous	0.1478	1.3430	0.3138	2.0670
Water surface (10 000m^2)	Continuous	0.0252	0.3463	0.0750	0.3942
Living in a village with market	Dummy	2.5423	4.3902	5.8114	12.9226
Red River Delta	Dummy	0.2535	0.4351	0.0882	0.2838
North-East	Dummy	0.1431	0.3503	0.1977	0.3986
North-West	Dummy	0.0340	0.1812	0.1067	0.3089
North Central Coast	Dummy	0.1379	0.3449	0.0882	0.2838
South Central Coast	Dummy	0.0952	0.2935	0.0583	0.2345
Central Highlands	Dummy	0.0560	0.2299	0.0612	0.2398
South-East	Dummy	0.1100	0.3129	0.0341	0.1817
Mekong River Delta	Dummy	0.1703	0.3760	0.3656	0.4819
Number of observations		501		703	

Source: Author's estimation from VHLSSs 2004 and 2006.

Note: Income and expenditure data of the 2004 VHLSS are deflated to the 2006 price for comparison.

Annex table A.3. Regressions of per capita income (thousand VND)

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	527.6***	666.3***	867.2***	858.0***
	[189.4]	[183.7]	[273.8]	[278.4]
Proportion of members under 16	-2 242.8***	-2 196.9***	-521.4	7 127.70
	[356.6]	[394.5]	[1 067.6]	[6 778.3]
Proportion of members over 60	-2 185.0***	-2,180.6***	-1 445.2*	28 494.6**
	[299.8]	[343.4]	[857.0]	[13 281.2]
Household size	-885.4***	-1 009.1***	-1 592.3***	-1 413.6**
	[130.5]	[142.3]	[270.5]	[588.4]
Household size squared	24.9**	34.3***	78.0***	98.6***
	[11.5]	[12.5]	[20.2]	[29.6]
Proportion of members having a technical diploma	7 904.3***	6 707.9***	2 827.7***	2 696.5***
	[503.2]	[516.4]	[937.9]	[956.2]
Proportion of members having post-secondary diploma	15 147.6***	12 625.1***	3 021.70	3 048.50
	[879.9]	[933.3]	[2 934.1]	[2 956.7]
Annual crop land (10 000 m^2)	1 524.6***	1 548.3***	1 776.1***	1 818.2***
	[93.8]	[103.0]	[478.5]	[492.4]
Perennial crop land (10 000 m^2)	1 792.4***	1 407.7***	-95.5	-53
	[116.6]	[123.6]	[570.7]	[583.3]
Forestry crop land (10 000 m^2)	113.1**	107.2**	94.9	100.3
	[48.1]	[49.1]	[112.2]	[114.5]
Water surface (10 000 m^2)	1 659.3***	1 450.6***	856.1***	864.4***
	[222.0]	[216.8]	[266.9]	[278.6]
Living in a village with market	-54.1***	-36.5***	-9.5	-8.7
	[10.7]	[10.1]	[7.0]	[7.3]
Red River Delta	Omitted			
North-East	-800.7***	-834.2***		
	[227.9]	[274.8]		
North-West	-2 574.8***	-2 820.2***		
	[356.8]	[426.5]		
North Central Coast	-947.0***	-1 001.3***		
	[235.6]	[286.4]		
South Central Coast	-635.3**	-660.0**		
	[266.4]	[324.3]		
Central Highlands	-1 020.4***	-897.2**		
	[331.2]	[398.6]		

Annex table A.3. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	1 316.5*** [264.2]	1 439.5*** [320.5]		
Mekong River Delta	742.6*** [215.3]	753.5*** [257.5]		
Time dummy (2006 = 1)	1 151.8*** [132.9]	1 151.0*** [97.8]	1 209.8*** [109.1]	1 195.1*** [108.4]
Interactions between regions and household characteristics	No	No	No	Yes
Constant	8 416.6*** [418.4]	8 715.0*** [453.7]	9 897.8*** [740.7]	9 703.6*** [784.1]
Observations	6 408	6 408	6 408	6 408
R-squared	0.23	0.23	0.11	0.12
Number of households	3 204	3 204	3 204	3 204

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.4. Regressions of log of per capita income

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	0.091***	0.100***	0.091***	0.088***
	[0.019]	[0.017]	[0.021]	[0.021]
Proportion of members under 16	-0.561***	-0.506***	-0.202***	1.09
	[0.035]	[0.039]	[0.077]	[0.983]
Proportion of members over 60	-0.324***	-0.319***	-0.228**	2.329
	[0.030]	[0.034]	[0.101]	[1.776]
Household size	-0.068***	-0.100***	-0.187***	-0.197***
	[0.013]	[0.014]	[0.029]	[0.054]
Household size squared	-0.001	0.001	0.008***	0.011***
	[0.001]	[0.001]	[0.002]	[0.003]
Proportion of members having a technical diploma	1.003***	0.787***	0.330***	0.321***
	[0.050]	[0.049]	[0.068]	[0.070]
Proportion of members having post-secondary diploma	1.509***	1.234***	0.476***	0.481***
	[0.087]	[0.090]	[0.136]	[0.140]
Annual crop land (10 000 m^2)	0.120***	0.127***	0.154***	0.154***
	[0.009]	[0.010]	[0.017]	[0.017]
Perennial crop land (10 000 m^2)	0.147***	0.118***	0.041**	0.044**
	[0.012]	[0.012]	[0.019]	[0.019]
Forestry crop land (10 000 m^2)	0.013***	0.009*	0.005	0.006
	[0.005]	[0.005]	[0.008]	[0.008]
Water surface (10 000 m^2)	0.181***	0.145***	0.089**	0.089**
	[0.022]	[0.020]	[0.036]	[0.037]
Living in a village with market	-0.009***	-0.005***	-0.001	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]
Red River Delta	Omitted			
North-East	-0.092***	-0.106***		
	[0.023]	[0.028]		
North-West	-0.432***	-0.489***		
	[0.035]	[0.043]		
North Central Coast	-0.164***	-0.177***		
	[0.023]	[0.029]		
South Central Coast	-0.089***	-0.098***		
	[0.026]	[0.033]		
Central Highlands	-0.064*	-0.077*		
	[0.033]	[0.041]		

Annex table A.4. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	0.170*** [0.026]	0.175*** [0.033]		
Mekong River Delta	0.124*** [0.021]	0.118*** [0.026]		
Time dummy (2006 = 1)	0.171*** [0.013]	0.172*** [0.009]	0.177*** [0.009]	0.177*** [0.009]
Interactions between regions and household characteristics	No	No	No	Yes
Constant	8.789*** [0.041]	8.867*** [0.044]	9.025*** [0.081]	8.983*** [0.085]
Observations	6 407	6 407	6 407	6 407
R-squared	0.34	0.34	0.23	0.24
Number of households	3 204	3 204	3 204	3 204

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.5. Regressions of per capita expenditure (thousand VND)

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	227.3***	228.9***	205.4	214.4
	[86.6]	[82.9]	[144.0]	[146.8]
Proportion of members under 16	-2 462.5***	-2 321.9***	-1 182.8***	3 675.60
	[163.0]	[180.5]	[324.1]	[2 655.9]
Proportion of members over 60	-871.1***	-910.1***	-786.4	13 126.6*
	[137.1]	[157.8]	[530.4]	[7 182.1]
Household size	-451.5***	-554.2***	-931.9***	-982.8***
	[59.7]	[65.0]	[162.3]	[306.2]
Household size squared	14.0***	20.5***	42.6***	49.6***
	[5.3]	[5.7]	[13.2]	[13.9]
Proportion of members having technical diploma	4 664.4***	3 545.8***	539.3	475.8
	[230.0]	[234.4]	[448.8]	[446.9]
Proportion of members having post-secondary diploma	7 621.0***	6 173.9***	878.8	845.8
	[402.2]	[425.0]	[1 341.7]	[1 275.8]
Annual crop land (10 000 m^2)	283.5***	258.1***	181.0**	169.3*
	[42.9]	[47.1]	[86.6]	[88.5]
Perennial crop land (10 000 m^2)	435.8***	419.5***	326.3***	318.5***
	[53.3]	[56.3]	[90.1]	[89.8]
Forestry crop land (10 000 m^2)	1.1	-15.9	-51.6***	-50.7**
	[22.0]	[22.3]	[18.7]	[21.2]
Water surface (10 000 m^2)	458.2***	341.9***	103.4	150
	[101.5]	[97.9]	[201.5]	[177.4]
Living in a village with market	-28.6***	-16.9***	-3.1	-0.9
	[4.9]	[4.6]	[3.5]	[3.6]
Red River Delta	Omitted			
North-East	-428.6***	-475.6***		
	[104.2]	[127.2]		
North-West	-1 052.9***	-1 205.2***		
	[163.1]	[197.2]		
North Central Coast	-470.2***	-524.8***		
	[107.7]	[132.7]		
South Central Coast	74.8	34.3		
	[121.8]	[150.2]		
Central Highlands	-36.5	-119.5		
	[151.4]	[184.4]		

Annex table A.5. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	1 285.1***	1 268.2***		
	[120.8]	[148.4]		
Mekong River Delta	722.6***	677.0***		
	[98.4]	[119.1]		
Time dummy (2006 = 1)	496.1***	502.9***	531.4***	538.1***
	[60.8]	[43.4]	[48.1]	[48.5]
Interactions between regions and household characteristics	No	No	No	Yes
Constant	5 851.9***	6 222.7***	7 455.7***	7 200.7***
	[191.3]	[207.4]	[490.6]	[527.7]
Observations	6 408	6 408	6 408	6 408
R-squared	0.30	0.29	0.12	0.05
Number of households	3 204	3 204	3 204	3 204

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.6. Regressions of log of per capita expenditure

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	0.056***	0.042***	0.014	0.014
	[0.016]	[0.014]	[0.019]	[0.019]
Proportion of members under 16	-0.609***	-0.556***	-0.324***	0.753
	[0.030]	[0.032]	[0.056]	[0.539]
Proportion of members over 60	-0.222***	-0.219***	-0.169**	1.966
	[0.025]	[0.029]	[0.075]	[2.069]
Household size	-0.053***	-0.079***	-0.135***	-0.174***
	[0.011]	[0.012]	[0.024]	[0.052]
Household size squared	-0.001	0.000	0.004*	0.006***
	[0.001]	[0.001]	[0.002]	[0.002]
Proportion of members having technical diploma	0.843***	0.566***	0.077	0.071
	[0.042]	[0.041]	[0.062]	[0.063]
Proportion of members having post-secondary diploma	1.226***	0.870***	0.074	0.052
	[0.073]	[0.075]	[0.135]	[0.128]
Annual crop land (10 000 m^2)	0.053***	0.051***	0.053***	0.051***
	[0.008]	[0.008]	[0.014]	[0.015]
Perennial crop land (10 000 m^2)	0.095***	0.082***	0.054***	0.053***
	[0.010]	[0.010]	[0.013]	[0.014]
Forestry crop land (10 000 m^2)	0.002	-0.005	-0.013***	-0.012***
	[0.004]	[0.004]	[0.003]	[0.004]
Water surface (10 000 m^2)	0.096***	0.062***	0.018	0.024
	[0.019]	[0.017]	[0.026]	[0.024]
Living in a village with market	-0.009***	-0.004***	0	0.001
	[0.001]	[0.001]	[0.001]	[0.001]
Red River Delta	Omitted			
North-East	-0.137***	-0.157***		
	[0.019]	[0.024]		
North-West	-0.405***	-0.469***		
	[0.030]	[0.037]		
North Central Coast	-0.153***	-0.170***		
	[0.020]	[0.025]		
South Central Coast	-0.044**	-0.056*		
	[0.022]	[0.029]		
Central Highlands	-0.108***	-0.133***		
	[0.028]	[0.035]		

Annex table A.6. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	0.186*** [0.022]	0.185*** [0.028]		
Mekong River Delta	0.112*** [0.018]	0.096*** [0.022]		
Time dummy (2006 = 1)	0.123*** [0.011]	0.125*** [0.007]	0.130*** [0.007]	0.130*** [0.007]
Interactions between regions and households characteristics	No	No	No	Yes
Constant	8.533*** [0.035]	8.629*** [0.037]	8.757*** [0.070]	8.710*** [0.072]
Observations	6 408	6 408	6 408	6 408
R-squared	0.38	0.36	0.19	0.11
Number of households	3 204	3 204	3 204	3 204

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.7. Regressions of annual working hours per capita

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	40.28***	38.02***	34.34*	37.13**
	[14.02]	[13.76]	[18.69]	[18.84]
Proportion of members under 16	-881.6***	-852.8***	-719.9***	-414.40
	[26.401]	[29.075]	[63.226]	[839.42]
Proportion of members over 60	-1 342.3***	-1 337.7***	-1 338.4***	1 148.69
	[22.196]	[25.177]	[86.393]	[1 913.6]
Household size	-37.39***	-41.70***	-59.308**	-109.56*
	[9.660]	[10.508]	[26.404]	[62.564]
Household size squared	1.247	1.546*	2.984	5.003*
	[0.852]	[0.923]	[2.089]	[2.841]
Proportion of members having technical diploma	75.985**	98.613**	173.734***	156.021**
	[37.251]	[38.437]	[65.082]	[65.494]
Proportion of members having post-secondary diploma	212.08***	256.81***	461.027**	434.952**
	[65.138]	[69.181]	[200.812]	[193.530]
Annual crop land (10 000 m^2)	-18.945***	-16.449**	2.225	-3.178
	[6.943]	[7.595]	[16.086]	[16.858]
Perennial crop land (10 000 m^2)	-7.613	-2.059	27.789**	25.863*
	[8.634]	[9.166]	[12.870]	[13.469]
Forestry crop land (10 000 m^2)	-1.483	0.132	8.841	10.121
	[3.558]	[3.655]	[6.984]	[6.808]
Water surface (10 000 m^2)	-1.651	22.280	77.400***	74.405***
	[16.434]	[16.232]	[27.350]	[28.738]
Living in a village with market	-1.522*	-1.223	-0.389	-0.326
	[0.794]	[0.762]	[1.074]	[1.098]
Red River Delta	Omitted			
North-East	77.163***	74.054***		
	[16.871]	[19.984]		
North-West	41.188	34.568		
	[26.415]	[31.045]		
North Central Coast	-60.084***	-61.001***		
	[17.439]	[20.807]		
South Central Coast	-54.799***	-56.339**		
	[19.726]	[23.555]		
Central Highlands	11.369	4.205		
	[24.521]	[28.997]		

Annex table A.7. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	58.875***	56.229**		
	[19.561]	[23.287]		
Mekong River Delta	-72.26***	-74.99***		
	[15.94]	[18.74]		
Time dummy (2006 = 1)	10.212	10.479	9.889	12.104
	[9.840]	[7.506]	[8.234]	[8.370]
Interactions between regions and household characteristics	No	No	No	Yes
Constant	1 418.4***	1 421.6***	1 404.4***	1 457.6***
	[30.972]	[33.487]	[82.036]	[95.273]
Observations	6 408	6 408	6 408	6 408
R-squared	0.42	0.42	0.4	0.18
Number of households	3 204	3 204	3 204	3 204

Source: Author's estimation from VHLSSs 2004 and 2006

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.8. Regressions of the share of non-farm income

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	0.040***	0.023***	0.004	0.002
	[0.010]	[0.009]	[0.010]	[0.010]
Proportion of members under 16	0.009	-0.029	-0.106***	-0.308
	[0.019]	[0.020]	[0.037]	[0.238]
Proportion of members over 60	-0.267***	-0.246***	-0.184***	-0.982
	[0.016]	[0.018]	[0.045]	[0.714]
Household size	0.059***	0.071***	0.106***	0.028
	[0.007]	[0.007]	[0.013]	[0.023]
Household size squared	-0.003***	-0.004***	-0.006***	-0.006***
	[0.001]	[0.001]	[0.001]	[0.001]
Proportion of members having technical diploma	0.204***	0.154***	0.083**	0.077*
	[0.027]	[0.025]	[0.041]	[0.040]
Proportion of members having post-secondary diploma	0.457***	0.382***	0.235***	0.235***
	[0.047]	[0.046]	[0.077]	[0.077]
Annual crop land (10 000 m^2)	-0.116***	-0.094***	-0.038***	-0.038***
	[0.005]	[0.005]	[0.010]	[0.011]
Perennial crop land (10 000 m^2)	-0.071***	-0.054***	-0.021**	-0.021**
	[0.006]	[0.006]	[0.009]	[0.009]
Forestry crop land (10 000 m^2)	-0.012***	-0.009***	-0.003*	-0.004**
	[0.003]	[0.002]	[0.002]	[0.002]
Water surface (10 000 m^2)	-0.092***	-0.055***	-0.019***	-0.024***
	[0.012]	[0.010]	[0.007]	[0.008]
Living in a village with market	-0.004***	-0.003***	-0.001**	-0.001**
	[0.001]	[0.000]	[0.000]	[0.000]
Red River Delta	Omitted			
North-East	-0.096***	-0.114***		
	[0.012]	[0.015]		
North-West	-0.091***	-0.138***		
	[0.019]	[0.024]		
North Central Coast	-0.081***	-0.089***		
	[0.013]	[0.016]		
South Central Coast	0.099***	0.092***		
	[0.014]	[0.018]		
Central Highlands	-0.057***	-0.091***		
	[0.018]	[0.022]		

Annex table A.8. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	0.142*** [0.014]	0.130*** [0.018]		
Mekong River Delta	0.065*** [0.011]	0.041*** [0.014]		
Time dummy (2006 = 1)	0.024*** [0.007]	0.023*** [0.004]	0.022*** [0.004]	0.024*** [0.004]
Interactions between regions and household characteristics	No	No	No	Yes
Constant	0.235*** [0.022]	0.216*** [0.023]	0.092** [0.040]	0.078* [0.043]
Observations	6 407	6 407	6 407	6 407
R-squared	0.26	0.26	0.11	0.12
Number of households	3 204	3 204	3 204	3 204

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.9. Regressions of proportion of children attending school

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
Living in a village with good road	0.010	0.001	-0.023	-0.025
	[0.011]	[0.011]	[0.020]	[0.020]
Proportion of members under 16	-0.016	-0.039	-0.127*	-0.543
	[0.028]	[0.030]	[0.071]	[0.615]
Proportion of members over 60	0.091**	0.077*	-0.126	3.918
	[0.038]	[0.043]	[0.159]	[19.707]
Household size	0.000	-0.002	0.013	-0.071
	[0.009]	[0.010]	[0.031]	[0.059]
Household size squared	-0.001	-0.001	0.000	-0.001
	[0.001]	[0.001]	[0.002]	[0.002]
Proportion of members having technical diploma	0.135***	0.113**	0.062	0.06
	[0.043]	[0.045]	[0.071]	[0.076]
Proportion of members having post-secondary diploma	0.078	0.067	0.003	-0.012
	[0.084]	[0.092]	[0.054]	[0.061]
Annual crop land (10 000 m^2)	-0.002	-0.003	-0.015	-0.013
	[0.005]	[0.006]	[0.014]	[0.014]
Perennial crop land (10 000 m^2)	0.015**	0.013**	0.008	0.001
	[0.006]	[0.006]	[0.008]	[0.007]
Forestry crop land (10 000 m^2)	0.003	0.002	0.000	-0.002
	[0.003]	[0.003]	[0.001]	[0.001]
Water surface (10 000 m^2)	0.020	0.008	-0.007	0.002
	[0.017]	[0.017]	[0.018]	[0.015]
Living in a village with market	-0.002***	-0.001**	0.001	0.001
	[0.001]	[0.001]	[0.002]	[0.002]
Red River Delta	Omitted			
North-East	0.000	-0.007		
	[0.014]	[0.017]		
North-West	-0.083***	-0.095***		
	[0.019]	[0.023]		
North Central Coast	-0.030**	-0.034**		
	[0.014]	[0.017]		
South Central Coast	-0.026	-0.025		
	[0.016]	[0.019]		
Central Highlands	-0.029	-0.032		
	[0.018]	[0.022]		

Annex table A.9. ***(continued)***

Explanatory variables	OLS	Random effects	Fixed effects without interactions	Fixed effects with interactions
South-East	-0.078***	-0.082***		
	[0.016]	[0.019]		
Mekong River Delta	-0.100***	-0.103***		
	[0.014]	[0.016]		
Time dummy (2006 = 1)	0.004	0.000	-0.005	-0.003
	[0.008]	[0.006]	[0.008]	[0.008]
Interactions between regions and household characteristics	No	No	No	Yes
Constant	0.990***	1.008***	0.950***	0.823***
	[0.034]	[0.038]	[0.113]	[0.152]
Observations	3 507	3 507	3 507	3 507
R-squared	0.06	0.05	0.06	0.07
Number of households	2 003	2 003	2 003	2 003

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex table A.10. Probit regression of good village road

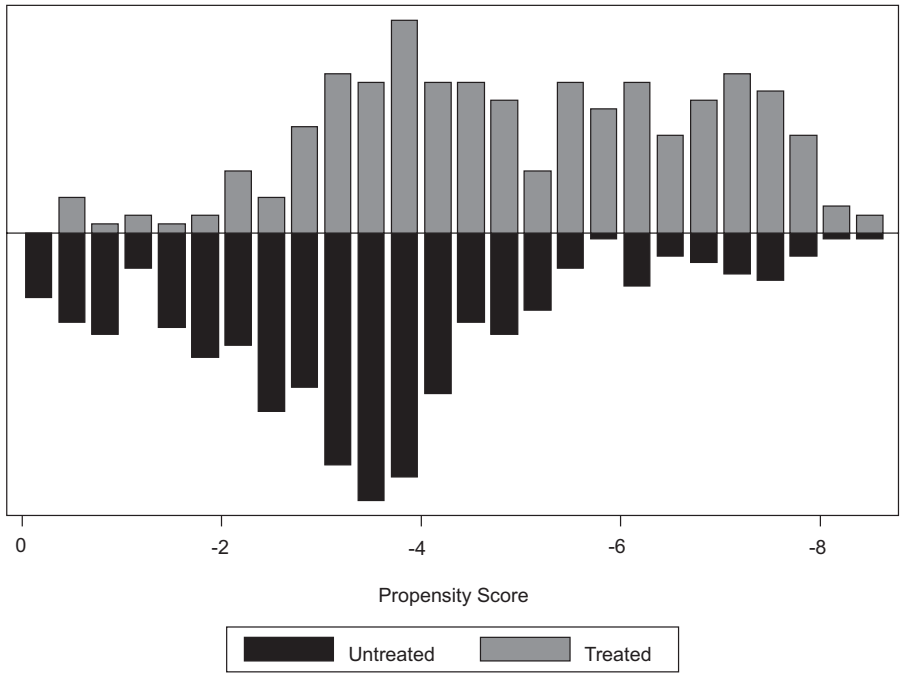
Explanatory variables	Coef.	Std. Err.	P>z
Proportion of members under 16	-0.410	0.282	0.146
Proportion of members over 60	-0.604	0.259	0.020
Household size	-0.042	0.034	0.210
Proportion of members having technical diploma	-0.190	0.486	0.696
Proportion of members having post-secondary diploma	-1.994	1.173	0.089
Annual crop land (10 000 m^2)	-0.079	0.061	0.194
Perennial crop land (10 000 m^2)	-0.116	0.104	0.263
Forestry crop land (10 000 m^2)	-0.019	0.023	0.403
Water surface (10 000 m^2)	-0.778	0.284	0.006
Living in a village with market	-0.030	0.007	0.000
Red River Delta	Omitted		
North-East	-0.626	0.213	0.003
North-West	-0.424	0.259	0.101
North Central Coast	-0.300	0.242	0.215
South Central Coast	0.128	0.247	0.605
Central Highlands	-0.320	0.299	0.284
South-East	-0.929	0.181	0.000
Mekong River Delta	0.977	0.223	0.000
Number of observations	667		
Pseudo R2	0.13		

Source: Author's estimation from VHLSSs 2004 and 2006.

Notes: Robust standard errors are shown in brackets. Standard errors are corrected for sampling weight and cluster correlation.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Annex figure A.1. Estimates of propensity score of the treatment and control groups



Source: Author's estimation from VHLSSs 2004 and 2006.

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