The Impact of Rural Road and Irrigation on Household Welfare: Evidence from Vietnam

Cuong Viet Nguyen
Tung Duc Phung
Van Khanh Ta*

Abstract

We measure the impact of road and irrigation projects on livelihoods of the households in the remote and poorest areas of Vietnam using Difference-in-Difference Method, Two-Part Model and Wealth Index. Results show that irrigation increases number of households growing annual crops as well as the land size for annual crops in each household, especially rice and potato. Irrigation projects initiate the greater scale of forestry land per household. It also helps rural households increase livestock herd with evidence of pig and chicken. At the downside, land size of perennial crop per household is decreased. Perhaps, better access to irrigation enables households cultivating more valuable crops, which require intensive watering. Also, expanding land area for rice and potato would result in greater quantity of output for rice and potato; hence more food available to expand livestock herds. On the contrary, the road projects have negative impact on crop land and no impact on livestock. Regarding positive effect of road project, people are more likely to find job in industrial sector while less likely to be employed in service sector. Possibly, better road transportation enables people shifting from cultivation to non-farm employment. Both rural road and irrigation facilitate households improving the access to safe water and increase the wealth of households, and the impact of irrigation is larger than the impact of road. We also find heterogeneous impacts of road and irrigation. Households with higher education tend to benefit more from the road project, while households with lower education are more likely to benefit greater from the irrigation project.

JEL classification: H43, O12, C14.
Keywords: impact evaluation, rural road, irrigation, household welfare, Vietnam.

* Authors are from Mekong Development Research Institute, Hanoi, Vietnam. Authors' email: cuongnguyen@mdri.org.vn; tungphung@mdri.org.vn; vanta@mdri.org.vn

1. Introduction

The availability of adequate infrastructure plays an essential role for both economic growth and poverty elimination (World Bank, 1994; Gannon and Liu, 1997; Lipton and Ravallion, 1995; Jalan and Ravallion, 2001; Brennenman and Kerf, 2002; Ali and Pernia, 2003; Jones, 2006). Infrastructure can enhance transport, trade and production which are indispensable to inclusive and higher growth. Their role in reducing an economy's vulnerability to natural disasters and climatic risks is also apparent (ADB, 2012; Fan and Kang, 2005).

Two important kinds of infrastructure for the poor and rural people are rural road and irrigation. According to Jalan and Ravallion (2001), rural road plays a key role in promoting rural income growth and reducing poverty. There are several ways that rural road can benefit local households. Firstly, farm income of household can be increased because of increasing access to markets, production inputs and capital. Access to rural roads can also increase agricultural productivity by improving access to advanced technology and reducing transaction costs. Secondly, non-farm employment and non-farm production can be increased by rural roads (Balisacan et al., 2002; Fan et al., 2002; Corral and Reardon, 2001; Escobal, 2001; Nguyen, 2011). For farm households, irrigation is very important, since it enables households to improve crop productivity and to cultivate more high-value crops, which in turn generate higher incomes and employment, earn a greater implicit wage rate for family labor (Hussain and Hanjra in 2003; Smith, 2004).

Vietnam is a developing country which has been successful in poverty reduction. However, it remains a rural country with more than two-thirds of the population living in rural areas. Poverty is rural phenomenon in Vietnam, since 95 percent of the poor are living in rural areas. To improve the living standards of rural households and reduce poverty, the government of Vietnam has implemented a large number of road and irrigation projects in rural areas, especially those with a high poverty rate and a higher proportion of ethnic minorities.

An important question is to what extent road and irrigation can help local households improve their livelihood and welfare in Vietnam. There are few studies on the impact of rural road projects in Vietnam. Mu and van de Walle (2011) and Cratty and Van de Walle (2002) found that a rural road project improves transport to and from local markets in Vietnam by using data collected from rural road rehabilitation projects.[1]Using panel data from 2004 and 2006 Vietnam Household Living Standard Surveys, Nguyen (2011) finds that rural roads help households increase per capita income and working hours, whilst these roads show no impact on household expenditure, share of non-farm income and children's schooling rate.

In this study, we will examine the effect of both rural road and irrigation projects on livelihood and welfare of households in the poorest areas in Vietnam. In Vietnam, there are 1,600 communes which are identified as the poorest communes (in the total number of around 11 thousand communes). These communes are located in poor and mountainous areas in 45 provinces, and they are characterized by large proportions of ethnic minority households and chronically poor. In an attempt to reduce poverty for these communes, Irish Aid has provided funding for communes to build infrastructures which are mainly road and irrigation. Availability of data on this Irish Aid project allows us to conduct impact evaluation of road and irrigation on local households.

Compared with previous quantitative impact evaluation, our study is differentiated in several aspects. Firstly, we compare the effect of road and irrigation projects. Most previous studies in Vietnam focus on the impact of roads. There is no quantitative impact evaluation of irrigation in Vietnam. Secondly, we focus on the impact of infrastructure in the poorest areas in Vietnam. The impact of infrastructure is heterogeneous, and whether road and irrigation can benefit the poorest households is a prior unknown. Thirdly, we will look at the impact on a series of outcomes including labor, agricultural activities and wealth index. By doing this, we expect to provide more insight into the process in which rural road and irrigation can improve household welfare. It is also expected that findings from this study can be relevant for other developing countries, especially for countries with a similar economic structure as Vietnam.

[1] These two studies evaluate the impact of the Vietnam Rural Transport Project I which implemented the rehabilitation of 5,000 kilometers of rural roads in communes in 18 provinces in Vietnam. The project was implemented during 1997-2001.

This paper is structured into six sections. The second section overviews the literature of impacts of road and irrigation in other countries. The third section presents the data sets and describes the irrigation and road projects which are evaluated in this paper. The fourth and fifth sections present the estimation method and empirical results of the impact evaluation, respectively. Finally, the sixth section is conclusion.

2. Economic literature

There is well-established evidence showing the impacts of infrastructure investment for accelerating growth and for reducing inequality and making growth patterns more pro-poor (World Bank, 1994; Gannon and Liu, 1997; Lipton and Ravallion, 1995; Jalan and Ravallion, 2001; Brennenman and Kerf, 2002; Jones, 2006). Infrastructure development promotes inclusive growth and directly or indirectly contributes to poverty reduction through job creation, production costs reduction through improvements in connectivity and transport, enhance production capacity, market connectivity as well as promote key services/facilities access improvement (ADB, 2012). This section provides a literature review on the impact of road and irrigation to agricultural output and employment both at international and Vietnamese contexts.

There is no doubt that road investment saves travelling time/efforts and reduces transportation costs. Adequate road work allows people, especially poor people in remote areas to redirect their time and efforts to other economic and social activities. Besides, providing adequate road works help lower the transportation costs which are usually expensive and inefficient in many developing countries. Accordingly, proper transport projects result in making the transportation of goods and services, particularly of agricultural inputs or outputs more convenient and affordable to poor users (World Bank, 1999; World Bank, 2000).

There are numerous studies in the world focusing on the impacts of road infrastructure on households as well as the significant role of road in economic growth, such as World Bank (1997), ADB (2012) and Rand (2011). In the study "Impact Evaluation Report: feeder Roads in Bahia" in Brazil, prepared by World Bank in 1997, the roads are to

be built in areas of Bahia with good agricultural potential but inadequate infrastructure. The impact evaluation then found that, the road construction has initiated production expansion, enhancing productivity and facilitated market linkage. The construction of rural roads is proved to bring about expansion of production activities of major commodities. Moreover, the crop productivity was raised due to greater opportunities for farmers in the project areas to implement machinery (World Bank, 1997).

Employment of CGE model, authors confirm that the operation of rural road projects obviously facilitate the people's transportation within a locality as well as with other areas. Enhanced connectivity is a key to development since it enables poor people to gain better access to additional job opportunities, education, market, health care and other public services (ADB, 2012). Evidently, employment opportunities for off-farm jobs rose by 1.7%. The workers in the expanding sectors earn higher wages, with a rise of 1.2% in average wage of semi-skilled non-agricultural labor. The average wages of semi-skilled agricultural labor rise by 0.9% and skilled agricultural labor rise by 1.2%, so do agricultural incomes and growth of rural household welfare (ADB, 2012). Similar evidence on job creation benefited from road project is found in other cases such as Fan (2005), World Bank (2002), and Goldstein (1993).

In Nicaragua, Rand (2011) finds the promising employment-generating impact of a tertiary road project. The estimation indicates that there is an increase in hours worked per week of around 9.5 – 12.3 hours as road intervention implemented. Interestingly, there is shift of sector employment in Nicaragua initiated by new road network. Specifically, the observed tendency of a graduation process take place in the labor market, agricultural sector (self-employment) absorbs unemployed whilst workers previously working in agriculture gradually take jobs in a newly created service sector. These effects are results of multi-reasons including: reduced travel time, better access to market and larger, more integrated road networks (Rand, 2011).

There are many studies at the international level examining the immediate outputs and the long term impact of irrigation provision on livelihood of households, such as Smith (2004);Hussain and Hanjra (2003); and Berg and Ruben (2006). In these studies, there is high consensus that irrigation brings positive impacts to agricultural production and livelihood of households.

A systematic review of previous studies on relationship between irrigation and rural poverty alleviation is done by Hussain and Hanjra in 2003; it reveals that irrigations allow households to improve crop productivity and to cultivate more high-value crops, which in turn generate higher incomes and employment, earn a greater implicit wage rate for family labor. Similar results are found in the study "Assessment of the Contribution of Irrigation to Poverty Reduction and Sustainable Livelihoods" (Smith, 2004).

In Ethiopia, evidence shows that irrigation is stimulus to the overall growth in Ethiopia. Regression analysis indicates the direct effects of irrigation on expenditure and labor demand (Berg, M. and Ruben, R. , 2006).

Few studies have mentioned the impacts of irrigation on agricultural productivity and its further long term impacts on income growth and poverty alleviation in Vietnam context. Tran and Hossain (2001) conducted a study on household-level using data from eight villages representing different ecologies from both North and South Vietnam to examine issue of poverty and income distribution. They found that irrigated land increases rice yield and reduces the unit cost of production substantially, as compared to cultivation under rain-fed conditions.

A systematic review of impacts of irrigation infrastructure on agricultural productivity in DFID supported countries showed a positive impact on agricultural productivity, especially in relation to income and poverty reduction (Knox J., Daccache A & Hess T., 2013). Vietnam is among the reviewed countries, and there is obvious evidence that irrigations funded by DFID facilitates the growth of income and reduce the poverty through increasing agricultural productivity due to more efficient irrigation systems.

In short, infrastructures like road and irrigation are the key factors to economic development in developing countries and their positive impact exists without doubt. Literature review reveals handful information at the global perspective regarding impacts of road and irrigation on agriculture production and livelihood of households, however there is little information available in Vietnam context. This paper aims to fill the gap in Vietnam using quantitative data collected from 720 households in rural of Vietnam in late 2014.

3. Project description

3.1. Project description

Despite recent rapid economic growth and impressive achievements in poverty elimination, Vietnam still has to face significant infrastructure deficiency, especially in mountainous and remote areas. It is, therefore, important to provide high quality and efficient infrastructure systems with the capacity to support more inclusive and higher economic growth. Acknowledging the vital role of infrastructure to poverty reduction, during 2007-2010, Irish Aid, an active donor, has provided €29 million in budget support to the poorest communes identified by a national program 'Socio-economic Development for the Communes Facing Greatest Hardships in the Ethnic Minority and Mountainous Areas'.[2]

In 2011 and 2012, as an interim extension of the Program, Irish Aid provided additional grants of €13 million to invest in small scale infrastructure in poor communes under the Program. The funding was allocated to 180 construction projects in 180 treatment communes located in 21 provinces to facilitate the poverty alleviation process in the poorest communes in Vietnam. In this regard, three main types of basic infrastructure investment are rural road (96 projects), clean water (21 projects) and irrigation (50 projects). Apart from main types of invested infrastructure in 2011-2012, other sponsored facilities include electricity, school, and levelling surface for housing, bridge and health clinic.

Two important criteria of Irish Aids disbursement include: (i) selection of infrastructure project ensures transparency, publicity and being prioritized for communes with highest poverty rate, (ii) maximum fund per commune should not exceed 2 billion dong and focusing on complete investment of small scale project.

[2]This program is also known as Program 135 (P135) which has been implemented since 1998 targeted the most vulnerable, poorest and socially excluded communes. Led by the Committee for Ethnic Minority Affairs (CEMA), P135-Phase 2 covers 1,600 of the poorest communes with the total budget from 2006 to 2010 of roughly US$ 1.1 billion. After 16 years of implementation, P135 has fundamentally changed the face of extremely poor areas. The lives of ethnic minority people have been notably improved while the poverty rate has fallen at an annual average of 3.6percent.

Criteria of commune selection for receiving the Irish Aids in interim program (i) P135 communes having the highest percentage of poor households in the same province/district, (ii) P135 communes suffered from natural disasters, lack of or huge damage of basic infrastructure (iii) communes with capacity of being decentralized and acting as an investor, and (iv) communes with high ratio of annual disbursement and be committed to deadline of project implementation (Government Office of Vietnam, 2013).

3.2. Data set

In this study, we conducted an endline survey of the Irish Aid infrastructure project for impact evaluation in November 2014. There are 180 treatment communes in the project. We randomly selected 18 treatment communes for the 2014 Project Survey from overlapped commune list between VHLSS 2010 and 180 treatment communes. To select comparable control communes, we used commune data from Vietnam Household Living Standard Survey 2010. We used the propensity score matching to select 18 control communes which have the closest distance of the propensity score to the selected treatment communes. The propensity score matching is a method to select a control group which has similar characteristics as the treatment group based on the probability of being selected into the project (called propensity scores). Detailed presentation of this method can be found in a large number of studies, e.g., Rubin (1979), Rosenbaum and Rubin (1983), Smith and Todd (2005).

Based on the selection criteria of the project communes, the covariates used in the matching include the poverty rates, ethnic minority population share, and exposure to natural disasters during the past three years. We also control for non-farm employment, market access, availability of road, population density and areas in the propensity score estimation.

After 18 control communes and 18 treatment communes are selected, the survey was conducted in these communes across 9 provinces by Mekong Development Research

Institute, Hanoi, Vietnam.[3] Each treatment commune has received one infrastructure project. Within 18 Irish Aid projects, 11 of them are rural road infrastructures, 6 are irrigation projects and one project is clean water. In short, there are 720 households in the sampling, including 359 control households and 361 treatment households. In this study, we focus on the impact evaluation of the road and irrigation projects. Thus, observations from the commune with the clean water project are not used.

The treatment and control groups can be different even in the absence of the projects. To estimate the impacts of the road and irrigation projects, we will use difference-in-differences estimators (see section 4 for detailed discussion). This method requires the baseline of households before the project implementation. In this study, baseline data are from the Rural Agriculture and Fishery Census (RAFC) in 2011. The RAFC were carried out by the GSO in July 2011. The censuses covered all households in rural areas. The censuses contain data on individuals and households including basic demography, employment and housing, and agricultural activities. There are 16,194,218 households covered in the census. More information on the 2011 RAFC can be found in MPI (2011).

There is no identification information of households in the 2011 RAFC. Thus we are not able to merge households between the 2011 RAFC and the 2014 Project Survey. Instead, we merge the two data sets by village codes. The number of households in the final merged data used for impaction evaluation is 2,660 in the 2011 RAFC and 587 in the 2014 Project Survey.

3.3. Outcomes of treatment and control variables

In this section, we present the means of outcomes of the treatment and control groups. Since we use the 2011 RAFC and the 2014 Project Survey for impact evaluation, outcome variables should be available in both the data sets. Table 1 presents the percentage of households having different types of land and the average land size. Table 2 presents the percentage of household growing different important annual crops and the land size used

[3] These provinces are Ha Giang, Cao Bang, BacKan, TuyenQuang, Dien Bien, Yen Bai, Lang Son, ThanhHoa, Kon Tum.

for different crops. It shows that households in these areas rely heavily on agricultural production. Most households have or use crop land. The pattern of agricultural land is similar between the treatment and control group.

Table 1: Agricultural land of the treatment and control groups

Outcome variables	Treatment group in the 2011 RAFC	Control group in the 2011 RAFC	Treatment group in the 2014 Project Survey	Control group in the 2014 Project Survey
Percentage of households having forestry land	57.9	55.7	45.7	46.0
	(1.4)	(1.3)	(2.8)	(3.0)
Forestry land for households having forestry land (m2)	27540.0	20391.1	33852.0	25891.2
	(1896.8)	(1553.9)	(3483.8)	(4134.4)
Percentage of households having annual crop land	96.7	97.8	97.1	96.3
	(0.5)	(0.4)	(0.9)	(1.1)
Annual crop land for households having annual crop land (m2)	7970.9	9765.5	6383.9	8758.4
	(148.2)	(253.2)	(406.2)	(699.7)
Percentage of households having perennial crop land	40.8	37.9	31.7	21.3
	(1.4)	(1.3)	(2.6)	(2.5)
Perennial crop land for households having perennial crop land (m2)	2378.2	1560.2	5131.1	6220.6
	(169.0)	(113.6)	(782.7)	(1523.4)

Note: Standard errors are in parentheses.
Source: The 2011 RAFC and the 2014 Project Survey.

Table 2: Crop land of the treatment and control groups

Outcome variables	Treatment group in the 2011 RAFC	Control group in the 2011 RAFC	Treatment group in the 2014 Project Survey	Control group in the 2014 Project Survey
Percentage of households growing rice	91.3	94.8	97.1	94.5
	(0.8)	(0.6)	(0.9)	(1.4)
Rice land for households growing rice(m2)	4340.8	4509.1	4699.4	4913.4
	(100.6)	(97.3)	(284.2)	(369.1)
Percentage of households growing corn	80.9	81.9	75.9	74.3
	(1.1)	(1.0)	(2.4)	(2.7)
Corn land for households growing corn(m2)	3229.7	5044.9	1950.2	4170.1
	(110.8)	(215.0)	(164.2)	(427.3)
Percentage of households growing potato	18.9	20.5	9.2	20.2
	(1.1)	(1.1)	(1.6)	(2.4)
Rice land for households growing potato (m2)	234.2	257.4	113.7	362.4
	(24.3)	(23.3)	(26.5)	(138.4)
Percentage of households growing cassava	43.5	32.4	36.2	36.0
	(1.4)	(1.3)	(2.7)	(2.9)
Rice land for households growing cassava (m2)	1903.1	2865.3	3005.3	2463.7
	(105.3)	(126.4)	(696.7)	(336.0)

Note: Standard errors are in parentheses.
Source: The 2011 RAFC and the 2014 Project Survey.

In Table 3, we examine the livestock activities of households. Overall, households in the treatment group tend to have greater scale of livestock and poultry per household than those in the control group.

Table 3: Livestock of the treatment and control groups

Outcome variables	Treatment group in the 2011 RAFC	Control group in the 2011 RAFC	Treatment group in the 2014 Project Survey	Control group in the 2014 Project Survey
The number of buffalo and cows	1.984	2.012	2.025	1.934
	(0.059)	(0.053)	(0.108)	(0.124)
The number of pigs	2.230	2.600	4.371	3.335
	(0.058)	(0.097)	(0.318)	(0.264)
The number of goats and sheep	0.323	0.126	0.590	0.533
	(0.052)	(0.028)	(0.152)	(0.186)
The number of chicken	12.273	9.821	26.968	21.915
	(0.358)	(0.300)	(1.539)	(1.448)
The number of ducks geese	2.525	1.890	5.854	4.816
	(0.172)	(0.121)	(0.795)	(0.613)

Note: Standard errors are in parentheses.
Source: The 2011 RAFC and the 2014 Project Survey.

Table 4 presents a very similar employment pattern in the treatment and control groups. The average proportion of working people per household is around 0.6. Among the working people, 90% of them are working in agricultural sector, and also 90% of the working people are self-employed.

Table 4: Employment of the treatment and control groups

Outcome variables	Treatment group in the 2011 RAFC	Control group in the 2011 RAFC	Treatment group in the 2014 Project Survey	Control group in the 2014 Project Survey
Proportion of members working	0.572	0.573	0.604	0.593
	(0.006)	(0.005)	(0.011)	(0.011)
Proportion of members having wage jobs	0.044	0.029	0.102	0.104
	(0.005)	(0.004)	(0.012)	(0.014)
Proportion of members working in agriculture	0.937	0.950	0.936	0.900
	(0.006)	(0.005)	(0.010)	(0.014)
Proportion of members working in industry	0.002	0.008	0.026	0.019
	(0.001)	(0.002)	(0.006)	(0.005)
Proportion of members working in service	0.057	0.040	0.035	0.079
	(0.006)	(0.005)	(0.007)	(0.012)

Note: Standard errors are in parentheses.
Source: The 2011 RAFC and the 2014 Project Survey.

Table 5 presents the durable ownership of households. There is an increase in access to safe water in both areas.[4]In 2014, households in the treatment groups are more likely to have access to safe water than their counterpart in the control group. However, they have a lower rate of having motorbike and electric fan than households in the control group.

Table 5: Durable of the treatment and control groups

Outcome variables	Treatment group in the 2011 RAFC	Control group in the 2011 RAFC	Treatment group in the 2014 Project Survey	Control group in the 2014 Project Survey
Having access to safe water (yes=1, no=0)	61.8	51.2	73.7	59.9
	(0.9)	(0.9)	(2.5)	(3.0)
Having motorbike (yes=1, no=0)	55.8	68.2	72.4	81.6
	(1.4)	(1.3)	(2.5)	(2.4)
Having line telephone (yes=1, no=0)	11.7	16.5	3.8	2.9
	(0.9)	(1.0)	(1.1)	(1.0)
Having mobile telephone (yes=1, no=0)	62.2	72.9	85.7	87.5
	(1.4)	(1.2)	(2.0)	(2.0)
Having electric fan (yes=1, no=0)	33.8	32.1	40.0	46.7
	(1.3)	(1.3)	(2.8)	(3.0)

Note: Standard errors are in parentheses.
Source: The 2011 RAFC and the 2014 Project Survey.

4. Estimation method

Difference-in-difference estimator

In this study, difference-in-differences estimator is used to estimate the impact of the Irish Aid project. Since the project is not randomized, there can be potential bias in measuring the impact of the project using quasi-experimental methods. A difficulty in impact evaluation of the Irish project is that there are no baseline data. Using only single cross sectional data after the project implementation can result in estimation bias. To reduce the bias, we will use the Rural Agriculture and Fishery Census (RAFC) in 2011 as baseline data and conduct a household survey after the project and apply difference-in-differences

[4]We define the safe drinking water as water from piped water, deep well, protected wells and spring, and rain water.

estimators.[5] The outcome variables are limited to those which are contained in both the 2011 RAFC and the Irish project data. The difference-in-difference estimator can be written as follows:

$$Y_{i,j,t} = \beta_0 + Road_j\beta_1 + Irrigation_j\beta_2 + T_t\beta_3 + Road_jT_t\beta_4$$

$$+Irrigation_jT_t\beta_5 + X_{i,j,t}\beta_6 + u_{i,j,t} \quad (1)$$

Where $Y_{i,j,t}$ is an indicator of household outcomes such as land areas of crops of household$_i$ in village$_j$ in the year t; $Road_j$ and $Irrigation_j$ are the treatment variables indicating whether village$_j$ received a road and irrigation project, respectively. These variables are dummy variables which are equal to 1 for the treatment group and 0 for the control group. T_t is the dummy year which equals 1 for the year 2014 (i.e., the Irish project survey), and 0 for the year 2011 (i.e., the 2011 RAFC). $X_{i,j,t}$ is the vector of exogenous control variables including both household-level variables and commune-level variables; $u_{i,j,t}$ is unobserved variables.

According to the difference-in-difference estimator, β_1 and β_2 captures differences in outcome between the treatment and control group before the projects of road and irrigation, respectively. β_3 is the estimate of the difference in the outcome variable of the treatment group overtime. The effect of the treatment on the outcome variable is measured by β_4 and β_5.

We can test whether the effect of the projects differs for households with different value of the $X_{i,j,t}$ variables by including the interaction between the project variables and the $X_{i,j,t}$ variables as follows:

$$Y_{i,j,t} = \beta_0 + Road_j\beta_1 + Irrigation_j\beta_2 + T_t\beta_3 + Road_jT_t\beta_4 + Irrigation_jT_t\beta_5$$

$$+X_{i,j,t}\beta_6 + X_{i,j,t}Road_jT_t\beta_7 + X_{i,j,t}Irrigation_jT_t\beta_8 + u_{i,j,t} \quad (2)$$

The main assumption of the difference-in-difference estimator is the over-time change in outcome of the control group can mimic the over-time change in outcome of the treatment group in the absence of the treatment. The selection bias of the difference-in-difference estimator is equal to difference between the over-time change in outcome of the

[5] Detail discussion of difference-in-differences estimator can be found in econometric textbook such as Wooldridge (2010).

control group and the over-time change in outcome of the treatment group in the absence of the treatment. In this study, we expect that this selection bias is negligible after a large set of observed explanatory variables are controlled.

Two-part model

It should be noted that in the 2011 RAFC there is data on land areas used for different types of crops, and there is no data on crop outputs. As a result, the effect of the projects on crop lands is examined instead of crop outputs. Several outcome variables such as landholding have zero values for a number of households. In the case of zero values of the dependent variables, a Tobit model can be used. However, Tobit estimators are not consistent if the assumption on the normality and homoskedaticity of error terms is violated (Cameron and Trivedi, 2009). In this study, we applied the Tobit model to test these assumptions. The test statistics strongly reject the assumption on the normality and homoskedaticity of error terms. Thus, instead of Tobit models, we use a two-part model which is also widely used to model a variable with a large number of zero values (Duan et al., 1983; Manning et al., 1987). The two-part model consists of two regressions: the first is the regression of dummy variable indicating whether the dependent variable is positive, and the second is the regression of the dependent variable conditional on positive values.

$$D_{i,j,t} = \beta_{D0} + Road_j\beta_{D1} + Irrigation_j\beta_{D2} + T_t\beta_{D3} + Road_jT_t\beta_{D4}$$

$$+Irrigation_jT_t\beta_{D5} + X_{i,j,t}\beta_{D6} + u_{i,j,t} \quad (3)$$

$$Ln(Y_{i,j,t}) = \beta_{Y0} + Road_j\beta_{Y1} + Irrigation_j\beta_{Y2} + T_t\beta_{Y3} + Road_jT_t\beta_{Y4}$$

$$+Irrigation_jT_t\beta_{Y5} + X_{i,j,t}\beta_{Y6} + u_{i,j,t} \quad (4)$$

where $D_{i,j,t}$ is a binary variable which equal 1 for $Y_{i,j,t} > 0$, and 0 if $Y_{i,j,t} = 0$. Subscript *D* and *Y* in parameters of equation (3) and (4) denote parameters in models of $D_{i,j,t}$ and $\ln(Y_{i,j,t})$, respectively. Equation (4) is a linear model for households with positive values of $Y_{i,j,t}$. An advantage of the two-part model is that it allows us to examine the effect of the projects on two kinds of households' decision: decision to use crop land or not, i.e.

transition of land, and decision to increase or decrease the land size. We can be also interested in the marginal effect of the project on the unconditional dependent variable, $\ln(Y_{i,j,t})$. First, we note that:

$$E\left[Ln\left(Y_{i,j,t}\right)\right] = E\left[Ln\left(Y_{i,j,t}\right)|Y_{i,j,t} > 0\right]E\left(D_{i,j,t} = 1\right). \quad (5)$$

From (5), we can get the impact of a project variable on the unconditional dependent variable. For example, the effect of the road project can be expressed as follows (the effect of the irrigation project is estimated using the same way):

$$\frac{\partial E\left[Ln\left(Y_{i,j,t}\right)\right]}{\partial Road_j} = \frac{\partial E\left[Ln\left(Y_{i,j,t}\right)|Y_{i,j,t}>0\right]}{\partial Road_j}E\left(D_{i,j,t} = 1\right) + \frac{\partial E\left(D_{i,j,t}=1\right)}{\partial Road_j}E\left[Ln\left(Y_{i,j,t}\right)|Y_{i,j,t} > 0\right]. \quad (6)$$

We can estimate (6) using the estimate of parameters from regression and the sample mean of the dependent variables:

$$\widehat{ME} = \hat{\beta}_{D4}\overline{Ln(Y_{i,j,t})|Y_{i,j,t} > 0} + \hat{\beta}_{Y4}\overline{Pr\left(D_{i,j,t} = 1\right)} \quad (7)$$

where $\hat{\beta}_{D4}$ and $\hat{\beta}_{Y4}$ are estimates from regressions of equations (3) and (4);$\overline{Ln(Y_{i,j,t})|Y_{i,j,t} > 0}$ is the average of $Ln(Y_{i,j,t})$ for household with positive land areas in the data sample; and $\overline{Pr\left(D_{i,j,t} = 1\right)}$ is the proportion of households with positive land areas in the data sample.

Wealth index

The main outcome variables used in this study are crop lands, livestock, employment and durables and access to safe water. There is no data on income or consumption in our data sets. In this case, a common solution is to compute a wealth index using a principal components approach, following Filmer and Pritchett (2001). According to this approach, an index is constructed based as the first principal component of a vector of assets of households, including durables goods, housing characteristics, and access to utilities. Filmer and Scott (2008) and Kolenikov et al. (2009) conclude that rankings of various measures of welfare, including outcomes for education, health care, fertility, child mortality, and the labor market, are very similar the ranking of asset indices. The principal

component approach defines a wealth index in terms of the first principal component of the variables used. The wealth index, denoted by A_j, for household *j* is computed as follows:

$$A_j = \sum_p a_p \left(\frac{x_{pj} - \bar{x}_p}{s_p} \right) \qquad (8)$$

where x_p denotes the asset *p*, and $\bar{x}$ denote a mean of households in the sample. *s* is a standard deviation of asset x_p, and the *p*-dimensional vector of weight *a* is chosen to maximize the sample variance of *A*, subject to $\sum_p a_p^2 = 1$.

In this study, the asset and housing variables include access to safe water, mobile and line telephone, motorbike and fan. Other variables such as latrine or television are not available or not comparable in the two data sets.

5. Estimation Results

In this section, we present the empirical findings from the impact of the Irish projects on households. We use all the outcomes which are available in both the 2011 RAFC and the 2014 Project Survey. The control variables include household-level and commune-level variables, and province dummies. We tend to use more exogenous control variables, which are not affected by the treatment variables, i.e., the Irish project (Heckman et al., 1999; Angrist and Pischke, 2008). However, we include commune-level variables which indicate whether communes received other socio-economic development projects since 2011. According to Nguyen et al. (2015), authority leaders allocate a project to different communes based on information on previous projects that have received by communes. It means that the assignment of the Irish project is correlated with the assignment of other projects and the implementation of other projects should be controlled for.

In this section, Tables only present the coefficients of the project variables, the time dummy, and the interactions between the project variables and the time dummy. The impact of the projects is measured by these interactions (highlighted by the grey color).

Control variables are not presented in these tables. The full regression results are presented in tables in Appendix.

Table 6 presents the impact of road and irrigation projects on the agricultural land areas managed or owned by households. There are no significant effects of the road project on forestry and perennial crop lands of households. However, the road project has a negative effect on annual crop land. Although, the rural road project does not affect the probability of managing annual crop land, it reduces the land size for growing annual crops by around 31% for households with annual crop land.

Table 6. The impacts of the project on agricultural lands

Explanatory variables	Having forestry land	Log of forestry land	Having annual crop land	Log of annual crop land	Having perennial crop land	Log of perennial crop land
Village road project*Year 2014	0.0353	0.0154	-0.0032	-0.3087***	0.0691	-0.2013
	(0.0432)	(0.2007)	(0.0198)	(0.1123)	(0.0461)	(0.2804)
Village irrigation project*Year 2014	-0.1017**	0.4511*	0.0210*	0.1641	0.0112	-0.8806***
	(0.0509)	(0.2338)	(0.0122)	(0.1107)	(0.0531)	(0.3034)
Village road project	-0.4615***	-1.4106***	-0.0104	-0.1258***	0.0692**	-0.8827***
	(0.0255)	(0.1795)	(0.0079)	(0.0455)	(0.0299)	(0.1854)
Village irrigation project	0.3629***	0.9163***	-0.0029	-0.5316***	-0.3336***	0.2921
	(0.0499)	(0.2087)	(0.0103)	(0.0818)	(0.0531)	(0.2573)
Time 2014 (year 2014=1, year 2011=0)	-0.1672***	0.1311	-0.0336***	-0.4191***	-0.2102***	1.4951***
	(0.0294)	(0.1327)	(0.0124)	(0.0711)	(0.0292)	(0.2220)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.3705***	4.8154***	0.7844***	8.2941***	0.3278***	8.0925***
	(0.0806)	(0.3768)	(0.0610)	(0.1975)	(0.0836)	(0.3488)
Observations	3,244	1,777	3,244	3,153	3,244	1,203
R-squared	0.473	0.572	0.373	0.456	0.282	0.625

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Irrigation mainly benefits annual crop lands (Table 6). As a result, the irrigation project increases the percentage of households growing annual crop by around 2.1 percentage points. For households who have annual crop land already, the effect of the irrigation on the size is positive but not significant. Due to the irrigation project, the percentage of household having forestry lands decreases by around 10.1%. However, for those having forestry lands in both years, the forestry land increases by around 45% per household. It implies that a number of households switched from growing forestry to annual crop, and their forestry land might be sold to the remaining households. As a result, the forestry land size per household increases. Households in villages with an irrigation project also decrease the land used for perennial crops. Using the equation (7), we can

compute the marginal effect (at the mean) of the irrigation project on the unconditional log of forestry land. The marginal effect at the mean is -0.64. It means that the total effect on forestry land areas is negative.

In Table 7 and 8, we examine the impact of road and irrigation on lands used for several main crops. In villages with a road project, land areas used for potato and cassava tend to be smaller than in villages without a road project. The road project tends to increase the proportion of household growing rice, but reduce the land size of paddies by 33%. Using equation (7), the effect on the unconditional land variable is estimated at 0.16. The irrigation project has positive effects on land area of rice, corn and potato, but negative effects on cassava. With irrigation, farmers can grow crops that require intensive watering but can yield higher income for households.

Table 7. The impacts of the project on annual crop: rice and corn

Explanatory variables	Growing rice (yes=1, no=0)	Log of rice-growing Area	Growing corn (yes=1, no=0)	Log of corn-growing area
Village road project * Year 2014	0.0582***	-0.3316***	0.0517	0.0677
	(0.0222)	(0.0831)	(0.0418)	(0.1151)
Village irrigation project * Year 2014	0.0121	0.2168**	0.0945**	-0.1799
	(0.0158)	(0.1080)	(0.0441)	(0.1539)
Village road project	-0.0479***	0.1921***	-0.0537***	-0.4304***
	(0.0174)	(0.0526)	(0.0197)	(0.0537)
Village irrigation project	-0.0117	-0.4563***	0.2546***	-0.8636***
	(0.0173)	(0.0753)	(0.0298)	(0.1026)
Time 2014 (year 2014=1, year 2011=0)	-0.0261*	-0.0694	-0.1329***	-0.3553***
	(0.0146)	(0.0545)	(0.0224)	(0.0748)
	(0.0320)	(0.0854)	(0.0436)	(0.0986)
Control variables	Yes	Yes	Yes	Yes
Constant	0.6835***	7.1710***	0.5426***	7.9028***
	(0.0680)	(0.1771)	(0.0771)	(0.1764)
Observations	3,244	3,037	3,244	2,604
R-squared	0.270	0.244	0.442	0.598

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table 8. The impacts of the project on annual crops: potato and cassava

Explanatory variables	Growing potato (yes=1, no=0)	Log of potato -growing Area	Growing cassava (yes=1, no=0)	Log of cassava - growing area
Village road project * Year 2014	-0.1596***	-0.6470	-0.2368***	-0.0415
	(0.0342)	(0.4718)	(0.0463)	(0.2413)
Village irrigation project * Year 2014	0.0907**	0.5200	-0.0188	-1.1329***
	(0.0437)	(0.4221)	(0.0593)	(0.2366)
Village road project	-0.0717***	1.0449***	0.2144***	-0.2506
	(0.0248)	(0.2500)	(0.0263)	(0.2551)
Village irrigation project	0.2486***	-1.6412*	0.2105***	3.4110***
	(0.0382)	(0.9906)	(0.0529)	(0.9484)
Time 2014 (year 2014=1, year 2011=0)	-0.0367	-0.5089***	0.0576*	0.1650
	(0.0245)	(0.1721)	(0.0315)	(0.1466)
Control variables	Yes	Yes	Yes	Yes
Constant	-0.0715	5.3959***	-0.0245	5.2117***
	(0.0641)	(0.7804)	(0.0814)	(0.8841)
Observations	3,244	609	3,244	1,216
R-squared	0.298	0.378	0.316	0.570

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

In Table 9, we examine the impact of the road and irrigation projects on livestock of households. There are no significant effects of the road project on livestock. Interestingly, we find a positive effect of the irrigation on the number of pigs and chicken raised by households. Possibly, irrigation can help households increase annual crop outputs, and households can use crop by-products for raising livestock. Improved irrigation can also save working time of household members in getting water for crop and they can spend more time on other activities such as raising livestock.

Table 9. The impacts of the project on livestock

Explanatory variables	The number of buffalo and cows	The number of pigs	The number of goats and sheep	The number of chicken	The number of ducks geese
Village road project * Year 2014	0.2647	0.4853	-0.1725	1.3959	1.9267
	(0.1890)	(0.4156)	(0.2783)	(2.2694)	(1.3844)
Village irrigation project * Year 2014	0.1047	2.5234***	-0.2061	7.0718**	-1.3716
	(0.2001)	(0.6909)	(0.3166)	(2.8219)	(0.9673)
Village road project	0.1982	-0.8964***	0.2376***	2.2304***	-1.3054**
	(0.1281)	(0.1686)	(0.0883)	(0.8307)	(0.5360)
Village irrigation project	-0.6136***	-1.7905***	0.4685***	-1.6613	5.7155***
	(0.1891)	(0.3578)	(0.1635)	(2.0959)	(0.7052)
Time 2014 (year 2014=1, year 2011=0)	-0.2490**	0.7724***	0.3525*	10.5312***	2.6680***
	(0.1226)	(0.2774)	(0.1860)	(1.3918)	(0.6403)
Control variables	Yes	Yes	Yes	Yes	Yes
Constant	-0.5318	1.6748***	-0.5489*	10.3945***	-0.5876
	(0.3342)	(0.5666)	(0.3273)	(2.6578)	(1.0669)
Observations	3,244	3,244	3,244	3,244	3,244
R-squared	0.251	0.231	0.033	0.264	0.111

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

In Table 10, we examine the effect of the project on employment of household members. Better access to road is expected to increase employment, especially non-farm employment for local people. The total effect on working and wage jobs is negligible and not significant. However, people in village with road projects are more likely to find jobs in the industrial sector, but less likely to work for services. In our data sets, there is no information on detailed occupation, and as a result we are not able to investigate the effect of the project on formal or informal employment. For the irrigation project, there are no significant effects on working pattern of households.

Table 10. The impacts of the project on employment of household members

Explanatory variables	Proportion of members working	Proportion of members having wage jobs	Proportion of members working in agriculture	Proportion of members working in industry	Proportion of members working in service
Village road project * Year 2014	0.0286	0.0094	0.0277	0.0230**	-0.0478***
	(0.0182)	(0.0216)	(0.0194)	(0.0093)	(0.0161)
Village irrigation project * Year 2014	0.0039	-0.0144	0.0141	0.0108	-0.0204
	(0.0216)	(0.0210)	(0.0197)	(0.0099)	(0.0166)
Village road project	-0.0202	0.0132*	-0.0189**	-0.0056	0.0270***
	(0.0131)	(0.0078)	(0.0095)	(0.0037)	(0.0085)
Village irrigation project	-0.0026	0.0078	-0.0022	-0.0100	0.0125
	(0.0254)	(0.0137)	(0.0162)	(0.0065)	(0.0140)
Time 2014 (year 2014=1, year 2011=0)	0.0143	0.0926***	-0.0725***	0.0096*	0.0528***
	(0.0118)	(0.0132)	(0.0137)	(0.0053)	(0.0123)
Control variables	Yes	Yes	Yes	Yes	Yes
Constant	0.2943***	0.0236	0.7141***	0.0289***	0.0154
	(0.0593)	(0.0231)	(0.0662)	(0.0107)	(0.0245)
Observations	3,244	3,244	3,244	3,244	3,244
R-squared	0.221	0.402	0.449	0.067	0.459

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table 11 presents the estimate of the project impacts on households' access to safe water and main durables. We define the safe drinking water as water from piped water, deep well, protected wells and spring, and rain water. Both the road and irrigation project help households have better access to safe water. More specifically, the road projects and the irrigation projects increase the probability of having safe drinking water by 10% and20%, respectively. Households in the project villages are more likely to have telephone than those in non-project villages. There are no significant effects on motorbike ownership. Regarding ownership of electric fan, households in villages with a road project are less likely to have an electric fan than those in village without a road project, while households

in villages with an irrigation project are more likely to own a fan than households without irrigation.

Table 11. The impacts of the project on households' durable and appliance

Explanatory variables	Having access to safe water (yes=1, no=0)	Having mobile telephone (yes=1, no=0)	Having line telephone (yes=1, no=0)	Having motorbike (yes=1, no=0)	Having electric fan (yes=1, no=0)	Wealth index
Village road project * Year 2014	0.1116***	0.1222***	0.0675***	0.0598	-0.0828*	0.1712**
	(0.0421)	(0.0375)	(0.0240)	(0.0426)	(0.0431)	(0.0809)
Village irrigation project*Year 2014	0.2010***	0.0504	0.0972***	-0.0065	0.1010*	0.2486***
	(0.0503)	(0.0376)	(0.0272)	(0.0475)	(0.0536)	(0.0913)
Village road project	-0.1802***	-0.1445***	-0.1521***	-0.1887***	0.2855***	-0.4146***
	(0.0165)	(0.0332)	(0.0272)	(0.0320)	(0.0259)	(0.1026)
Village irrigation project	-0.2838***	-0.1389***	0.0709**	-0.2475***	0.0971**	-0.1957***
	(0.0288)	(0.0537)	(0.0298)	(0.0580)	(0.0461)	(0.0619)
Time 2014 (year 2014=1, year 2011=0)	0.4973***	0.1313***	-0.1515***	0.1351***	0.0851***	0.5503***
	(0.0292)	(0.0241)	(0.0157)	(0.0258)	(0.0267)	(0.0470)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.1628***	0.3487***	-0.1710***	0.1847**	-0.1561**	-1.2748***
	(0.0460)	(0.0845)	(0.0551)	(0.0922)	(0.0738)	(0.1676)
Observations	3,244	3,244	3,244	3,244	3,244	3,244
R-squared	0.587	0.159	0.103	0.227	0.370	0.334

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Overall, households in villages with projects have higher value of the wealth index than households in villages without projects. The wealth index is normalized to follow the standard normal distribution. It means that the road project and irrigation project increase households' wealth index by 0.17 and 0.25 of standard deviation, respectively.

Finally, we examine whether the effect of the projects on households' wealth index differ for households with different characteristics. Interacted characteristics include age and gender of household head, the proportion of female members, and the proportion of members with vocational training or post-secondary. There are only a few Kinh households, and as a result we do not interact Kinh variable with the project variables.

The interactions between the project variables, time dummy and explanatory variables reflect whether the effect of the projects differ for different values of explanatory variables (these variables are highlighted in shading cells in Table 12). It shows that households with male heads are less likely to benefit from the road project but more likely to benefit from the irrigation project than households with female heads. Households with

higher education tend to benefit more from the road project. Possibly, better access to road helps them find more non-farm employment opportunities. On the contrary, households with lower education attainment are more likely to benefit more from the irrigation project. These households rely mainly on crop production, and improved irrigation can bring more positive impacts for them.

Table 12: Regressions of wealth index of households with interaction variables

Explanatory variables	Model 1	Model 2	Model 3	Model 4
	Wealth index	Wealth index	Wealth index	Wealth index
Village road project * Year 2014	0.5037**	-0.1467	0.2923*	0.1685**
	(0.2054)	(0.2126)	(0.1666)	(0.0813)
Village irrigation project * Year 2014	-0.3334*	0.4711*	0.4263*	0.2546***
	(0.1998)	(0.2603)	(0.2231)	(0.0916)
Village road project * Year 2014 *Head ismale	-0.3702*			
	(0.2073)			
Village irrigation project * Year 2014 * Head ismale	0.6118***			
	(0.2026)			
Village road project * Year 2014 * Head's age		0.0073*		
		(0.0043)		
Village irrigation project * Year 2014 * Head's age		-0.0052		
		(0.0056)		
Village road project * Year 2014 * Proportion of female members			-0.2172	
			(0.2587)	
Village irrigation project * Year 2014 * Proportion of female members			-0.3032	
			(0.3368)	
Village road project * Year 2014 * Proportion of members with vocational training or post-secondary				1.3797**
				(0.6364)
Village irrigation project * Year 2014 * Proportion of members with vocational training or post-secondary				-3.9651***
				(0.5427)
	(0.1115)	(0.1117)	(0.1115)	(0.1116)
Control variables	Yes	Yes	Yes	Yes
	(0.1678)	(0.1680)	(0.1669)	(0.1677)
Observations	3,244	3,244	3,244	3,244
R-squared	0.335	0.334	0.334	0.334

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

6. Conclusion

This study compares the impact of rural road and irrigation in the poorest communes of Vietnam using difference-in-differences estimator, two-part model and wealth index. It finds that the irrigation project is very useful for annual crop activities.

There is increasing percentage of households growing annual crop land in villages with irrigation provision. More specifically, irrigation project has positive effects on land area of rice, corn and potato but negative effects on cassava. The outcome of irrigation project also implies an increasing scale of forestry land by 45% for households having forestry land before and after the implementation of irrigation facility in their villages. Interestingly, irrigation has positive effect on number of pigs and chicken raised by households.

Regarding impact of road project on local production, there is no significant effect of the road project on forestry and perennial crop lands of households, but road project has negative effect on annual crop land. It is found that people in village with road projects are more likely to find jobs in the industrial sector, but less likely to work for services. Irrigation project shows no significant effects on working pattern of households.

Households in project villages have better access to safe water use than their counterpart without Irish Aids projects. Model estimation reconfirms both road and irrigation project help households have better access to safe water. Road and irrigation projects increase ownership of durables for households in project villages. Overall, households in villages with projects have higher value of the wealth index than households in villages without projects.

References

ADB. (2012). *Supporting Inclusive Growth and Poverty Reduction in Asia* . Mandaluyong City, Philippines: Asian Development Bank.

Ali I. and E. M. Pernia (2003). "Infrastructure and poverty reduction. What is the connection?", ERD Policy Brief No. 13 (Manila, Asian Development Bank).

Angrist JD., Pischke JS. (2008), *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press.

Balisacan, A. M., E. M. Pernia and A. Asra (2002). "Revisiting growth and poverty reduction in Indonesia: what do subnational data show?", ERD Working Paper Series No. 25, Economics and Research Department (Manila, Asian Development Bank).

Berg, M. and Ruben, R. . (2006). Small-Scale irrigation and income distribution in Ethiopia. *Journal of Development Studies* , Vol. 42 (5).

Bhattarai, M., Sakthivadivel, R. & Hussain, I. (2002). *Working paper 39: Irrigation Impacts on Income Inequality and Poverrty Alleviation.* Colombo, Sri Lanka : International Water Management Institute .

Brennenman, A. & Kerf, M. (2002). *Infrastructure and Poverty Linkages: A literature review*. Washsinton, D.C: The World Bank.

Cameron, A. C. and P. K. Trivedi (2009), Microeconometric using Stata, Stata Press.

Corral, L. and T. Reardon (2001)."Rural nonfarm incomes in Nicaragua", *World Development*, vol. 29, No. 3, pp. 427-442.

Duan, N., Manning, W.G., Moris, C., and Newhouse, J.P., 1983. A comparison of alternative models for the demand for medical care. *Journal of Business and Economics Statistics* 1, 115–126.

Escobal, J. (2001). "The determinants of nonfarm income diversification in rural Peru", *World Development*, vol. 29, No. 3, pp. 497-508.

Fan, S. and Kang, C.C. (2005). *Road Development, Economic Growth, and Poverty Reduction in China* . Washington D.C. : International Food Policy Research Institute .

Fan, S., L. X. Zhang and X. B. Zhang (2002). "Growth, inequality, and poverty in rural China: the role of public investments", Research Report 125 (Washington, D.C., International Food Policy Research Institute).

Filmer, Deon, and Kinnon Scott. 2008. "Assessing asset indices." The World Bank.

Filmer, D., and L. H Pritchett. 2001. "Estimating wealth effects without expenditure data-or tears: an application to educational enrollments in states of India." *Demography* 38(1): 115–132.

Jalan, J. and M. Ravallion (2001). "Geographic poverty traps? A micro econometric model of consumption growth in rural China", *Journal of Applied Econometrics*, vol. 17, No. 4, pp. 329-346.

Gannon, C. and Z. Liu (1997). "Poverty and transport", TWU discussion papers, TWU-30 (Washington, D.C., World Bank).

Gertler, P. & Glewwe, P. (1990). The willingness to pay for education in developing

Government Office of Vietnam (2013), "Documents on the Irish Aid Funding for the Program 135", 2013, the Government Office of Vietnam, Hanoi, Vietnam. countries: evidence from rural Peru . *Journal of Public Economics* , 251-275.

Hanjra, M.A., Ferede, T. & Gutta, D.G. (2009). Reducing poverty in sub-Saharan Africa through investments in water and other priorities . *Agricultural Water Management* , 1062-1070.

Heckman J, R Lalonde, Smith J. (1999), The economics and econometrics of active labor market programs. *Handbook of Labor Economics* 1999; Volume 3, Ashenfelter, A. and D. Card, eds., Elsevier Science.

Hussain, I. and Hanjra, M.A. . (2003). Does irrigation water matter for rural poverty alleviation? Evidence from South and South-East Asia. *Water Policy* , 429-442.

Jones, S. . (2006). Infrastructure Challenges in East and Sout Asia. *IDS Bulletin* , Vol. 36, No. 3.

Khandker, S.R., Bakht, Z. & Koolwal, G.B. (2009). The Poverty Impact of Rural Roads: Evidence from Bangladesh . *Chicago Journals* , 685-722.

Knox J., Daccache A & Hess T. (2013). *What is the impact of infrastructural investments in roads, electricity and irrigation on agricultural productivity?* . Department for International Development .

Kolenikov, Stanislav, and Gustavo Angeles. 2009. "Socioeconomic Status Measurement with Discrete Proxy Variables: Is Principal Component Analysis a Reliable Answer?." *The Review of Income and Wealth* 55: 128-165.

Lavy, V. (1996). School supply constraints and children's educational outcomes in rural Ghana. *Journal of Development Economics* , 291-314.

Lipton, et. al. . (2003). The effects of irrigation on poverty: a framework for analysis . *Water Policy* , 413-427.

Lipton, M. and M. Ravallion (1995). "Poverty and policy", in J. Behrman and T. N. Srinivasan, eds., *Handbook of Development Economics (Handbooks inEconomics 9)*, vol. 3B , pp. 2551-2657 (Amsterdam, Elsevier Science).

Manning, W.G., Duan, N., and Rogers, W.H., 1987.Monte Carlo evidence on the choice between sample selection and two-part models.*Journal of Econometrics* 35, 59–82.

Ministry of Planning and Investment (MPI) (2011), "Decision on the Plan of The Rural Agriculture and Fishery Census 2011", Decision No. 338-BKHDT, dated on march 17, 2011, Ministry of Planning and Investment (MPI) of Vietnam, Vietnam.

Mu, R. and Van de Walle, D. (2011), "Rural Roads and Local Market Development in Vietnam" published in *Journal of Development Studies* 47, no. 5 (2011), pages 709-34.

Nguyen. (2011). Estimation of the impact of rural roads on household welfare in Vietnam. *Asia-Pacific Development Journal* , 105-135.

Nguyen, C., Phung, T. and Westbrook, D., (2015)"Do the Poorest Ethnic Minorities Benefit from a Large-Scale Poverty Reduction Program? Evidence from Vietnam', *The Quarterly Review of Economics and Finance*, accepted.

Rand, J. (2011). Evaluating the emplyment-generating impact of rural roads in Nicaragua . *Journal of Development Effectiveness* , 28-43.

Rosenbaum, P. and R. Rubin (1983), "The Central Role of the Propensity Score in Observational Studies for Causal Effects", *Biometrika* 70(1), pp. 41-55.

Rubin, Donald B. (1979), "Using Multivariate Sampling and Regression Adjustment to Control Bias in Observational Studies", *Journal of the American Statistical Association* 74, pp. 318–328.

Smith, J. and Todd P. (2005). 'Does matching overcome LaLonde's critique of nonexperimental estimators?',*Journal of Econometrics*, 125(1–2), pp. 305–353.

Smith, L. (2004). Assessment of the Contribution of Irrigation to Poverty Reduction and Sustainable Livelihoods . *Water Resources Development* , 243-257.

Tran, T.U. and Hossain, M. (2001). Modern Farm Technology and Infrastructure in Vietnam: Impact on Income Distribution and Poverty . *Economic and Political Weekly* , 4638-4643.

Van de Walle, D. and Cratty, D. (2002). *Impact Evaluation of rural road rehabilitation project.* report of a World Bank project on rural road rehabilitation in Viet Nam.

Van de Walle, D. (2002). Choosing rural road investments to help reduce poverty. *World Development* , 575-589.

Wooldridge J. M. (2010), *Econometric Analysis of Cross Section and Panel Data,*The MIT Press, Cambridge, Massachusetts London, England.

World Bank. (1997). *Brazil: Impact Evaluation Report Feeder Roads in Bahia.* Washington D.C: The World Bank.

World Bank. (2001). *Honduras Poverty Diagnostic 2000.* Washington, D.C : The World Bank .

World Bank. (1999). *Vietnam Moving Forward: Achievements and Challenges in the Transpprt Sector*. Washington D.C.: World Bank.

World Bank (1994).*World Development Report 1994: Infrastructure for Development*(New York,OxfordUniversity Press).

Appendix

Table A.1 Summary statistics of explanatory variables

Explanatory variables	Type	The 2011 RAFC		The 2014 Project Survey	
		Mean	Std. Dev.	Mean	Std. Dev.
Kinh (Kinh=1, ethnic minorities=0)	Binary	0.0282	0.1656	0.0153	0.1230
Household size	Discrete	5.1368	2.0137	5.1618	1.9793
Age of household head	Discrete	39.506	11.739	42.876	12.240
Head is male	Binary	0.9177	0.2749	0.9284	0.2580
Head has vocational training or post-secondary	Binary	0.0417	0.2000	0.0017	0.0414
Proportion of female members	Continuous	0.4923	0.1616	0.5641	0.2252
Proportion of members with vocational training or post-secondary	Continuous	0.0346	0.1486	0.0033	0.0343
The number of commune road projects	Discrete	0.4192	0.5477	0.4736	0.5639
The number of inter-village road projects	Discrete	1.1459	0.7881	1.1312	0.7237
The number of within-village road projects	Discrete	0.5387	1.9616	0.5247	1.9536
The number of bridge projects	Discrete	0.9793	1.6144	0.9574	1.6063
The number of irrigation projects	Discrete	1.0729	0.8457	1.0443	0.9134
The number of market projects	Discrete	0.1071	0.3763	0.1704	0.4581
The number of electricity projects	Discrete	0.5049	0.5730	0.4940	0.5645
The number of Irish irrigation projects	Discrete	0.3105	0.5771	0.2998	0.5245
The number of Irish road projects	Discrete	0.4643	0.5771	0.4327	0.5574
Number of observations		2660		587	

Table A.2. Regressions of agricultural lands of households

Explanatory variables	Having forestry land	Log of forestry land	Having annual crop land	Log of annual crop land	Having perennial crop land	Log of perennial crop land
Village road project * Year 2014	0.0353	0.0154	-0.0032	-0.3087***	0.0691	-0.2013
	(0.0432)	(0.2007)	(0.0198)	(0.1123)	(0.0461)	(0.2804)
Village irrigation project * Year 2014	-0.1017**	0.4511*	0.0210*	0.1641	0.0112	-0.8806***
	(0.0509)	(0.2338)	(0.0122)	(0.1107)	(0.0531)	(0.3034)
Village road project	-0.4615***	-1.4106***	-0.0104	-0.1258***	0.0692**	-0.8827***
	(0.0255)	(0.1795)	(0.0079)	(0.0455)	(0.0299)	(0.1854)
Village irrigation project	0.3629***	0.9163***	-0.0029	-0.5316***	-0.3336***	0.2921
	(0.0499)	(0.2087)	(0.0103)	(0.0818)	(0.0531)	(0.2573)
Time 2014 (year 2014=1, year 2011=0)	-0.1672***	0.1311	-0.0336***	-0.4191***	-0.2102***	1.4951***
	(0.0294)	(0.1327)	(0.0124)	(0.0711)	(0.0292)	(0.2220)
Kinh (Kinh=1, ethnic minorities=0)	-0.2578***	-0.1667	-0.5290***	-0.1970*	-0.2386***	0.2887
	(0.0423)	(0.4079)	(0.0498)	(0.1023)	(0.0386)	(0.2369)
Household size	0.0062	0.0329**	0.0054***	0.1059***	0.0186***	0.0337*
	(0.0038)	(0.0160)	(0.0012)	(0.0077)	(0.0042)	(0.0173)
Age of household head	0.0143***	0.0247*	0.0033*	0.0102	0.0037	0.0059
	(0.0031)	(0.0142)	(0.0020)	(0.0067)	(0.0030)	(0.0126)
Squared age of household head	-0.0001***	-0.0002	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0002)	(0.0000)	(0.0001)	(0.0000)	(0.0002)
Head is male	0.0769***	0.1847	0.0906***	0.2758***	0.0796**	-0.0336
	(0.0281)	(0.1197)	(0.0183)	(0.0633)	(0.0319)	(0.1318)
Head has vocational training or post-secondary	-0.1109*	-0.1954	0.0188	0.0387	-0.0125	0.1928
	(0.0662)	(0.2462)	(0.0329)	(0.1063)	(0.0734)	(0.2927)
Proportion of female members	-0.0199	-0.1019	0.0861***	0.0989	0.0718	-0.2461
	(0.0433)	(0.1897)	(0.0263)	(0.0983)	(0.0479)	(0.2010)
Proportion of members with vocational training or post-secondary	0.2605***	1.0585***	-0.2161***	-0.1728	0.0230	0.0862
	(0.0818)	(0.3265)	(0.0623)	(0.1805)	(0.0988)	(0.3911)
Commune with commune road project	0.0825***	1.9175***	0.0084	0.6270***	0.1417***	-1.1060***
	(0.0192)	(0.1092)	(0.0056)	(0.0415)	(0.0207)	(0.1918)
Commune with inter-village road project	-0.1795***	-0.3256*	0.0022	-0.8600***	0.2184***	1.2348***
	(0.0219)	(0.1888)	(0.0066)	(0.0504)	(0.0269)	(0.2230)
Commune with within-village road project	-0.0449***	-0.7416***	-0.0092***	-0.1292***	-0.0360***	0.5824***
	(0.0122)	(0.0848)	(0.0033)	(0.0261)	(0.0135)	(0.1132)
Commune with bridge project	0.1067***	1.0194***	0.0158***	0.3371***	0.0759***	-0.6873***
	(0.0177)	(0.1483)	(0.0051)	(0.0399)	(0.0191)	(0.1880)
Commune with irrigation project	-0.2045***	1.0427***	-0.0224***	-0.1116***	-0.0175	0.4747***
	(0.0196)	(0.1227)	(0.0056)	(0.0309)	(0.0199)	(0.0950)
Commune with market project	-0.0763***	0.9336***	-0.0035	0.0365	0.1296***	-0.6596***
	(0.0208)	(0.1083)	(0.0056)	(0.0345)	(0.0229)	(0.0973)
Commune with electricity project	0.1526***	0.4197***	-0.0144*	0.0907*	-0.2605***	-1.1025***
	(0.0276)	(0.1338)	(0.0074)	(0.0489)	(0.0266)	(0.1443)
Commune has a Irish irrigation project	-0.1071***	-1.9306***	0.0112	0.3315***	0.0878***	-0.4417***
	(0.0221)	(0.1822)	(0.0074)	(0.0437)	(0.0280)	(0.1124)
Commune has a Irish road project	0.4088***	1.2416***	-0.0040	0.3402***	-0.0935***	0.5288**
	(0.0320)	(0.2149)	(0.0083)	(0.0608)	(0.0287)	(0.2430)
Province fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.3705***	4.8154***	0.7844***	8.2941***	0.3278***	8.0925***
	(0.0806)	(0.3768)	(0.0610)	(0.1975)	(0.0836)	(0.3488)
Observations	3,244	1,777	3,244	3,153	3,244	1,203
R-squared	0.473	0.572	0.373	0.456	0.282	0.625

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table A.3. Regressions of rice and corn crops of households

Explanatory variables	Growing rice (yes=1, no=0)	Log of rice-growing area	Growing corn (yes=1, no=0)	Log of corn-growing area
Village road project * Year 2014	0.0582***	-0.3316***	0.0517	0.0677
	(0.0222)	(0.0831)	(0.0418)	(0.1151)
Village irrigation project * Year 2014	0.0121	0.2168**	0.0945**	-0.1799
	(0.0158)	(0.1080)	(0.0441)	(0.1539)
Village road project	-0.0479***	0.1921***	-0.0537***	-0.4304***
	(0.0174)	(0.0526)	(0.0197)	(0.0537)
Village irrigation project	-0.0117	-0.4563***	0.2546***	-0.8636***
	(0.0173)	(0.0753)	(0.0298)	(0.1026)
Time 2014 (year 2014=1, year 2011=0)	-0.0261*	-0.0694	-0.1329***	-0.3553***
	(0.0146)	(0.0545)	(0.0224)	(0.0748)
Kinh (Kinh=1, ethnic minorities=0)	-0.5614***	0.2219**	-0.2454***	0.2246
	(0.0459)	(0.0883)	(0.0440)	(0.1535)
Household size	0.0123***	0.0899***	0.0143***	0.0593***
	(0.0023)	(0.0076)	(0.0030)	(0.0082)
Age of household head	0.0063**	0.0230***	0.0023	-0.0003
	(0.0025)	(0.0067)	(0.0027)	(0.0067)
Squared age of household head	-0.0001**	-0.0002**	-0.0000	0.0000
	(0.0000)	(0.0001)	(0.0000)	(0.0001)
Head is male	0.1021***	0.1296**	0.0881***	0.1376**
	(0.0228)	(0.0617)	(0.0265)	(0.0655)
Head has vocational training or post-secondary	0.0466	0.0460	0.0130	0.0890
	(0.0415)	(0.1205)	(0.0485)	(0.1242)
Proportion of female members	0.0633**	-0.0084	0.0764*	-0.0383
	(0.0320)	(0.0854)	(0.0436)	(0.0986)
Proportion of members with vocational training or post-secondary	-0.2750***	0.1224	-0.1853**	-0.2659
	(0.0748)	(0.1781)	(0.0764)	(0.2040)
Commune with commune road project	0.0127	0.3038***	0.2954***	0.9617***
	(0.0087)	(0.0370)	(0.0170)	(0.0518)
Commune with inter-village road project	-0.0194*	-0.2712***	-0.4332***	-1.3704***
	(0.0106)	(0.0511)	(0.0214)	(0.0716)
Commune with within-village road project	-0.0282***	-0.1342***	-0.0005	0.0082
	(0.0059)	(0.0258)	(0.0104)	(0.0324)
Commune with bridge project	0.0515***	0.3176***	0.0600***	0.2308***
	(0.0089)	(0.0378)	(0.0151)	(0.0464)
Commune with irrigation project	-0.0404***	0.0119	-0.2876***	-0.2515***
	(0.0096)	(0.0319)	(0.0144)	(0.0486)
Commune with market project	0.0389***	0.1682***	-0.0760***	0.0448
	(0.0115)	(0.0359)	(0.0116)	(0.0340)
Commune with electricity project	0.0206*	0.0993**	0.3368***	0.3612***
	(0.0121)	(0.0440)	(0.0244)	(0.0814)
Commune has a Irish irrigation project	-0.0016	-0.0983**	0.1176***	0.6187***
	(0.0181)	(0.0482)	(0.0150)	(0.0459)
Commune has a Irish road project	0.0017	0.0084	0.1620***	0.5518***
	(0.0159)	(0.0586)	(0.0249)	(0.0627)
Province fixed-effects	Yes	Yes	Yes	Yes
Constant	0.6835***	7.1710***	0.5426***	7.9028***
	(0.0680)	(0.1771)	(0.0771)	(0.1764)
Observations	3,244	3,037	3,244	2,604
R-squared	0.270	0.244	0.442	0.598

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table A.4. Regressions of potato and cassava crops of households

Explanatory variables	Growing potato (yes=1, no=0)	Log of potato -growing area	Growing cassava (yes=1, no=0)	Log of cassava - growing area
Village road project * Year 2014	-0.1596***	-0.6470	-0.2368***	-0.0415
	(0.0342)	(0.4718)	(0.0463)	(0.2413)
Village irrigation project * Year 2014	0.0907**	0.5200	-0.0188	-1.1329***
	(0.0437)	(0.4221)	(0.0593)	(0.2366)
Village road project	-0.0717***	1.0449***	0.2144***	-0.2506
	(0.0248)	(0.2500)	(0.0263)	(0.2551)
Village irrigation project	0.2486***	-1.6412*	0.2105***	3.4110***
	(0.0382)	(0.9906)	(0.0529)	(0.9484)
Time 2014 (year 2014=1, year 2011=0)	-0.0367	-0.5089***	0.0576*	0.1650
	(0.0245)	(0.1721)	(0.0315)	(0.1466)
Kinh (Kinh=1, ethnic minorities=0)	-0.0715**	-0.1397	-0.4364***	-0.1753
	(0.0321)	(0.2379)	(0.0462)	(0.2780)
Household size	0.0076**	0.0547**	0.0221***	0.0387***
	(0.0031)	(0.0213)	(0.0039)	(0.0124)
Age of household head	0.0008	0.0195	0.0032	-0.0162
	(0.0027)	(0.0124)	(0.0032)	(0.0131)
Squared age of household head	0.0000	-0.0002	-0.0000	0.0002
	(0.0000)	(0.0001)	(0.0000)	(0.0002)
Head is male	0.0461*	0.0246	0.0568*	0.2316**
	(0.0254)	(0.1222)	(0.0301)	(0.1052)
Head has vocational training or post-secondary	0.0295	0.1694	-0.0370	-0.0026
	(0.0720)	(0.2010)	(0.0719)	(0.2919)
Proportion of female members	0.1049***	0.1847	0.0257	0.0214
	(0.0380)	(0.2366)	(0.0446)	(0.2055)
Proportion of members with vocational training or post-secondary	-0.0076	-0.5141	-0.1552	-0.0860
	(0.0895)	(0.3555)	(0.1002)	(0.3536)
Commune with commune road project	0.0614***	-0.1663	-0.4550***	-1.5864***
	(0.0158)	(0.4030)	(0.0226)	(0.1588)
Commune with inter-village road project	-0.1781***	0.5094	0.4532***	2.1078***
	(0.0198)	(0.4546)	(0.0270)	(0.2341)
Commune with within-village road project	0.0311***	0.5781*	0.0827***	0.5016***
	(0.0103)	(0.3346)	(0.0132)	(0.1172)
Commune with bridge project	-0.0485***	-0.8330*	-0.2095***	-1.4488***
	(0.0138)	(0.4989)	(0.0206)	(0.2251)
Commune with irrigation project	-0.2243***	-0.1623	0.2688***	0.6016***
	(0.0152)	(0.3700)	(0.0189)	(0.1702)
Commune with market project	-0.1900***	-0.3444	0.0073	-1.1014***
	(0.0163)	(0.2120)	(0.0200)	(0.1989)
Commune with electricity project	0.0604***	0.1778	-0.1689***	-0.0652
	(0.0196)	(0.4492)	(0.0290)	(0.1517)
Commune has a Irish irrigation project	0.1407***	0.4190*	-0.2249***	-0.8530***
	(0.0248)	(0.2500)	(0.0247)	(0.2078)
Commune has a Irish road project	0.1057***	-1.2476**	-0.2929***	-1.1062***
	(0.0198)	(0.4861)	(0.0344)	(0.1848)
Province fixed-effects	Yes	Yes	Yes	Yes
Constant	-0.0715	5.3959***	-0.0245	5.2117***
	(0.0641)	(0.7804)	(0.0814)	(0.8841)
Observations	3,244	609	3,244	1,216
R-squared	0.298	0.378	0.316	0.570

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table A.5. Regressions oflivestock of households

Explanatory variables	The number of buffalo and cows	The number of pigs	The number of goats and sheep	The number of chicken	The number of ducks geese
Village road project * Year 2014	0.2647	0.4853	-0.1725	1.3959	1.9267
	(0.1890)	(0.4156)	(0.2783)	(2.2694)	(1.3844)
Village irrigation project * Year 2014	0.1047	2.5234***	-0.2061	7.0718**	-1.3716
	(0.2001)	(0.6909)	(0.3166)	(2.8219)	(0.9673)
Village road project	0.1982	-0.8964***	0.2376***	2.2304***	-1.3054**
	(0.1281)	(0.1686)	(0.0883)	(0.8307)	(0.5360)
Village irrigation project	-0.6136***	-1.7905***	0.4685***	-1.6613	5.7155***
	(0.1891)	(0.3578)	(0.1635)	(2.0959)	(0.7052)
Time 2014 (year 2014=1, year 2011=0)	-0.2490**	0.7724***	0.3525*	10.5312***	2.6680***
	(0.1226)	(0.2774)	(0.1860)	(1.3918)	(0.6403)
Kinh (Kinh=1, ethnic minorities=0)	-0.4013***	2.0969***	-0.0127	-0.0705	0.2570
	(0.1134)	(0.6639)	(0.0445)	(1.6154)	(0.7538)
Household size	0.2335***	0.1951***	0.0329**	0.8600***	0.1871***
	(0.0202)	(0.0297)	(0.0135)	(0.1379)	(0.0612)
Age of household head	0.0631***	0.0571***	0.0167*	0.1940**	0.0665
	(0.0134)	(0.0181)	(0.0087)	(0.0880)	(0.0439)
Squared age of household head	-0.0005***	-0.0006***	-0.0001	-0.0018*	-0.0007
	(0.0002)	(0.0002)	(0.0001)	(0.0010)	(0.0006)
Head is male	0.3439**	0.4578**	-0.0345	-0.0245	-0.7521
	(0.1335)	(0.2160)	(0.1604)	(1.1621)	(0.6353)
Head has vocational training or post-secondary	0.1007	-0.3869	-0.3259	1.4610	-0.0884
	(0.3986)	(0.4580)	(0.3062)	(2.4971)	(1.1103)
Proportion of female members	-0.0525	-0.0385	0.0983	0.3420	-0.6328
	(0.1864)	(0.4210)	(0.2343)	(1.8580)	(0.7572)
Proportion of members with vocational training or post-secondary	-0.2782	-0.1405	0.5278	-0.8516	1.8229
	(0.4974)	(0.5709)	(0.4760)	(4.2038)	(2.2316)
Commune with commune road project	0.0208	1.5871***	0.0315	0.3310	-2.4347***
	(0.0933)	(0.1809)	(0.0965)	(0.7619)	(0.3755)
Commune with inter-village road project	-0.3227***	-3.0835***	-0.1385	0.7394	1.6115***
	(0.1132)	(0.2439)	(0.1227)	(0.9098)	(0.4437)
Commune with within-village road project	-0.3087***	-0.9487***	0.0389	-0.7289*	0.0064
	(0.0614)	(0.1176)	(0.0596)	(0.4102)	(0.2006)
Commune with bridge project	0.4555***	1.7727***	-0.0716	0.7148	0.0203
	(0.0896)	(0.1907)	(0.0887)	(0.6064)	(0.3005)
Commune with irrigation project	0.2394***	-0.4566***	-0.0037	1.6296***	0.0583
	(0.0722)	(0.1156)	(0.0583)	(0.5857)	(0.2585)
Commune with market project	0.3714***	0.3827**	0.5304***	-1.5473**	-1.6445***
	(0.1100)	(0.1578)	(0.1934)	(0.6662)	(0.3155)
Commune with electricity project	-0.2623**	-0.3282*	0.1357	0.3753	0.4141
	(0.1167)	(0.1967)	(0.1452)	(1.0068)	(0.4716)
Commune has a Irish irrigation project	0.0170	0.9480***	-0.0957	-2.4710***	-3.0660***
	(0.1187)	(0.1586)	(0.0931)	(0.8823)	(0.3886)
Commune has a Irish road project	-0.4437***	1.9706***	-0.0431	-0.7732	-0.6455
	(0.1341)	(0.2212)	(0.0975)	(0.8988)	(0.6991)
Province fixed-effects	Yes	Yes	Yes	Yes	Yes
Constant	-0.5318	1.6748***	-0.5489*	10.3945***	-0.5876
	(0.3342)	(0.5666)	(0.3273)	(2.6578)	(1.0669)
Observations	3,244	3,244	3,244	3,244	3,244
R-squared	0.251	0.231	0.033	0.264	0.111

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table A.6. Regressions ofemployment of household members

Explanatory variables	Proportion of members working	Proportion of members having wage jobs	Proportion of members working in agriculture	Proportion of members working in industry	Proportion of members working in service
Village road project * Year 2014	0.0286	0.0094	0.0277	0.0230**	-0.0478***
	(0.0182)	(0.0216)	(0.0194)	(0.0093)	(0.0161)
Village irrigation project * Year 2014	0.0039	-0.0144	0.0141	0.0108	-0.0204
	(0.0216)	(0.0210)	(0.0197)	(0.0099)	(0.0166)
Village road project	-0.0202	0.0132*	-0.0189**	-0.0056	0.0270***
	(0.0131)	(0.0078)	(0.0095)	(0.0037)	(0.0085)
Village irrigation project	-0.0026	0.0078	-0.0022	-0.0100	0.0125
	(0.0254)	(0.0137)	(0.0162)	(0.0065)	(0.0140)
Time 2014 (year 2014=1, year 2011=0)	0.0143	0.0926***	-0.0725***	0.0096*	0.0528***
	(0.0118)	(0.0132)	(0.0137)	(0.0053)	(0.0123)
Kinh (Kinh=1, ethnic minorities=0)	0.0252	0.1702***	-0.4637***	0.0585***	0.4030***
	(0.0233)	(0.0403)	(0.0465)	(0.0196)	(0.0486)
Household size	-0.0304***	-0.0060***	0.0067***	-0.0003	-0.0076***
	(0.0023)	(0.0013)	(0.0016)	(0.0004)	(0.0014)
Age of household head	0.0206***	0.0028***	0.0046**	0.0005*	0.0022**
	(0.0023)	(0.0009)	(0.0022)	(0.0003)	(0.0009)
Squared age of household head	-0.0002***	-0.0000***	-0.0000**	-0.0000**	-0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Head is male	0.0306*	-0.0415***	0.1044***	-0.0124	-0.0441***
	(0.0172)	(0.0140)	(0.0202)	(0.0080)	(0.0146)
Head has vocational training or post-secondary	-0.1207***	-0.0104	0.0211	0.0187	-0.0461
	(0.0329)	(0.0388)	(0.0395)	(0.0154)	(0.0407)
Proportion of female members	-0.1621***	-0.0440**	0.0963***	-0.0199***	0.0045
	(0.0269)	(0.0211)	(0.0292)	(0.0075)	(0.0209)
Proportion of members with vocational training or post-secondary	0.2139***	0.6845***	-0.6681***	-0.0149	0.6968***
	(0.0440)	(0.0610)	(0.0612)	(0.0198)	(0.0606)
Commune with commune road project	0.0360***	0.0058	0.0143*	-0.0063**	-0.0060
	(0.0093)	(0.0071)	(0.0075)	(0.0028)	(0.0068)
Commune with inter-village road project	-0.0123	0.0031	-0.0057	0.0033	0.0073
	(0.0122)	(0.0072)	(0.0081)	(0.0034)	(0.0069)
Commune with within-village road project	-0.0263***	0.0051	-0.0065	0.0019	0.0051
	(0.0064)	(0.0042)	(0.0047)	(0.0020)	(0.0042)
Commune with bridge project	0.0309***	-0.0131**	0.0154**	-0.0013	-0.0169***
	(0.0094)	(0.0061)	(0.0069)	(0.0029)	(0.0060)
Commune with irrigation project	-0.0057	0.0118**	-0.0200***	-0.0019	0.0225***
	(0.0087)	(0.0056)	(0.0066)	(0.0024)	(0.0061)
Commune with market project	-0.0066	0.0067	-0.0074	-0.0006	0.0031
	(0.0088)	(0.0072)	(0.0078)	(0.0025)	(0.0074)
Commune with electricity project	-0.0406***	0.0019	0.0017	-0.0083**	0.0059
	(0.0126)	(0.0093)	(0.0100)	(0.0038)	(0.0092)
Commune has a Irish irrigation project	0.0151	-0.0019	0.0191**	0.0013	-0.0194**
	(0.0111)	(0.0073)	(0.0086)	(0.0028)	(0.0077)
Commune has a Irish road project	0.0355**	-0.0041	0.0112	0.0012	-0.0180*
	(0.0139)	(0.0102)	(0.0115)	(0.0050)	(0.0099)
Province fixed-effects	Yes	Yes	Yes	Yes	Yes
Constant	0.2943***	0.0236	0.7141***	0.0289***	0.0154
	(0.0593)	(0.0231)	(0.0662)	(0.0107)	(0.0245)
Observations	3,244	3,244	3,244	3,244	3,244
R-squared	0.221	0.402	0.449	0.067	0.459

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.

Table A.7. Regressions ofhouseholds' durable and appliance

Explanatory variables	Having access to safe water (yes=1, no=0)	Having mobile telephone (yes=1, no=0)	Having line telephone (yes=1, no=0)	Having motorbike (yes=1, no=0)	Having electric fan (yes=1, no=0)	Wealth index
Village road project * Year 2014	0.1116***	0.1222***	0.0675***	0.0598	-0.0828*	0.1712**
	(0.0421)	(0.0375)	(0.0240)	(0.0426)	(0.0431)	(0.0809)
Village irrigation project * Year 2014	0.2010***	0.0504	0.0972***	-0.0065	0.1010*	0.2486***
	(0.0503)	(0.0376)	(0.0272)	(0.0475)	(0.0536)	(0.0913)
Village road project	-0.1802***	-0.1445***	-0.1521***	-0.1887***	0.2855***	-0.4146***
	(0.0165)	(0.0332)	(0.0272)	(0.0320)	(0.0259)	(0.1026)
Village irrigation project	-0.2838***	-0.1389***	0.0709**	-0.2475***	0.0971**	-0.1957***
	(0.0288)	(0.0537)	(0.0298)	(0.0580)	(0.0461)	(0.0619)
Time 2014 (year 2014=1, year 2011=0)	0.4973***	0.1313***	-0.1515***	0.1351***	0.0851***	0.5503***
	(0.0292)	(0.0241)	(0.0157)	(0.0258)	(0.0267)	(0.0470)
Kinh (Kinh=1, ethnic minorities=0)	0.2733***	0.1620***	0.0357	0.2134***	0.3531***	0.7946***
	(0.0458)	(0.0414)	(0.0356)	(0.0394)	(0.0443)	(0.0893)
Household size	-0.0022	0.0333***	0.0055*	0.0335***	-0.0002	0.0620***
	(0.0026)	(0.0041)	(0.0032)	(0.0042)	(0.0039)	(0.0082)
Age of household head	0.0022	0.0132***	0.0037*	0.0201***	0.0127***	0.0435***
	(0.0018)	(0.0031)	(0.0021)	(0.0035)	(0.0029)	(0.0064)
Squared age of household head	-0.0000	-0.0002***	-0.0000	-0.0002***	-0.0001***	-0.0005***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
Head is male	0.0032	0.0345	0.0047	0.0965***	0.0104	0.1338**
	(0.0224)	(0.0313)	(0.0238)	(0.0334)	(0.0292)	(0.0629)
Head has vocational training or post-secondary	-0.0419	-0.0125	0.0179	-0.0348	-0.0671	-0.1187
	(0.0432)	(0.0423)	(0.0740)	(0.0522)	(0.0678)	(0.1191)
Proportion of female members	0.0127	0.0199	0.0066	-0.1063**	0.0423	-0.0383
	(0.0343)	(0.0453)	(0.0314)	(0.0475)	(0.0434)	(0.0909)
Proportion of members with vocational training or post-secondary	0.2365***	0.4230***	0.0292	0.4358***	0.5229***	1.3655***
	(0.0712)	(0.0571)	(0.0969)	(0.0740)	(0.0873)	(0.1603)
Commune with commune road project	-0.1363***	-0.0151	0.0617***	-0.1507***	-0.1112***	-0.3080***
	(0.0136)	(0.0222)	(0.0160)	(0.0214)	(0.0219)	(0.0436)
Commune with inter-village road project	0.2496***	0.0479	0.0662***	0.1664***	0.0314	0.3702***
	(0.0168)	(0.0301)	(0.0198)	(0.0287)	(0.0228)	(0.0544)
Commune with within-village road project	0.0026	0.0010	-0.0868***	-0.0303*	0.1116***	0.0502*
	(0.0083)	(0.0158)	(0.0132)	(0.0156)	(0.0128)	(0.0292)
Commune with bridge project	0.0051	0.0240	0.0872***	0.0797***	-0.1979***	-0.0487
	(0.0124)	(0.0239)	(0.0186)	(0.0236)	(0.0190)	(0.0438)
Commune with irrigation project	0.0692***	0.0993***	-0.0056	0.2135***	-0.1011***	0.2429***
	(0.0131)	(0.0207)	(0.0117)	(0.0182)	(0.0174)	(0.0384)
Commune with market project	-0.0173	0.0320	0.0151	0.0810***	0.1485***	0.2235***
	(0.0133)	(0.0226)	(0.0205)	(0.0242)	(0.0234)	(0.0486)
Commune with electricity project	-0.3166***	-0.0447	-0.0722***	-0.1312***	0.0952***	-0.2647***
	(0.0176)	(0.0288)	(0.0199)	(0.0268)	(0.0273)	(0.0553)
Commune has a Irish irrigation project	-0.0157	-0.1333***	-0.0424*	-0.2488***	0.0355	-0.3435***
	(0.0143)	(0.0284)	(0.0223)	(0.0278)	(0.0248)	(0.0570)
Commune has a Irish road project	0.3287***	-0.0223	0.0830***	-0.0479	-0.2125***	-0.0549
	(0.0212)	(0.0371)	(0.0284)	(0.0359)	(0.0317)	(0.0697)
Province fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.1628***	0.3487***	-0.1710***	0.1847**	-0.1561**	-1.2748***
	(0.0460)	(0.0845)	(0.0551)	(0.0922)	(0.0738)	(0.1676)
Observations	3,244	3,244	3,244	3,244	3,244	3,244
R-squared	0.587	0.159	0.103	0.227	0.370	0.334

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: The 2011 RAFC and the 2014 Project Survey.