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Impact Evaluation of a Rural Road Rehabilitation Project

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Abstract

Assessing the welfare impacts of rural roads poses a number of problems, with implications for data collection and evaluation methods. The paper reports on a study being conducted to assess the impacts on living standards of a World Bank rural road rehabilitation project in Viet Nam. The evaluation approach combines double differencing with propensity score matching. Subject to a number of caveats, preliminary findings suggest impact on road quality in the project communes along with a shift in rehabilitation efforts from earth to sealed roads. We find that the project was to some extent targeted to poor communes and that time savings were most pronounced for the poorest households.

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1 Introduction

Rural roads are being extensively championed as poverty alleviation instruments by the World Bank and donor institutions. It is argued that rural roads are key to raising living standards in poor rural areas (for example see Gannon and Liu, 1997). Claims have also been made that by reducing isolation, better roads reduce vulnerability and dampen income variability. Yet despite a general consensus on the importance of rural roads, there is surprisingly little hard evidence on the size and nature of their benefits, or the distributional impacts. This paper aims to contribute to knowledge on these issues by assessing the first-round impacts of a World Bank-financed rural transport project in Viet Nam.[1]

It is hard to disagree with the proposition that providing people with access and lines of communication to the rest of society is beneficial. But so are many other goods and services that require government intervention. An aid donor faced with a limited budget needs to know more in order to make informed decisions between a road or, say, an education intervention — also believed to have considerable impacts on well-being.

Furthermore, even if donors agreed that roads are needed most, it remains unclear that externally funded road financing will actually improve roads, given aid fungibility.[2] The recipient government has its own preferences over spending, and may not agree that roads are the highest priority. Then the government may simply cut its own funding of roads in response to the external aid. In the extreme fungibility case, all external funding for roads goes into consolidated spending and there is no earmarking for roads per se.

[1] The Viet Nam Rural Transport Project I, see World Bank (1996) for details.
[2] Note that the arguments given here concerning roads and fungibility apply to all sectors.

One then expects an income effect of the extra aid on road (and other) spending, but no differential impact on project communes.

At the other extreme, one can imagine cases in which road spending is even higher in project areas due to the government's responses. This can happen when the government agrees that roads are the highest priority but donors only permit low-cost construction methods for rural roads (a not uncommon situation). The government would prefer a more expensive technology and so uses its own spending to top up the project spending. This results in a kind of multiplier effect in the project communes. Or there may be other responses at local level, such as when labor inputs are supplied locally and are fixed; the project funds may then encourage a switch in local road rehabilitation efforts away from more labor intensive techniques (more sealed roads than unsealed roads, for example). The paper's evaluation of road project impacts allows a test of these behavioral responses to aid financing of development projects.

There have of course been other attempts at assessing rural road impacts (see Grootaert's, 2001, review of alternative approaches). But, in recent years, research has newly underlined the enormous difficulties inherent in estimating the magnitude of the effects attributable to infrastructure. Most studies can be faulted in one or more ways. Problems arise due to the endogeneity of much infrastructural development and the many other factors that are at work (see Binswanger et al. 1993, Grossman 1994, Jalan and Ravallion 1998). Not allowing for initial conditions and the way in which infrastructure is allocated to specific regions will tend to bias impact estimates, often downwards in poor areas. The analytical methods used in the past have tended to share a number of weaknesses. The most common criticisms of past impact evaluations of roads are that

they did not have appropriate controls, that they did not follow projects long enough to capture full impacts, and that the results were not likely to be robust to unobserved factors influencing both program placement and outcomes.

This study was designed to avoid these drawbacks, within the constraints facing the evaluation. A special panel data set was created of communes and households within those communes. The study aims to throw light on impacts of rural roads, as an input to policy discussion about how best to allocate scarce public resources. This paper reports on an interim analysis of the baseline and first post-project data bases to explore first round effects. In addition to being based only on one round of post-project data, the present analysis is also constrained by a small sample size of completed projects. We therefore leave the exploration of certain interesting issues — those, for example, that require disaggregation across the treatment communes — for a later stage of the study, to be undertaken with the final round of data to be collected in 2003.

The paper first discusses evaluation issues that are specific to rural road impact evaluation. This is followed by a brief description of the project being evaluated and the rural Viet Nam country setting. Section 4 describes the survey instrument, while section 5 discusses descriptive statistics. The next section presents the methods used for evaluating impacts. Sections 7 and 8 turn to discussions of some first-round commune and household level impacts. A final section concludes.

2 General issues in assessing impacts of rural roads

The benefits of roads are indirect and dependent on interactions with other investments, other social and physical infrastructure, geographical, community and

household characteristics. Further, roads and road networks are widely believed to have economy-wide effects. Finally, roads are clearly not randomly placed, and it is highly likely that the factors that led to the road placement will also affect outcomes.

What are the implications for evaluation? Clearly, one must control for the heterogeneity of factors that jointly influence outcomes and road placement. However, if there are indeed economy-wide effects from roads, then a lot of what one sees as potential controls for heterogeneity may well have themselves been determined by the road investment. Traditional evaluation methods such as instrumental variables or propensity score matching ex-post cannot be relied upon since observable characteristics may be contaminated by the effects of the project. Even when lots of data are available, much of what we see in the data is plausibly determined by the road. This is an important problem in road evaluations and leads us to be pessimistic about conducting a worthwhile road impact evaluation without baseline (pre-intervention) data.

The fact that roads are targeted geographically (to communities) suggests a problem of endogeneity of program placement. Roads are built (or rehabilitated) in certain locations and not in others for a whole host of reasons. For example, because an area is deemed to have economic potential or because it has a strong political constituency. Unless we can control for those reasons, impact measures will be biased. There is also likely to be an endogeneity problem when looking at impacts at the individual level (e.g., the users). This is because there are likely to be individual characteristics that are unobserved but geographically determined and correlated with the things that influence program placement. The potential for randomization to evaluate roads and deal with these issues seems low, if for no other reason than that the full

impacts of a road intervention may take a long time to play themselves out. The second phase might thus have to be delayed beyond what would ever be acceptable.

Little is known about the distributional impacts of rural road investments. There is a real possibility that in addition to gainers there will be losers, as there almost always are with policy change. On average, benefits may well be positive but it is key to understand who the losers are if one is to understand distributional impacts, and the heterogeneity of impacts at given levels of living. For example, if new roads lead to higher land values there may be a tendency towards land concentration and landlessness. Those with greater initial land, education, wealth or influence will be better able to take advantage of the changes. The distribution of current income and future income earning opportunities may widen. There will almost certainly be a reduction in common property resources which may hurt the poor the most. As cheaper goods are brought in, there may be traditional job displacement. Of course, one needs to make a distinction between short and longer term impacts. In the longer term even initial losers may win. But this is an empirical question. It is therefore important to collect data that allows one to distinguish impacts across groups and to follow the experience of those groups long enough after the road is built so that the full effects can be understood.

An assessment of impacts will also need to allow for the heterogeneity in the condition of the roads before rehabilitation, as well as in their post-rehabilitation situation.[3] The impacts from rehabilitating a road to allow all weather four wheel drive can be expected to be quite different for a road that was previously never passable by motor-vehicle, than for one where four wheel drive was possible in dry weather. One way to capture this heterogeneity is to report the impacts disaggregated by the level of

road rehabilitation. We have a project database with information on the pre- and post-works road condition that will eventually be used to do so. Unfortunately our sample is too small at this time to allow reliable estimation of disaggregated commune impacts.

An issue also arises in defining the zone of a road's influence and the data collection domain. Where do we look for impacts? In practice, this decision is likely to be influenced by the practicalities of the evaluation and data collection. Road links in the project to be assessed all pass through communes, and a majority link up commune centers—where facilities and services are located—with the road network. Data are often, and more easily, collected at the commune level in Viet Nam. For these reasons, the zone of a road's influence is defined as the commune through which the road passes. This may not be ideal but it makes sense given the constraints faced.

Finally, the evaluation of road impacts needs to deal with the issue of externalities. Suppose commune *A* does not have a project, but its neighboring commune *B* does. There may well be positive externalities to Commune *A* from the project, or so-called 'contamination' if commune *A* is a comparison commune. Alternatively, the local authorities may decide that for the sake of fairness, commune *A* should get a higher share of local spending on infrastructure since it is not benefiting from the national road rehabilitation project. This too is a kind of externality that one needs to watch out for in assessing rural road project benefits.

[3] The evaluation of longer-term impacts will also need to allow for the level of road maintenance.

3 The setting and project

Viet Nam has poor physical infrastructure and high levels of income poverty (van de Walle 1998). Many have argued that basic infrastructure investments, and rural roads specifically, will reduce poverty in Viet Nam. The country only recently came out of a long period as a planned market economy where production was organized around cooperatives in agriculture and in State Owned Enterprises (SOE) in other sectors. Viet Nam began to adopt a market economy in 1987 and has since been experiencing remarkable changes in all aspects of economic life. The last decade has seen considerable—though geographically unequal—growth. There have been rising opportunities and rising mobility. Labor and land markets are just now developing, as are the legal and judicial systems governing private property. Government policy and public finance have also had to adapt to become more conducive to the new economic framework. The key issue for evaluation is to succeed in isolating impacts due to the road as opposed to the myriad other changes and shocks hitting the economy and simultaneously affecting living standards. This is the crux of the problem in all impact evaluations. But the magnitude of the difficulties can be expected to be larger in present day Viet Nam.

The Viet Nam Rural Transport Project I (RTPI) is a large-scale rural roads rehabilitation project aiming to reduce poverty (World Bank 1996). It was launched in 1997 for implementation in 18 poor provinces over 3 to 5 years, at a cost of about $61 million. It aimed to rehabilitate 5,000 kilometers of roads—including 3,500 and 1,500 of district and communal roads respectively. In each participating province, road links are

identified for rehabilitation through least cost techniques.[4] Originally, the project strategy was to identify specific locations along the road link that restrict accessibility and carry out low-cost spot improvements. In practice, a more complete rehabilitation standard was generally enforced. No 'new' roads are built although the prior existence of a road does not in any way imply that it was usable. In many cases, bridges are missing and whole road sections are impassable by a motor vehicle for much of the year. A proposed road is eligible for the project subject to average investment costs being no more than $15,000 per km and the population served being at least 300 people per km. Bridges are also eligible for rehabilitation, based on the priority assigned to the road and construction costs being less than $50,000.

Two levels of access were aimed for under the project: 'reliable access' providing relatively consistent and safe access with only short-term road closures (due to bad weather); and 'minimum access' which provides basic and essential access to local populations, although with longer closures than under 'reliable access.' Roads appear to have been rehabilitated more often to the former standard. It should also be noted that, in an effort to extend project benefits to low density, mountainous areas with concentrations of ethnic minority populations, twenty percent of each province's rehabilitation funds can be set aside for roads not justified under the population and cost criteria. In practice, it appears that few roads have been chosen under these 'social' criteria, at least initially.

Table 1 provides some summary data on the projects that were completed by March 1999 and are the focus of our analysis here. In some cases, one project covers a number of communes that are in our database. As can be seen, only one sub-project had

[4] Least cost techniques refer in this project to the minimum cost engineering solution that ensures a certain level of motorized passability.

been completed in time in Binh Tuan and none in Kon Tum to be included in this analysis. The sample also contains a few projects chosen under the social criteria.

It should be noted that RTPI is implemented against a backdrop of large increases in the road network and infrastructure development throughout the country during the 1990s. This points to the importance of not relying on reflexive comparisons (tracking gains solely in project communes) but introducing instead a comparison group.

4 The SIRRV data

We use a data set that was especially created for analyzing the impact on living standards of the rural roads constructed under RTPI, aiming to avoid the drawbacks of previous studies. The "Survey of Impacts of Rural Roads in Viet Nam" (SIRRV) is a panel data set of pre-project baseline and post-project data for both project ("treatment") and non-project ("comparison") areas. The data were collected in six out of the 18 provinces that are included in RTPI. The provinces were randomly picked to be representative of Viet Nam's 6 geographical regions. There are thus two provinces each from the north (Lao Cai and Thai Nguyen), the center (Nghe An and Binh Thuan) and south (Kon Tum and Tra Vinh) of the country.

In each of these provinces, samples of project and non-project communes were drawn for a total of 200 surveyed communes. The Ministry of Transport had not yet finalized the list of approved projects or the sub-project implementation schedule by the time we needed to sample and begin data collection. In each province, all districts that did not have a project proposal prior to March-April 1997 were excluded; the remainder covering 38 districts in the chosen 6 provinces, were considered as potential survey areas.

The project communes were therefore randomly selected from lists of all communes with proposed projects in each province. A list was then drawn up of all remaining communes in districts with proposed sub-projects from which a random sample of non-project communes was drawn. The sampled 200 communes were located in 29 of the possible 38 districts.

Ideally, comparison communes differ from the treatment group only in so far as they do not receive an intervention. However, we did not at the time have the requisite data to make informed choices on ideal controls. (The data being collected for this study is in part for the purpose of choosing a comparison set.) For practical and logistical reasons, it was also desirable to limit the field work to certain regions. The strategy was therefore to pick potential comparison communes in the vicinity of, and indeed in the same districts as, the treatment communes. Districts are large, and although contamination from project to non-project commune seems unlikely to occur, this needs to be carefully checked.

The comparison areas chosen this way should share many of the same characteristics as the project areas. However, we cannot be confident that they are a good comparison group on a priori grounds. For this reason, we use matching techniques based on the data collected for the evaluation to test the selection of comparison groups. Any communes from the set of selected non-project communes with unusual attributes (relative to the treatment communes) can be deleted from the comparison group.

As noted, project sites were only approved after we had sampled. One unexpected outcome is that many of our sampled project areas did not get a planned project by the time the second SIRRV round was implemented. Indeed, using a cut-off of

completion prior to March 1999 for this analysis of first round impacts, we only have a sample of 25 communes with completed projects. One small advantage of this delay is that the communes still awaiting projects can also be used as comparison communes.

A detailed commune-level data base was created in part by drawing on annually collected records—both current and retrospective—at the commune level and augmenting with various other key supplementary data. This approach is feasible in Viet Nam as there is a tradition of data collection at the local level. Each commune appoints one or more 'statisticians' whose role it is to collect and maintain certain types of information, such as pertaining to demographics, land use, distribution and production activities. There is some concern that the reliability of these data varies across communes according to average levels of living standards and education. Another concern is with Viet Nam's tendency to compile statistics that conform to pre-determined 'plans.' To minimize these potential problems, we will focus on data that is likely to be less vulnerable to these problems and rely on household level data for these other factors. The commune questionnaire includes sections on general commune characteristics, infrastructure, employment, sources of livelihood, agriculture, land and other assets, living conditions, education, health care, development programs, community activities and organizations, commune finance and prices.

Three other surveys were conducted in addition to the commune survey. In each sampled commune, a household questionnaire was administered to 15 randomly sampled households. Since the sample size is small, and there was no feasible method of instructing interviewers on which households to pick in advance of going to the commune, there was a concern that the samples may not be representative of the main

socio-economic groups in the commune. For example, the interviewers might avoid the poorest. Since the study is concerned with impacts on poverty and distribution, ensuring that sampled households came from different positions in the distribution of income was deemed important.

To deal with this concern, a system of stratified sampling was used whereby 5 households were chosen from each of three administrative lists, containing the poorest, middle and richest thirds of all households in the commune. The lists were based on a welfare ranking done by the commune authorities. Clearly, these rankings are to some extent subjective, but stratified sampling on this basis should assure a sample that is reasonably representative of each commune's main socio-economic groups.

Households were asked about general characteristics, employment, assets and amenities, production and employment activities, participation in and access to education, health, markets, credit, community activities, social security and poverty programs, and transport. The commune and household questionnaires are primarily quantitative although both also include some qualitative questions.

The main objective of the household survey is to capture information on household level access to various facilities and services and how this alters over time. No attempt is made to measure a household level indicator of welfare such as income or consumption expenditures. This decision reflects a careful weighing of the constraints faced by the survey instrument and the severe difficulties involved in collecting reliable welfare information. However, a large number of questions were included that replicate questions in the Viet Nam Living Standards Measurement Survey (VNLSS), the only nationally representative household survey for Viet Nam. As described below, using

information on household characteristics common to both surveys, we use regression techniques to combine the data and estimate where each household fits in the national distribution of welfare.

"Communes" belong to "districts" that belong to "provinces" in Viet Nam. A short district level survey was implemented to help put the commune level data in context. This includes information on population, land use, the economy, infrastructure, social indicators and prices. Finally, as road project impacts will vary according to the magnitude of the change resulting from a project as well as the method of project implementation, a project level database for each of the project areas surveyed is also constructed.

The baseline data collection began in June of 1997 in the 200 randomly sampled communes. A second round followed in the summer of 1999, and a third in the summer of 2001. Ideally, a fourth round will follow in 2003.

Each SIRRV round tracks the implementation process followed for previous rounds of data collection as closely as possible. The same in-country (Vietnamese) study supervisor has been responsible for overseeing and running the entire survey effort. Six Vietnamese survey experts and teams conduct the surveys in the six provinces. They undergo careful training before each round. Many interviewers have worked on more than one round. Local staff needed to help with contacting local authorities and to assist with interviews, guides and interpreters are hired as needed. Three to four days are needed for each commune, though communes with worse data may require more time and effort. The time spent in the field is around 100 to 140 days (4 to 5 months) for each survey round

Communes and households surveyed are the same in each round. Surveying begins simultaneously in each province, and coverage of districts is timed across months to coincide as much as possible with the schedule followed during the baseline. However, the weather has posed some problems. Severe flooding caused by a typhoon in Binh Tuan and an especially bad monsoon in Kon Tum during the summer of 1999 delayed the survey implementation by a few months in these two provinces.

As noted, we also make use of the 1997/98 Viet Nam Living Standards Measurement Survey (VNLSS), a detailed household consumption and income survey, to predict consumption expenditures for SIRRV households. Using data from the VNLSS survey, the log of real per capita expenditures is regressed on a large series of household characteristics that can be expected to be highly correlated with household consumption and also exist, similarly defined, in the 1997 SIRRV household data.[5] The fit is good.[6] The regression coefficients are then used to predict real 1998 log per capita consumption expenditures for the 1997 SIRRV households using the corresponding variables in the SIRRV. Mean predicted log per capita expenditures for the SIRRV sample is 7.634 (with a standard deviation of .41). When the same coefficients are combined with the 1999 SIRRV household data, the mean predicted log of consumption is 7.732 (with a standard deviation of .45). The results from this procedure allow us to draw out implications for household level welfare indicators and rank the SIRRV households into welfare groups.

[5] The included variables are household durables and farm equipment; area of different types of land; housing size, construction, and amenities such as water and fuel source; household demographics, such as household size, the head's gender, ethnicity, marital status, and employment status, and years of education. A dummy variable for urban-rural location is also included.

[6] Corrections are made for heteroscedasticity and sample clustering using the STATA robust and cluster commands. The adjusted R^2 is .70, the Root MSE is .32694, the F(69, 193) is 129.89, and n=5999. Actual mean log per capita consumption is 7.845 (with a standard deviation of .59) and the predicted (or fitted) value from the regression is 7.889 (with a standard deviation of .52).

The information contained in the first two rounds should allow an assessment of initial impacts, though we are hampered by a small sample size of completed projects. At any rate, it will be necessary to look at the third and fourth rounds before drawing conclusions about the longer-term impacts.

5 Descriptive statistics

It should be noted that since the non-project communes were chosen specifically to be as similar as possible to the project communes, they can not be used to assess project targeting. This would require a nationally representative random sample of communes to see whether those selected to receive the project differ in systematic ways.

However, by combining the SIRRV household data with that of the nationally representative 1998 VNLSS as described above, we can say something about where in the distribution of national welfare the population represented by the SIRRV household sample in project communes falls. This also allows us to make some inferences about the project communes.

The last column of Table 2 shows the distribution across national population deciles of baseline SIRRV (project commune) households weighted by household size and ranked by their predicted per capita expenditures. This can be compared to the distribution of Viet Nam's rural population in the third column. The table shows that a greater percentage of the SIRRV population is found in the bottom deciles and the incidence of poverty is higher at 47.5 percent compared to 40.2 for the total rural

Vietnamese population and 32.9 for Viet Nam as a whole.[7] So, there are definite signs of project targeting to areas with poorer population groups.

That said, the project is also likely to benefit some wealthier households. Indeed, instead of asking how the project has performed in reaching poor households compared to what one would expect with a random distribution across the overall rural population, one might ask how much better it might have done by targeting the poorest communes. Suppose, for example, that the project had aimed to target communes with the lowest mean consumption. To test this, we identify rural communes in the VNLSS with the lowest mean household per capita consumption and covering around 40 percent of the rural population which is the rural poverty rate. How well one reaches poor households through targeting poor areas depends on the heterogeneity and inequality within those areas. Column 3 gives the weighted distribution of households living in those communes. The incidence of poverty at 65 percent is evidence of substantial though not a complete concentration of poor households. Geographical targeting would still lead to 35 percent leakage to the non-poor. But, contrasting with column 4 in Table 2, it is clear that the project could have done a whole lot better from the point of view of reaching poor households by better targeting the poorest areas. Of course, whether or not rehabilitating roads in these areas would have the greatest impact on poverty is a different question.

Next, we examine simple descriptive statistics on baseline characteristics for our 25 project and 103 non-project commune samples.[8] This helps give some feeling for the

[7] We use the national poverty lines for 1998 described in Glewwe et al. (2000). Our poverty rates differ because we use the best available measure of consumption for 1998 whereas Glewwe et al. use an alternative measure that is more appropriate for making comparisons with the 1993 VNLSS.

setting, and also allows a judgment of how similar the 25 project communes are on average to the non-project communes.

Table 3 indicates little difference with respect to average distances in kilometers from their commune centers to a national or provincial road, the closest big city, railway or waterway. The only statistically significant difference is in how far the closest district center is (14 versus 10 km for non-project versus project communes). Turning to road endowments in Table 4, we again find no statistically significant differences in terms of total kilometers of communal roads, and kilometers of communal roads built or rehabilitated during the past three years. The two samples appear to be very similar. Table 5 finds the same for baseline statistics on distances and time taken to reach various facilities and services.

6 Evaluation methodology

Our approach combines double differencing with propensity score matching methods. Matching methods are used to select ideal comparison communes from among the one hundred sampled non-project communes. The impact of the road infrastructure is then identified by the difference between outcomes in the project areas after the program and before it, minus the corresponding outcome difference in the matched comparison areas. This "matched double difference" estimate will give an unbiased estimate of project impacts in the presence of unobserved time invariant factors influencing both the selection of project areas and outcomes.

[8] As a result of changes by the Ministry of Transport after the study's sampling and baseline data collection, the dataset now contains 97 project and 103 non-project communes.

We use propensity score matching (PSM) to construct comparison groups for the project communes. PSM finds a non-project commune that is similar in observed covariates to the project commune. The mechanics of PSM involve comparing the propensity scores – the predicted probability of a commune getting a project – of project and non-project communes (Rosenbaum and Rubin, 1983, 1985). A non-project commune whose propensity score is the "closest" to the propensity scores of a project commune is declared to be a matched comparison commune for that project. Once the matched comparison group is constructed, the mean impact estimate is the difference between the project (treatment) and the matched comparison communes in the different outcome indicators associated with the project.

In technical terms, suppose there are two types of communes: those that have a road project (D_i =1) and those that do not (D_i=0). Communes with projects (treated group) are matched to those without (comparison group) on the basis of the propensity score. The population propensity score for commune *i* is defined as:

$$P(X_i) = Prob(D_i = 1 | X_i) \qquad (0 < P(X_i) < 1)$$

where X_i is a vector of pre-project explanatory variables. Rosenbaum and Rubin (1983) show that if (i) the D_i's are independent over all *i*, and (ii) outcomes are independent of project participation given X_i (i.e. unobserved differences across the treated and the comparison groups do not influence being in a specific group), then outcomes are also independent of project participation given $P(X_i)$, just as they would be if participation is assigned randomly.[9] PSM uses $P(X)$ or a monotone function to select comparison

[9] Assumption (ii) is sometimes referred to in the literature as the "conditional independence" assumption, and sometimes as "strong ignorability."

subjects for each of those treated. Exact matching on $P(X)$ implies that the resulting matched comparison and treated subjects have the same distribution of the covariates. PSM thus eliminates bias in estimated treatment effects due to observed heterogeneity.

The propensity score must be estimated. Here we follow the common practice in PSM applications of using the predicted values from a standard logit model to construct the propensity score for each observation in the treatment and the non-project samples.[10] Matched-pairs of communes are then constructed on the basis of how close the estimated scores are across the two samples. The nearest neighbor to the *i*'th project participant is defined as the non-project that minimizes $[P(X_i)- P(X_j)]^2$ over all j in the set of non-projects. Matches are only accepted if $[P(X_i)- P(X_j)]^2$ is less than 0.001.[11] We end up with 22 matched pairs, as three project communes were lost because suitable matches could not be found.

In calculating the average outcome indicator of the matched non-participants several weighting schemes can be used, ranging from "nearest neighbor" weights to non-parametric weights based on kernel functions of the differences in scores (Heckman et al., 1997).[12] We use the nearest neighbor estimator, which takes the outcome measure of the closest matched non-participant as the counter-factual for each participant.[13]

So far, the above assumes that only cross-sectional data is available. However, we have pre-project (baseline) and post-project data for the same communes. This allows

[10] Dehejia and Wahba (1999) report that their PSM results are robust to alternative estimators and alternative specifications for the logit regression.
[11] We experimented with more stringent tolerance limits and the results were robust. However, with more stringent limits we also had to discard more participants while calculating our impacts. Given that we start with only 25 project communes, we chose to report the results pertaining to a tolerance limit of 0.001.
[12] Jalan and Ravallion (2001) discuss the choice further, and find that their results for estimating income gains from an anti-poverty program are reasonably robust to the choice.
[13] Rubin and Thomas (2000) use simulations to compare the bias in using the nearest five neighbors to just the nearest neighbor; no clear pattern emerges.

us to implement a panel data difference-in-difference matching estimator. Here, the idea is to take the difference in the impact estimators across the two periods and across the matched project and non-project communes. An advantage of having panel data is that it allows us to control for idiosyncratic unobservables that may influence selection into the program. (This is the standard sample selection problem on unobservables in the econometrics parlance). This is not feasible with cross-section data. Assuming that these unobservables can be represented as a time-invariant error component, selection bias can be eliminated by taking first differences over time. Propensity score matching using panel data also allows us to separate the impact of the roads from the general economic development which would have happened had there been no roads project.

Let Y_{it}^{k} be the outcome observed for commune i in time t=(0,1) with participation status k (taking the value 1 for participants and 0 otherwise). The difference in mean outcomes between the n treatment communes and the n matched comparison communes in the baseline is

$$\sum_{\substack{i=1 \\ \{D_i=1\}}}^{n} [Y_{i0}^{1} - Y_{i0}^{0}]/n \qquad (1)$$

where Y_{i0}^{0} is the value of the outcome indicator for the nearest neighbor to i among the non-participants at date 0. The corresponding difference found in the second (follow-up) survey is:

$$\sum_{\substack{i=1 \\ \{D_i=1\}}}^{n} [Y_{i1}^{1} - Y_{i1}^{0}]/n \qquad (2)$$

in obvious notation. Then the difference-in-difference (DD) matching estimator is simply the difference between (2) and (1), namely:

$$DD = \{ \sum_{\substack{i=1 \\ \{D_i=1\}}}^{n} [Y_{i1}^{1} - Y_{i1}^{0}] - \sum_{\substack{i=1 \\ \{D_i=1\}}}^{n} [Y_{i0}^{1} - Y_{i0}^{0}] \} / n \quad (3)$$

So far we have discussed matching at the point at which the intervention takes place. That is, under the project, communes were chosen in which roads and missing bridges were to be rehabilitated and/or repaired. Thus we match communes with road projects to communes without projects. However, even though the (treatment) program is the same for all households living in the commune, the program benefits may differ across households within the commune conditional on the importance of a passable road in the household's welfare function. To get at this heterogeneity of impacts across households within matched communes, we implement a second matching where we match households in project areas to households in non-project areas but within matched communes. That is, if commune *A* is matched with commune *B* from our first-stage matching, in the second stage, we match households in commune *A* to households in commune *B*. The main reason for implementing this second matching stage to get at household impacts is that we lack a household census within the matched communes. The SIRRV only samples 15 households within each commune. One would expect some sampling error and/or selection problems at the household level that could in turn bias the impact estimator. To circumvent this bias we resort to a household level matching within previously matched communes. The mechanics of matching are identical to that described earlier.

7 Commune level impacts

Table 6 presents the estimates from the logit model of commune participation. The dependent variable takes the value one for communes that had a project and zero for those that did not. We control for geographical characteristics, ethnicity, population density, availability of different infrastructure and a few other measures of population characteristics (households with war invalids, disabled population and homeless households). There are few significant explanatory variables. Communes in the plains and in the uplands were less likely to get a project than coastal ones. The presence of a waterway reduced the likelihood of a project, while it was enhanced by a greater number of households with war invalids and disabled individuals. Figure 1 shows that there is significant overlap in the kernel density of the estimated propensity scores for project and non-project communes. The match is quite good. It should be noted, however, that because the sample is so small, we are unable at this stage to control for as many observable characteristics of the communes as we would ideally like.

Tables 7 to 12 provide matched double difference estimates of impact at commune level for a varied set of outcome indicators. Under our assumptions, these estimates reflect causal effects of the road rehabilitation. In looking at the results, however, it is important to keep two caveats in mind. First, remember that little time has elapsed since most projects were completed. It is only 15 months on average (ranging from a minimum of 6 to a maximum of 20 months) between project completion and the start of data collection. Second, our sample is relatively small at 25 communes with completed projects, and only 22 matched commune pairs.

All (double difference) impact estimates represent the before and after mean change in the outcome variable in the project communes over and above the before and after mean change in the matched non-project communes. The tables also present the breakdown of this impact into the change that occurred over time in the project and non-project comparison communes separately. One or two stars indicate whether each change is significantly different from zero (at the 5 and 10 % significance levels respectively). In the discussion below, we focus on the statistically significant impact estimates.

The impacts reported in Table 7 are related to kilometers of rural roads in the commune and missing bridges.[14] There was a reduction in the percentage of project communes with missing bridges. However, the reduction was larger in the non-project communes producing an overall net impact of 4.5 percent more communes with missing bridges. Kilometers of all weather paved roads and earth roads — due to either new construction or rehabilitation — have each increased by 2 km on average more in the project than in the matched comparison areas, while the length of paved, sometimes impassable, rural roads has declined relatively. There are also significant positive impacts on the kilometers of paved all weather and sometimes impassable communal roads that were rehabilitated over the past two, relative to the prior two years. Indeed, the bulk of the gain in paved all-weather roads occurred in the last two years.

By contrast, the results indicate a considerable reduction in efforts to rehabilitate earth roads in the project compared to the non-project communes. During the last two years, around six and four kilometers less of all weather and sometimes impassable earth roads were rehabilitated in the intervention compared to the comparison communes.

[14] Note that "rural" roads refers to commune as well as district level roads that pass through the commune.

These results suggest that the Bank's project caused a shift in road rehabilitation efforts from earth roads to paved roads within project communes. A plausible interpretation for this is that labor resources for rehabilitation are fixed within communes and what the project provides is the extra money needed for non-labor inputs.

So, we can reject a case of extreme fungibility. The government could have simply cut its own road spending, with little net gain in project communes relative to non-project communes. However, the results of Table 7 clearly indicate that the project has had impact on road quality in the selected communes. This externally financed road project does appear to have achieved its immediate aims, though possibly at the cost of a switch away from earth road rehabilitation. But are there signs of impacts on living standards?

Table 8 turns to transport-related variables. We find that there was a 9 percent increase in access to freight transport services as a result of the project. However, no impact on passenger transport services can be attributed to the project. Still, the occurrence of daily bus service has risen (though not significantly so), and 'other' daily passenger services (boat, horse cart or railroad) are now available in 5 percent more of the project relative to the comparison areas. By contrast, the daily availability of two or three wheel motorcycle service shows a significant reduction in 13 percent of project communes relative to the comparison group. This may well reflect substitution to cheaper alternatives such as horse cart or bus service, that were not previously feasible due to the bad road condition. Furthermore, it is also highly probable that there has been substitution with freight transport services that allow transport of people along with their produce or belongings.

The percentage of project communes reporting that bad road conditions act as an important constraint to communication between households and participation in the activities of the mass organizations has declined, and the percentage now saying that road conditions present only minor, or no problems, has risen. However, similar patterns are evident in the non-project communes too, with the one exception of the percentage saying that road conditions cause small problems which has declined.

We would expect rapid impact on the time it takes to get to key destinations as long as they remain fixed. It will simply be faster to get anywhere the road can be used to get to. Reductions in travel time may also occur due to facilities and services relocating closer to the commune center as a direct result of better access. However, the opposite can also happen — facility relocation after the road improvement may increase travel times. This is more plausible for some things than for others. A small stall, set up as an outlet of a larger store elsewhere, can more easily relocate than a health clinic, say. Some "facilities" (such as natural resources) cannot relocate.

The impact results on the time taken to various destinations given in Table 9 are mixed.[15] Access to the forest for the collection of firewood appears to have become less time-consuming. In response to whether the average time needed has risen, stayed the same or fallen, the percent of communes claiming a rise dropped by 36% more in the project communes, while those claiming no change or a fall, rose by 27 and 5 percent more.

There is an impressive and statistically significant decline in the time required to reach the closest provincial hospital by the most common transport mode in case of a

[15] Note that the impacts here are averaged over zeroes when the facility or service is located in the commune center.

serious injury. This declined by 46 minutes over and above the decline in comparison communes as a result of the rehabilitated roads. There are also significant time gains in walking to the closest pharmacy.

In contrast, the time needed to reach a shop selling food and/or consumer goods has increased. The latter effect is significant and high at three-quarters of an hour longer. This overall effect can be decomposed into a large reduction in time in the comparison communes as a result of stalls setting up there, and essentially no change in the project communes. This is puzzling but can perhaps be explained in the following way. The road improvements may have led to more food stalls opening up in some communes, while some moved away in other communes because it is now much faster to reach more distant but better shops by motorcycle or bicycle, say, even though walking there still takes a long time. Imagine, for example, a small trader who lived off periodically transporting a few essential commodities to be sold for a profit in the village. He may be driven out of business now that the bigger and better store is more accessible due to the road improvement.

Related to the time taken to facilities is their availability. Table 10 presents impacts on the presence of various services in the commune. Overall, we see either no impact (or insignificant negative impact) or significant positive impacts on the availability of different services in the project relative to the comparison communes due to the roads. For example, there are no discernible first-round impacts on the presence of a post-office, food shops, or bicycle repair shops. Against that, 14% more communes have pharmacies, and credit from the Agricultural Bank of Viet Nam is available to households in 18 percent more communes, as a result of the road rehabilitation. There is

no impact on the availability of Bank for the Poor branches or credit, or of other credit sources, however. On a priori grounds, it is not clear how better roads will affect employment opportunities for porters, and so far, no impacts are found either way. Finally, project communes got more of an increase in other government infrastructure development programs during the last two years. This could indicate that it is now easier to provide or implement other infrastructural investments given the newly rehabilitated road. Alternatively, it might be evidence that one intervention attracts another—a kind of externality effect. We cannot tell which it is.

One would expect better roads to alter mobility and migration patterns as well as income earning opportunities and levels of off-farm diversification. Is there evidence of any early impacts on employment and livelihood patterns? Table 11 reveals a small but significant increase attributable to the road project of 3.3 percentage points in the share of commune households that engage in non-farm activities. The change in the percent of households adopting primary livelihood activities outside agriculture is also positive though not significantly different from zero. The results also suggest a small (0.8%) but statistically significant negative impact on temporary out migration of labor during the last, relative to the previous year, though no impact on workers temporarily coming to work inside the commune. This could presage a rise in local employment opportunities or may be connected to the increased availability of work related to the road project.

Table 12 looks at changes in a few consumer durables and production-related tools. Impacts on these variables from better roads can be expected eventually through both easier availability and lower prices, and higher household living standards. The projects had no impact on the percentage of households building new homes. These

wealth effects will no doubt take more time to materialize. There are, however, significant positive impacts on the percentage of households owning radio cassette players and bicycles. Telephones per capita have declined a little. One could argue that since poor roads provide one incentive for having a phone, and since that incentive is now gone, the result is not counter to expectations. At any rate, it may be too early for impacts on most consumer durables.

We also find significant positive impacts on the per capita availability of threshers and boats used for productive purposes in the communes. Looking at the availability of rental markets for productive equipment in the communes, however, we find no significant impact on either water pump or cattle rentals that can be attributed to the road projects.

8 Household level impacts

Table 13 presents the household level logit regression used to match households between matched communes. Few variables are significant suggesting that sampled households are similar between matched communes. There is a negative effect on the probability of living in a project relative to a non-project commune for households of Kinh ethnicity, with a locally born head and one who is employed in agriculture, and with a higher share of members who attended school last year. A higher share of illiterate adults has a positive effect.

In Tables 14 and 15 we turn to causal impacts discernible at the household level. In particular, we are interested in seeing whether there are distributional impacts, whereby impacts vary across households of different income. In order to test for this we

use predicted household per capita consumption to rank the SIRRV households into welfare groups. Results are presented for all households, and separately for the bottom 40 percent of the national per capita expenditure distribution.

Table 14 presents household level impacts on the time taken to reach various places and activities. Averaged over all sampled households in the project communes, time taken to get to places has tended to decline. However, there are systematic differences in the time effects aggregated over all households versus those for the bottom 40 percent. In all cases, reductions in time are larger for the poorest group. For example, whereas the change in the time taken to walk to the closest road passenger transport has gone down by ten minutes overall, the reduction is of 36 minutes for the bottom 40 percent. The time taken to walk to the closest post office has decreased by close to 30 minutes more for the poorest.

The larger time impact results for the poorest group of households suggest that in communes where a majority of poorer households reside, the road rehabilitation brought a greater improvement than in the communes where richer households live. Because roads were in relatively worse condition and there was generally a greater need for the project investment in the poorer communes, impacts on time have been commensurately larger there. The fact that a concentration of the bottom 40 percent of households come from a limited set of communes (8 of the 22 communes each contain 6 or more of the poorest households) provides some backing for this interpretation.

Table 15 reports on some occupation related impacts. We find a 5 percent increase in the percent of households reporting that some of their members temporarily left to look for work over the last year as a result of the project. The impact is similar

across income groups. It should be noted that these findings appear to contradict those for the commune level (Table 11) which found a small reduction of 0.8 in the percentage of the population leaving temporarily in search of work. However, the reliability of this particular type of information is undoubtedly better when gathered at the household than at the commune level.

Table 15 also indicates significant increases in the number of person days (close to 7) hired by project commune households overall for help in the family farm, and a concomitant drop in agricultural labor days sold by households in the project areas. The latter reduction was larger for the poorest at 7 less days compared to 2 less for the overall sample. Households also reduced the labor days sold to off-farm businesses in the trade and services sectors, though they increased the number of wage labor days to industry and cottage industries by almost the same amount. The latter are likely to pay a better wage than either unskilled farm or trade and services work. The road may have made agricultural activities much more profitable, so that households can better afford to leave casual wage employment or be more selective about it, as well as hire labor from outside the commune. However, labor-related impacts may well be very volatile for a time after the road rehabilitation and first-round effects may have little bearing on the medium to longer-term impacts.

9 Conclusions

This paper presents findings on initial impacts on living standards of a World Bank rural roads project in Viet Nam. As time passes, more projects will be completed,

and larger benefits might emerge from completed projects. Nonetheless, some notable results emerge from this study.

First, we find that the project was pro-poor in that it reached more poor households than it would have if it had simply been equally distributed across rural communes. We also find that, in general, the quality of roads improved in the project communes. Thus, the commune level results reject the extreme fungibility model of external aid. However, we find evidence of behavioral responses by implementing agents, notably in the evident switch in road rehabilitation from earth roads to paved roads.

What about impacts on living standards? We find a number of significant effects both at commune and household level. For example, the road rehabilitation projects significantly increased the availability of freight services in the project communes, although they had no overall impact on passenger transport. The time needed to reach the closest hospital in case of a serious injury declined by an impressive three-quarters of an hour. Against that, there is some evidence of increases in the time needed to reach some shops and services that can easily relocate. In general, however, there are positive (or non-negative) impacts on the availability of services in the project communes. In particular, increases in pharmacies, in the availability of credit from the Agricultural Bank of Viet Nam and in other government development projects were attributable to the road projects.

The most interesting finding at the household level is that impacts significantly vary across income groups, and that the strongest impacts were for the poorest

households. In particular, although the time needed to walk to various places declined overall, time savings were more pronounced for the poorest 40 percent of households.

As we have cautioned, these are first-round impacts that may well be volatile and alter as more time passes since the roads were rehabilitated. In follow-up work we will have more rounds of data which will allow us to look at a greater variety of outcome variables. Furthermore, given longer time elapsed between project completion and data collection, we will be able to say more about how short- or long-lived the impacts we have identified here are destined to be.

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Table 1: Details of road projects completed between 1998-1999

Province	District	Road		Communes	Project end date	Population density (persons per square km)	Social criteria	Total cost per km (VND)	Cost of materials (VND)	Cost of unskilled Labor (VND)	Cost of skilled Labor (VND)
		From	To								
Tra Vinh	Tra Cu	Phuoc Hung	Don Xuan	Tan Hiep, Long Hiep	6/19/98	460	Yes	176,283,435	-	3,340,082	-
		Phuoc Hung	Don Xuan	Tan Hiep, Long Hiep	6/19/98	460	Yes	148,894,104	-	3,340,820	37,427,804
		Phuoc Hung	Don Xuan	Tan Hiep, Long Hiep	6/19/98	460	Yes	161,633,328	-	6,680,902	-
Thai Nguyen	Dinh Hoa	Quan Vuong	Minh Tien	Trung Hoi	12/23/98	4070	No	48,888,016	101,492,098	55,277,544	6,463,030
		Na Guong	Dinh Bien	Dong Thing, Ding Bien	1/5/98	1063	No	93,313,865	434,697,206	175,957,131	10,339,689
	Dai Tu	Dai Tu	Quan Chu	Bing Thuan, Ky Phu	1/11/98	3100	No	-	-	-	-
	Pho Yen	Hong Tien	Nui Cang	Hong Tien, Dien Thuy	1/21/98	520	Yes	-	-	-	-
		Thanh Xuyen	Cha	Dong Cao	2/18/99	7200	No	-	-	-	-
	Dong Hy	Linh Nhan	Deo Khe	Khe Mo	3/24/99	9800	No	-	-	-	-
		Deo Nhan	Khe Mo	Van Han, Khe Mo	1/20/99	1600	No	-	-	-	-
	Phu Binh	Cau Ca	Duong Thnah	Thanh Ninh	12/14/97	3700	No	-	-	-	-
Nghe An	Hung Nguyen	Hung Thang	Hung My	Hung Thang	3/10/98	1286	No	-	-	-	-
	Quynh Luu	Tien Thuy	Quynh Luong	Tien Thuy	1/9/98	703	No	119,105,000	214,390,000	53,597,500	6,431,700
	Quy Hop	Thi Tran	Nam Son	Chau Quang, Chau Thai, Chau Ly, Nam Son	12/10/97	1071	No	189,932,625	911,676,600	227,919,150	27,350,298
BinhThuan	Ham Tan	Doi duong	Cau Cay chanh	Tan Binh	3/15/98	499	No	114,162,815	141,576,815	43,665,853	16,154,775
Lao Cai	Sa Pa	Thi Tran Sa Pa	Ban Den	Lao Chai, Ta Van, Hau Thao, Su Phan, Sa Pa	9/30/98	475	Yes	217,018,192	3,321,157,631	446,536,220	1,088,783,435

Notes: - indicates data not available

Table 1 (cont.): Details of road projects completed between 1998-1999

Province	District	Road		Communes	Pre-project				Post-project		
		From	To		Road type	Estimated road length (km)	Road width (meters)	Access	Length of rehabilitated road (km)	Width (meters)	Access
Tra Vinh	Tra Cu	Phuoc Hung	Don Xuan	Tan Hiep, Long Hiep	Commune	4	5	Fair	4	5	Good
		Phuoc Hung	Don Xuan	Tan Hiep, Long Hiep	Commune	4.6	5	Fair	4.6	5	Good
		Phuoc Hung	Don Xuan	Tan Hiep, Long Hiep	Commune	8.6	5	Fair	2.6	5	Good
Thai Nguyen	Dinh Hoa	Quan Vuong	Minh Tien	Trung Hoi	District	4.1	3-3.5	Good	4.1	5	Excellent
		Naguong	Dinh Bien	Dong Thing, Ding Bien	District	12.3	3-3.5	Good	12.3	5	Excellent
	Dai Tu	Dai tu	Quan Chu	Bing Thuan, Ky Phu	District	18.2	4.5-5	Poor	18.2	5	Excellent
	Pho Yen	Hong Tien	Nui Cang	Hong Tien, Dien Thuy	Commune	9	3.5	Impassable	9	4	Excellent
		Thanh Xuyen	Cha	Dong Cao	Commune	3.3	4.5-5	Poor	3.3	5	Excellent
	Dong Hy	Linh Nhan	Deo Khe	Khe Mo	Commune	4	4.5-5	Poor	4	5	Excellent
		Deo Nhan	Khe Mo	Van Han, Khe Mo	Commune	14.6	4.5-5	Poor	14.6	5	Excellent
	Phu Binh	Cau Ca	Duong Thanh	Thanh Ninh	District	9.7	4.5-5	Poor	9.7	5	Excellent
Nghe An	Hung Nguyen	Hung Thang	Hung My	Hung Thang	Commune	6	3.5	Fair	-	-	-
	Quynh Luu	Tien Thuy	Quynh Luong	Tien Thuy	Commune	3	3.5	Poor	7	5	Excellent
	Quy Hop	Thi Tran Quy Hop	Nam Son	Chau Quang, Chau Thai, Chau Ly, Nam Son	Commune	10	2.5	Poor	8	5	Excellent
BinhThuan	Ham Tan	Doi duong	Cau Cay chanh	Tan Binh	-	2.4	3.5	Good	2.4	5	Excellent
Lao Cai	Sa Pa	Thi Tran Sa Pa	Ban den	Lao Chai, Ta Van, Hau Thao, Su Phan, Sa Pa	District	33	3-5	Poor	33	3-3.5	Excellent

Notes: Excellent: 2 wheel-drive car in all-weather; Good: 2 wheel-drive car in dry season; Fair: 4 wheel-drive (cong-nong) in all-weather; Poor: 4 wheel-drive (cong-nong) in dry season; Failed: not passable by 4 wheel-drive (cong nong); Impassable: not passable due to missing infrastructure.

Table 2: The distribution of project commune sample population by national per capita expenditure deciles

National population deciles	VNLSS national population	VNLSS rural population	Population from poorest VNLSS communes	SIRRV project commune population sample
1	10.02	12.6	26.6	15.9
2	9.98	12.2	19.4	15.5
3	10.0	12.0	15.2	13.1
4	10.0	12.0	12.9	11.1
5	10.02	11.5	9.4	10.0
6	9.99	11.0	7.0	10.4
7	10.0	10.2	4.7	9.5
8	10.0	8.9	3.3	8.0
9	10.01	6.7	1.1	4.6
10	9.99	2.9	0.3	1.9
total (%)	100	100	100	100
# of h'holds	5999	4269	1534	1439
Poverty incidence (%)	32.9	40.2	65.0	47.5

Note: The SIRRV population sample is ranked by predicted consumption per capita. The poverty headcounts are calculated using a poverty line based on the cost-of-basic-needs (Glewwe et al. 2000).

Table 3: 1997 Baseline data on average distances to closest geographical points from the commune center in project and non-project areas

To closest:	Mean (kilometers)	
	Project communes (N=25)	Non-project communes (N=103)
Big city	222.12	249.53
(Hanoi, Haiphong, HCMC, Danang)	(127.82)	(121.42)
Provincial center	51.24	51.64
	(40.24)	(38.21)
District center*	9.50	13.73
	(6.51)	(10.21)
National road [a]	9.98	9.92
	(10.64)	(12.44)
Provincial road [a]	6.84	10.34
	(7.95)	(14.06)
Railway station [a]	47.70	42.88
	(58.92)	(60.68)
River/canal port [a]	38.15	41.39
	(28.88)	(56.20)
Forest	9.09	14.86
	(26.94)	(34.26)

Note: Standard deviations in parentheses. [a] indicates that distances are averaged including zeroes for those communes that have the service within them. *indicates the difference across project and non-project communes is statistically significant at the 5% level. Project communes refer to those with projects completed by March 1999.

Table 4: 1997 Baseline data on the road situation in project and non-project communes during the prior 3 years

	Mean	
	Project communes (N=25)	Non-project communes (N=103)
% communes through which a national road passes	20.0	31.7
	(40.8)	(46.8)
km of national road in commune area (if in commune)	1.3	1.9
	(2.9)	(3.3)
% communes through which a provincial road passes	32.0	28.9
	(47.6)	(45.5)
km of provincial road in commune area (if in commune)	1.3	1.44
	(2.4)	(3.0)
km of communal (rural) roads in commune:		
Paved all weather roads	0.66	1.4
	(1.79)	(2.9)
Paved, sometimes impassable	0.06	0.6
	(0.30)	(2.1)
Earth road, motor vehicle passable	17.40	17.2
	(13.75)	(18.9)
Earth road, motor vehicle impassable	17.12	13.24
	(25.74)	(16.0)
km of new communal roads built in last 3 years:		
Paved, all weather roads	0.04	0.1
	(0.2)	(0.8)
Paved, sometimes impassable	0.0	0.1
	(0.0)	(1.0)
Earth road, motor vehicle passable	3.9	2.5
	(7.7)	(4.6)
Earth road, motor vehicle impassable	1.8	1.4
	(6.0)	(5.0)
Km of new communal roads rehabilitated in last 3 years:		
Paved, all weather roads	0.1	0.6
	(0.5)	(2.2)
Paved, sometimes impassable	0.0	0.2
	(0.0)	(1.2)
Earth road, motor vehicle passable	9.5	7.2
	(12.0)	(8.3)
Earth road, motor vehicle impassable	6.6	4.4
	(12.5)	(7.5)

Note: Standard deviations in parentheses. * indicates the difference across project and non-project communes are statistically significant at the 5% level. Project communes refer to those with projects completed by March 1999.

Table 5: 1997 Baseline data on time and distances to various facilities nearest to the centers of project and non-project communes

Facilities nearest to commune center [a]	Project communes (N=25)		Non-project communes (N=103)	
	Distance (Kilometers)	Time (Minutes)	Distance (Kilometers)	Time (Minutes)
Market	3.23	44.67	3.24	43.69
	(7.73)	(89.19)	(5.81)	(95.07)
Stand/shop (selling food consumer goods)	3.10	41.67	4.57	62.74
	(3.89)	(51.99)	(6.97)	(106.74)
Bicycle/motorcycle repair shop	2.00	25.24	2.44	31.02
	(7.54)	(87.61)	(5.93)	(81.20)
Barber/hairdresser	5.24	66.67	4.17	59.14
	(8.02)	(96.92)	(6.73)	(109.20)
Pharmacy	4.19	53.33	3.98	57.10
	(7.89)	(91.62)	(7.41)	(123.26)
Seamstress/tailor	0.76	12.86	2.32	32.74
	(2.41)	(40.88)	(6.35)	(103.95)
Photographer/photo shop	6.81	89.05	6.33	88.98
	(7.80)	(96.45)	(8.19)	(131.40)
Tea shop/café	1.95	30.00	2.37	33.33
	(3.64)	(56.13)	(5.19)	(74.24)
Hotel	10.71	138.95	14.23	183.51
	(8.29)	(88.67)	(12.94)	(164.94)
Lower secondary school	1.12	13.00	2.36	23.37
	(2.39)	(29.44)	(6.07)	(52.88)
Upper secondary school	8.96	92.40	12.14	110.35
	(6.55)	(109.81)	(11.07)	(116.59)
Inter-commune clinic	4.28	56.40	5.89	77.78
	(7.44)	(103.40)	(7.63)	(95.52)
Hospital	9.64**	137.40	13.22	173.60
	(6.76)	(101.11)	(10.07)	(137.17)
Public pharmacy shop	8.64	123.60	9.75	124.96
	(7.12)	(101.89)	(10.19)	(133.06)
Private pharmacy shop	4.20	57.80	4.29	58.25
	(7.43)	(105.20)	(7.91)	(112.52)
Inter-commune clinic in case of serious illness	4.83	45.83	6.03	37.15
	(2.56)	(30.40)	(5.08)	(47.17)
District hospital to treat serious illness	9.80	64.80	12.67	75.49
	(6.83)	(61.13)	(9.81)	(100.61)
Provincial hospital to treat serious illness	47.75	134.25	46.45	133.73
	(35.38)	(87.34)	(37.36)	(122.33)

Note: Standard deviations in parentheses. Project communes refer to those with projects completed by March 1999. [a] indicates that distances are averaged including zeroes for those communes that have the facility/service within them. However, this does not apply to health facilities in case of serious illness. ** indicates the difference across project and non-project communes are statistically significant at the 10% level.

Table 6: Logit estimates for commune matching

Variables	Coefficient estimate	t-statistic
Lao Cai (dummy)	-0.066	-0.06
Thai Nguyen (dummy)	1.281	1.42
Mountains (dummy)	-1.977	-1.34
Upland (dummy)	-2.888	-1.82**
Plains (dummy)	-3.313	-2.13*
Population density	0.546	1.10
Population growth	-3.854	-0.30
Kinh x population of commune	0.227	0.55
Whether a new road was constructed in 1996	0.219	0.40
Whether roads were rehabilitated in 1996	1.026	1.56
Whether a national road passes through the commune	-0.540	-0.79
Whether a provincial road passes through the commune	0.077	0.12
Whether a railroad passes through the commune	-0.547	-0.62
Whether waterways passes through the commune	-1.826	-1.71**
Proportion of homeless households (1996)	12.763	1.15
Proportion of households with war invalids or death due to war (1996)	16.674	1.82**
Proportion of disabled persons in the commune	5.963	1.72**
Constant	-3.859	-1.23
Log-likelihood	-51.475	
Number of observations	121	
% of correct predictions	66.942	

*indicates 5% or lower level of significance
**indicates significance level between 5%-10%

Figure 1: Kernel density of estimated propensity scores of project and non-project communes using commune data

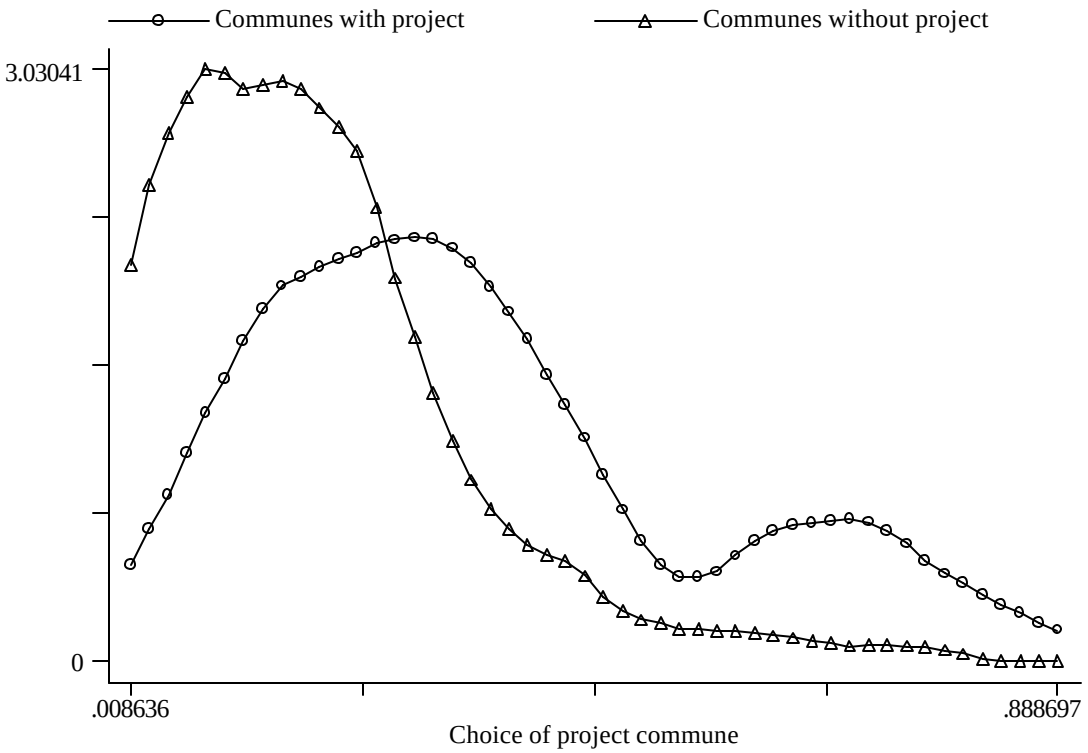

Table 7: Commune level impact estimates using nearest neighbor matching estimator: Road-related variables

Outcome indicator	Change between 1999 – 1997		
	Project	Comparison	Difference
km of paved, all weather communal roads in commune	2.659* (0.915)	0.364 (0.739)	2.296* (0.177)
km of paved, sometimes impassable communal roads	0.273 (0.273)	1.364 (0.836)	-1.091* (0.133)
km of earth roads in commune	-2.936 (4.195)	-5.355 (4.899)	2.418* (0.972)
km of paved, all weather communal roads rehabilitated during last 2 years	1.991* (0.938)	0.045 (0.450)	1.946* (0.157)
km of paved, sometimes impassable commune roads rehabilitated during past 2 years	0.591 (0.409)	0.00 (0.00)	0.591* (0.062)
km of all weather earth roads rehabilitated during past 2 years	-7.723* (2.781)	-1.945 (1.928)	-5.777* (0.510)
km of sometimes impassable earth roads rehabilitated during past 2 years	-6.727* (2.843)	-2.500 (1.743)	-4.227* (0.503)
% communes where missing bridge means a boat/ ferry must be taken to travel to closest urban center	-9.09 (6.27)	-13.64** (7.49)	4.55* (1.47)

Note: standard errors are given in parentheses. *indicates significantly different from zero at 5% or lower level of significance. ** indicates significantly different from zero between 5%-10% level of significance.

Table 8: Commune level impact estimates using nearest neighbor matching estimator: Transport-related variables

Outcome indicator	Change between 1999 – 1997		
	Project	Comparison	Difference
% communes with passenger transport service	4.55 (14.06)	4.55 (14.61)	0 (3.06)
% communes with daily passenger bus service	4.55 (14.61)	0.00 (13.74)	4.55 (3.02)
% communes with daily passenger taxi/3 wheel motorcycle service	-13.64 (12.27)	0.00 (6.43)	-13.64* (2.09)
% communes with other daily passenger transport (boat, horse cart, railway)	4.55 (9.77)	0.00 (0.00)	4.55* (1.47)
% communes with freight transport service	4.55 (7.75)	-4.55 (14.61)	9.09* (2.49)
% communes reporting serious problems in communication and participation in activities of mass organizations due to bad roads	-22.73 (14.20)	-18.18 (14.10)	-4.55 (3.02)
% communes reporting only minor problems in communication and participation in activities of mass organizations due to road conditions	4.55 (15.40)	-4.55 (15.40)	9.09* (3.29)
% communes reporting that road conditions present no problem in communication and participation in activities of mass organizations	18.18 (11.57)	22.73** (11.94)	-4.55** (2.51)

Note: standard errors are given in parentheses. *indicates significantly different from zero at 5% or lower level of significance. ** indicates significantly different from zero between 5%-10% level of significance.

Table 9: Commune level impact estimates using nearest neighbor matching estimator: Time taken (including zero time if facility is in commune)

Outcome indicator	Change between 1999 – 1997		
	Project	Comparison	Difference
% communes reporting time to collect firewood has risen during past 2 years	-27.27** (14.78)	9.09 (15.11)	-36.36* (3.19)
% communes reporting time to collect firewood is the same during past 2 years	9.09 (13.67)	-18.18 (14.10)	27.27* (2.96)
% communes reporting time to collect firewood has fallen during past 2 years	18.18 (13.45)	13.64 (13.20)	4.55 (2.84)
Time by foot to closest shop that sells food/consumer goods (min)	3.43 (22.72)	-40.94* (15.56)	44.37* (4.34)
Time by foot to closest bicycle/motorcycle repair shop (min)	16.69 (27.38)	15.74 (20.83)	0.95 (5.44)
Time by foot to closest pharmacy (min)	0.05 (28.09)	10.13 (15.75)	-10.08* (5.13)
Time to closest provincial hospital for serious injury using most common transport mode (min)	-52.66 (32.73)	-7.03 (74.86)	-45.63* (15.81)

Note: standard errors are given in parentheses. *indicates significantly different from zero at 5% or lower level of significance. ** indicates significantly different from zero between 5%-10% level of significance.

Table 10: Commune level impact estimates using nearest neighbor matching estimator: Location of services

Outcome indicator	Change between 1999 – 1997		
	Project	Comparison	Difference
% communes with post-office	18.18 (12.62)	18.18 (10.21)	0.0 (2.45)
% communes with a stand/shop selling food/consumer goods	22.73 (15.01)	27.27** (14.85)	-4.55 (3.18)
% communes with a bicycle/motorcycle repair shop	-4.55 (14.06)	0.00 (14.37)	-4.55 (3.03)
% communes with a pharmacy	9.09 (15.37)	-4.55 (15.27)	13.64* (3.27)
% communes with people working as porters	13.64 (15.27)	18.18 (15.11)	-4.55 (3.24)
% communes where Agricultural Bank credit is available to households	-4.55 (15.01)	-22.73** (11.94)	18.18* (2.89)
% communes where Bank for the Poor credit is available to households	0.00 (12.93)	0.00 (14.37)	0.00 (2.91)
% communes where other sources of credit are available to h'holds (Mass org., nat'l programs, NGOs, other)	13.64 (15.14)	9.09 (15.37)	4.55 (3.25)
% communes with a Bank for the Poor branch	0.00 (8.87)	0.00 (6.43)	0.00 (1.65)
% communes that had government infrastructure development projects during last two years	13.64 (14.48)	0.00 (8.87)	13.64* (2.6)

Note: standard errors of the difference between the means are given in parentheses. *indicates significantly different from zero at 5% or lower level of significance. ** indicates significantly different from zero between 5%-10% level of significance.

Table 11: Commune level impact estimates using nearest neighbor matching estimator: Occupational changes

Outcome indicator	Change between 1999 – 1997		
	Project	Comparison	Difference
% h'holds not engaged in any farm activities	0.64 (1.35)	-2.63 (3.76)	3.27* (0.6)
% h'holds whose main activity is not farming	1.34 (1.58)	0.14 (4.96)	1.20 (0.79)
Temporary labor out-migration during last year as a % of population	-0.19 (0.36)	0.60 (0.58)	-0.79* (0.10)
Temporary labor in-migration during last year as a % of population	-0.23 (0.34)	-0.23 (0.24)	0 (0.06)

Note: standard errors are given in parentheses. *indicates significantly different from zero at 5% or lower level of significance. ** indicates significantly different from zero between 5%-10% level of significance.

Table 12: Commune level impact estimates using nearest neighbor matching estimator: Miscellaneous

Outcome indicator	Change between 1999 – 1997		
	Project	Comparison	Difference
% commune households who have built a house in the last two years	-1.57 (1.32)	-1.15 (1.24)	-0.42 (0.27)
% commune households owning a radio cassette player	12.87 (7.45)	10.09 (6.54)	2.78** (1.49)
% commune households owning a bicycle	9.82 (12.41)	4.99 (11.55)	4.83** (2.56)
Telephones per capita	0.0026 (0.002)	0.0073* (0.003)	-0.0047* (0.001)
Threshers per household	0.0409 (0.061)	-0.0170 (0.021)	0.0579* (0.010)
Sprayers per household	0.0013 (0.010)	0.0034 (0.003)	-0.0022 (0.002)
Boats per household	0.0055 (0.007)	-0.0070 (0.010)	0.0125* (0.002)
% communes reporting availability of rentals for water pumps	9.09 (12.86)	9.09 (14.31)	0.00 (2.90)
% communes reporting availability of rentals for cattle for ploughing	0.00 (15.37)	-4.55 (14.06)	4.55 (3.14)

Note: standard errors are given in parentheses. *indicates significantly different from zero at 5% or lower level of significance. ** indicates significantly different from zero between 5%-10% level of significance.

Table 13: Logit estimates for household matching

Variables	Coefficient estimate	z
kinh ethnicity	-0.742	4.04*
household size	-0.061	1.39
age of household head	0.002	0.05
age squared x 10^3	-0.175	0.38
h'hold head is married	0.022	0.06
h'hold head is male	-0.413	1.22
h'hold head is born in commune	-0.353	2.00*
head is illiterate	-0.780	1.71
head has primary schooling	-0.331	1.06
head has lower secondary schooling	-0.121	0.48
head's employment sector is agriculture/fisheries/ forestry	-0.997	3.61*
share of infants	-0.182	0.27
share of children in household	0.413	0.74
share of males in household	-0.297	0.68
member is suffering from long term/chronic illness	0.173	0.89
h'hold is defined poor or hungry by commune	-0.193	1.11
share of h'hold members attending school during last year	-1.073	1.96*
share of illiterate adults in h'hold	0.778	2.18*
share of adults with primary education	-0.208	0.70
share of adults with lower secondary education x 10^6	-0.424	0.54
share of adults with upper secondary education	-0.553	1.42
h'hold has semi-permanent housing	0.200	0.99
h'hold has temporary housing	-0.316	1.19
per capita area of dwelling	0.006	0.94
land per capita x 10^3	0.028	1.13
irrigated land per capita x 10^3	-0.183	1.42
Constant	2.481	2.15*
Log-likelihood	-644.541	
Number of observations	1050	
% of correct predictions	63	

*indicates 5% or lower level of significance
**indicates significance level between 5%-10%

Table 14: Household-level impacts using nearest neighbor matching: Time taken to various places & activities

Outcome indicator	Overall	Bottom 40 percent
Time to walk to closest motorable road	-3.002**	-3.833*
	(0.30)	(0.66)
Time to walk to closest road on which bicycle/motorcycle/horse can pass	0.753*	-3.156*
	(0.09)	(0.27)
Time to walk to closest road passenger transport	-9.783*	-36.477*
	(0.69)	(1.72)
Time to walk to closest navigable waterway	-0.416*	-138.522*
	(3.10)	(7.59)
Time to walk to reach closest post office	-14.071*	-42.888*
	(0.50)	(1.40)
Time to walk to closest hospital	-16.824*	-21.90*
	(0.69)	(1.70)
Time taken to reach lower secondary school by main mode of transport	2.578*	-8.777
	(0.14)	(0.40)

Note: Standard errors in parentheses. * indicates statistical significance at 5% level or lower

Table 15: Household-level impact estimates using nearest neighbor matching: Occupation related variables

Outcome indicator	Overall	Bottom 40 %
% of households with temporary out-migrants during last year	4.58* (0.1)	4.36* (0.4)
Average no. of person days hired in by household to help with cultivation	6.889* (0.22)	1.682 (0.23)
Average no. of person days per household sold as labor to businesses	-0.399* (0.11)	-2.957* (0.18)
Average no. of person days per h'hold sold as labor to industry/handicraft	0.099* (0.12)	2.5330* (0.36)
Average no. of person days per h'hold sold as labor for cultivation	-2.073* (0.19)	-7.431* (0.40)

Note: Standard errors in parentheses. * indicates statistical significance at 5% level or lower.