Rural Roads and Local Market Development in Vietnam

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Abstract

We assess impacts of rural road rehabilitation on market development at the commune level in rural Vietnam and examine the variance of those impacts and the geographic, community, and household factors that explains it. Double difference and matching methods are used to address sources of selection bias in identifying impacts. The results point to significant average impacts on the development of local markets. They also uncover evidence of considerable impact heterogeneity, with a tendency for poorer communes to have higher impacts due to lower levels of initial market development. Yet, poor areas are also saddled with other attributes that reduce those impacts. These findings have important policy implications.

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1 Introduction

A growing literature has emphasized how the reductions in transport costs attained through rural road improvements can raise the prices received by producers in remote (and often poor) rural areas, and/or reduce the prices they face for inputs and consumer goods.[1] Better access to markets is seen in turn to generate increased commercial trade, specialization and diversification with corresponding shifts in the structure of production, and higher living standards.

However, this way of thinking about the impacts of rural roads says little or nothing about the role rural roads might play in local market and market-related institutional development. It may not even be valid to assume that markets exist in the first place. Initial conditions in remote poor areas are often characterized by highly geographically incomplete and non-existent prices. The goods concerned are simply not available in these areas, given high transport costs. Logically the prior step to looking at prices is to explore the implications of better roads for local market development.

And even when the goods concerned are initially available locally, but at high prices net of transport costs, it can be important to distinguish two ways in which access to markets can improve. One is through reduced travel costs to existing markets and institutions. The other is through the induced relocation of markets and institutions. The rural road impacts literature appears to have the first in mind, at least implicitly. But markets are mobile ─ not least so in developing countries. One response to road improvements could be the development of local markets.

[1] For example see Gannon and Liu (1997); Khandker, Bakht and Koolwal (2008); Escobal and Ponce (2004); Dercon, Gilligan, Hoddinott and Woldehanna (2006); Jacoby (2001), Jacoby and Minten (2007); Lokshin and Yemtsov (2005).

Why should we care about whether the residents of a poor area have goods commercially transported to their community and available in a local market, rather than travel themselves to an outside central market? While it should not be presumed that local market development is welfare enhancing, supportive arguments for that view can be made. One possible reason is that there could be large external benefits to having a local market. The economic geography literature has postulated that externalities ─ agglomeration economies ─ play a crucial role in the spatial concentration of economic activity.[2] A local market's physical presence and facilitation of trade could be an instigating factor in a process of shifting production structures to more diversified and higher value activities, improved access to various services, and broader economic development in an area. Such benefits are external in the sense that decisions by the commercial carrier to transport goods to the community or not will not take them into account. Local market development may then create a virtuous circle whereby the stimulation of off-farm development and new income earning opportunities result in higher perceived returns to education and in time, higher schooling. We will dub this the hypothesis of "transport-induced local-market development (TILD)."

However, it is far from clear that public investments in transport improvements will actually promote local market development in poor areas. In its analysis of where economic activities take place and why, the new economic geography insists on increasing returns to scale leading to agglomeration economies. This may make it hard for markets to develop in poor areas even with large reductions in transport costs. And as we show

[2] The now classic contribution is Krugman's (1991) "new economic geography" model in which one sector of the economy is subject to increasing returns to scale and is (hence) non-competitive. At the same time the new economic geography literature doesn't pay much attention to rural transport improvements and there has been little effort to link these literatures.

later with a simple model, theoretical arguments can be made that road improvements could either be good or bad for local market development. Under certain conditions, they will encourage local market development; under others, road improvements could discourage it as local residents in the targeted areas can now more easily reach established markets.

Do new roads linking poor isolated rural areas to the outside world promote local market development and under what conditions? Despite a general consensus on the importance of rural roads, there is surprisingly little hard evidence, for or against, TILD. We know rather little about the size and nature of the impacts of transport improvements on local market development, about the contextual factors that influence such outcomes, or the conditions that encourage TILD.

This paper aims to test TILD by assessing the impacts of a World Bank-financed rural road rehabilitation project implemented in Vietnam between 1997 and 2001.[3] The project was intended to be targeted to poor communes and to develop local market activity and hence economic development. The paper focuses on whether the road improvements lead to the development of local markets and whether there are also impacts on off-farm development that may be consistent with the idea of a virtuous cycle as discussed above. Our data and methods allow us to assess this in a methodologically rigorous way ─ controlling for how road sub-projects are allocated to specific communes and for initial conditions that may affect subsequent outcome trends, and monitoring communes long enough to capture impacts.

The paper concentrates on three sets of questions. The first concerns average impacts on local market development of the rehabilitation of rural roads. The World Bank

project coincided with a period of rapid economic development in Vietnam. Access to markets of various kinds increased substantially over the study period. How much of the change observed in communes covered by the project can be attributed to the road intervention? A further, related issue is how impacts vary over time. If the transport cost saving is large enough and the types of expenditures and agglomeration effects noted above are present, then we would expect impacts of the roads project to increase over time. Existing evidence on this point is scarce.[4] Our data allow us to test if that is the case.

Our second set of questions concern cross-commune differences in the project's impacts on local markets and what explains those differences.[5] Heterogeneity of impacts can be expected to arise according to the economic, social and political characteristics of the community where the road intervention is placed. We aim to test for heterogeneity and try to identify the key contingent factors relevant to impacts.

In this context, a potentially important issue for project design is whether higher levels of initial development enhance or diminish impacts. Should we be targeting places that are well endowed and have the market institutions necessary for further economic development on the grounds that impacts will be higher there, or focus our resources on the places without such attributes? In practice, it appears that project selection often tries to favor poor areas with poor road conditions. Poor places tend to have less market development to begin with. This alone would suggest greater potential for roads to have

[3] The Vietnam Rural Transport Project I, see World Bank (1996) for details.
[4] In one of the few cases in which impacts of a poor area development project (including rural roads) were tracked over time, the impacts declined over time rather than showing cumulative gains (Chen, Mu and Ravallion, 2007).
[5] While impact heterogeneity has received surprisingly little attention in the context of rural roads, it has been emphasized in social sector programs; see, for example, Galasso and Ravallion (2005).

impacts on market development in poor areas. But poor areas are typically also saddled with attributes that may well prevent markets from being attracted to those areas. The degree to which poor road conditions coincide with other important bottlenecks to increased development and market activity ─ such as poor agro-climactic endowments, low population density, low education levels, high risk, and less well functioning credit and other markets ─ will clearly mediate impacts of road improvements across communities. There is no obvious reason why placement in poor areas with poor roads will maximize TILD. Depending on precisely how road benefits depend on initial conditions, project design may also need to consider complementary inputs and policies to achieve the full potential benefits from the road.

This leads to our third set of questions, which concern the structure of the cross-commune differences in impacts. It is well recognized, in principle at least, that the same intervention can have different impacts on different places and households, depending on their characteristics. However, when there are multiple outcomes of interest and they cannot be aggregated into a single outcome (as is often the case in project evaluation) the policy implications of such heterogeneity depend crucially on whether it shares a <u>common structure</u> across different outcome variables. For example, if communes with better educated households tend to derive larger impacts for improved access across all kinds of markets, then a robust conclusion can be drawn about the gains from targeting such commune covariates. If the relevant sources of cross-commune differences in impacts vary greatly across multiple outcomes then it will clearly be hard to exploit heterogeneity to assure better projects.

Section 2 develops a simple model to show that the impacts of better roads on local markets are theoretically ambiguous. Section 3 then provides a brief description of the project being evaluated, our data and initial conditions in our sample of rural communes. Section 4 discusses our methods for evaluating impacts and exploring cross-commune differences in impacts. Section 5 discusses our results, while Section 6 offers some conclusions.

2 Roads and local market development

When will a local market exist and when not? How will this differ between poor areas and non-poor areas? How will the presence of a local market be affected by a road improvement project? Before we address these questions empirically, it helps to outline a simple theoretical model.

We assume that trade exists but that whether or not a market exists in a specific rural area ("commune") depends on the difference between the cost of freighting traded goods to that area from a central market and the cost to residents of the commune going instead to the central market to shop, and bringing the goods back themselves. The two costs will differ if the value of travel time for commune residents differs from the wage rate for the commercial freight carrier for the traded goods. There can also be differences in the non-labor cost, notably when there are economies of scale, such that the unit transport cost is lower for the commercial carrier given the bulk of the goods transported.

To formalize these ideas in a simple model, let w be the wage rate for the commercial carrier and v be the value of time for local residents; we can think of value of time as a function of various characteristics (x) of local residents, as $v(x)$. Also let t denote

travel time from the commune to the central market. Travel time is a strictly increasing function of the straight-line distance from the commune center to the central market *d*, and whether the road improvement project (D=0, 1) is implemented; travel time with the project is $t(d,1)$ and it is $t(d,0)$ without the road project, and of course $t(d,1) < t(d,0)$.[6] The project also lowers the non-wage cost of transport for the commercial carrier; the road improvement reduces wear and tear on transport equipment and may also allow cheaper modes of transport to be feasible. The non-wage cost to the commercial carrier is $k_c(1)$ with the project and $k_c(0)$ without it, with $k_c(1) < k_c(0)$.[7] Local residents who travel to the central market also incur a non-wage cost, k_r, but this is assumed to be small ($k_r < k_c(1)$) and to be unaffected by the road improvement.

The market exists in a given commune if (and only if) the commercial carrier has the cost advantage; otherwise it would be cheaper for the local residents to travel to the central market. The roads project reduces labor costs for both the carrier and the local residents, and it reduces non-labor cost for the commercial carrier. The cost advantage of the commercial carrier is:

$$C(d,D,x) \equiv [v(x) - w]t(d,D) + k_r - k_c(D) \quad (D=0, 1) \qquad (1)$$

When $C(d,D,x) > 0$ the commercial carrier can transport goods more cheaply than local residents and so the local market will exist; the opposite is true when $C(d,D,x) < 0$. Let

[6] Note that *t* will of course also be a function of terrain and typology such as location in mountainous areas.

[7] In a more general model, one could also allow k_c to vary with *d*. This could stem from wear and tear on transport equipment (k_c rises with *d*) or economies of scale (k_c falls with *d*). One might also allow for an interaction effect between *d* and *D* in influencing k_c. As long as the marginal effect of *d* on k_c is small, the above results will still hold.

d^* denote the critical distance at which $C(d^*, D, x) = 0$; d^* is a function of D and x. The impact of the project on the cost advantage of the commercial carrier is:

$$C(d,1,x) - C(d,0,x) = [v(x) - w][t(d,1) - t(d,0)] + k_c(0) - k_c(1) \qquad (2)$$

Now consider three cases:

(i) A "low-income commune", defined as one in which $v(x) < w$: the cost advantage of the commercial carrier falls with distance ($C_d(d, D, x) < 0$), so that local markets are found up to distance d^*, but not at more remote places. It can be seen from equation (2) that the road project will increase the cost advantage of the commercial carrier, so it will increase the probability of having a local market at any given distance. The value of d^* will rise and the project will promote local market development.

(ii) A "middle-income commune", defined as one in which $w < v(x) < w + [k_c(1) - k_c(0)]/[t(d,1) - t(d,0)]$. The fact that $v(x) > w$ implies that the cost advantage of the carrier rises with distance ($C_d(d, D, x) > 0$); local markets will tend to be found at higher distances from the central market. Given that $v(x) < w + [k_c(1) - k_c(0)]/[t(d,1) - t(d,0)]$, the project will increase the cost advantage of the commercial carrier at any given distance. Thus the value of d^* will fall and the project will promote local market development.

(iii) A "high-income commune", defined as one in which $v(x) > w + [k_c(1) - k_c(0)]/[t(d,1) - t(d,0)] > w$. Again the cost advantage of the carrier rises with distance, so that local markets are not found close to the central market, but now the project reduces the cost advantage, d^* increases and local markets retreat. The project displaces markets at middle distances and leads to fewer local markets.

We can summarize the empirical implications of these observations as follows. The poorer the commune the more likely the project will promote local market development. There is also likely to be a potentially complex interaction effect between how poor the commune is and its distance from the central market. Among poor and middle-income communes the impacts on local market development will tend to be at middle distances, while among the relatively high income communes, it is the negative impacts that will tend to be higher at middle distances. In all three cases above, the outcome will depend on the characteristics of local residents (x), as these determine the value of their travel time.

3 The project, data and setting

3.1 The rural road project intervention

The Vietnam Rural Transport Project I (RTPI) aimed to link commune centers to markets, stimulate market development and reduce poverty through the rehabilitation of 5,000 kilometers of rural roads (World Bank 1996). The project was implemented between 1997 and 2001 in communes located in 18 provinces scattered around Vietnam. Participating provinces were responsible for choosing communes for inclusion in RTP1, as well as the road links to be rehabilitated within them. On paper, road links were identified through least cost techniques, and eligible if the road's zone of influence had a population of over 300 per kilometer, and average rehabilitation costs were below $15,000 per kilometer.[8] In mountainous communes with a high density of ethnic minority households, provisions were made for the possible waiving of the population and cost

[8] Least cost techniques refer here to the minimum cost engineering solution that ensures a certain level of motorized passability.

criteria. In practice these eligibility criteria identify considerably more road links than could be covered by the project. How the included links were selected among these is unclear. It should be noted that the selection of project communes was complete prior to the project start date and based on conditions in early 1997.

Many of the targeted roads were in very bad condition, some with impassable sections year round. A rehabilitation standard of 'reliable access' was enforced that provides relatively consistent and safe access with only short-term road closures (due to bad weather). The project expressly stipulated that no 'new' roads would be built.

Aid or central government spending for road projects may substitute for local government spending intended for the same purpose, by being diverted to other sectors or to neighboring non-project areas. Elsewhere we have ascertained that the project did produce differential impacts on the kilometers of improved roads in project compared to non-project comparison communes (van de Walle and Mu 2007). We found no evidence that resources were diverted to non-project communes for roads or other basic infrastructure. However, we also showed that project funds were used not only to rehabilitate roads as intended by the project, but also to build new roads. Therefore, the impacts we study in this paper are due to both types of improvements.

Using the methods to be described in Section 5 we have also checked to see whether the period under analysis was marked by differences in the implementation of other development projects in the project and non-project communes. For a long list of potential interventions for which information is available in our data, we find no evidence that project or non-project communes were treated differently.[9] Based on the findings, we

[9] We looked at education, health care, family planning, child nutrition, reforestation, opening up new land, anti-opium, job creation and TV and radios distribution programs, as well as various schemes that are part of

are confident in attributing any differences in outcome changes over time to rural road rehabilitation and construction.

3.2 The SIRRV data

Collected specifically for evaluating the impacts of the rural roads rehabilitated under RTPI, the "Survey of Impacts of Rural Roads in Vietnam" (SIRRV) consists of a panel of 200 communes and 3000 households. The survey design implicitly takes the commune as the project's zone of influence. This is justified by the project objectives ─ namely to link commune centers (where key social, economic and administrative facilities are located) with road and market networks ─ and because the commune is an enumeration level at which data is commonly collected in Vietnam.

The baseline was collected pre-project starting in June 1997, while subsequent rounds followed in the summers of 1999, 2001 and 2003, tracing the implementation process and schedules of prior rounds. The analysis for this paper makes use primarily of the first and last rounds, though we will also test impact dynamics using the 2001 round.

Project ("treatment") and non-project ("comparison") communes, and households within them, were surveyed in six of the 18 provinces participating in the project ─ Lao Cai and Thai Nguyen in the north, Nghe An and Binh Thuan in the center, and Kon Tum and Tra Vinh in the south of the country.[10] Project communes were randomly selected from province-specific lists of all communes with proposed projects. Another list was drawn up of remaining communes in districts with proposed sub-projects from which a

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the Hunger Elimination and Poverty Reduction Program, including credit loans, school fee and health care exemptions, free land allocation and new infrastructure.

[10] Lao Cai, Thai Nguyen or Nghe An are located in what was previously known as North Vietnam or the Democratic Republic of Vietnam.

random sample of non-project communes was drawn. The eventually sampled communes (100 project and non-project each) were located in 29 of 38 potential survey districts.

Non-project communes located in the same districts as the treatment communes will share many of the same characteristics as the project communes. But we additionally use matching techniques to ensure selection of the most appropriate comparison communes. Districts are large and the distances between project and non-project communes tend also to be large.[11] Contamination from project to non-project communes is unlikely for the type of small localized road improvements under study.

The commune data were acquired in part by drawing on annually collected commune records. Each commune appoints a 'statistician' who collects and maintains commune-level information such as pertaining to vital statistics, land use and distribution, production activities and finances. There is some concern that the reliability of these data varies according to average commune income and education, and local pressures to compile statistics that conform to pre-determined 'plans.' To minimize such potential problems, we focus on variables likely to be less vulnerable to these biases and rely on household data otherwise. Our analysis here focuses on commune level impacts and uses primarily the commune data.

Fifteen households in each sampled commune also answered a household questionnaire. A welfare ranking implemented by commune authorities was used to divide households into the poorest, middle and richest thirds of each commune's households. Five were then randomly selected from each of these equal sized groupings.[12]

[11] Early on during data collection, we mapped many of the non-project communes and judged them to be sufficiently far from our road links to be confident that contamination is unlikely.

[12] Since the groups were equal and equal-sized samples were drawn from each, weights are not required for constructing commune level variables from the household data.

The household ranking is undoubtedly subjective, but stratified sampling on this basis should ensure a sample that is reasonably representative of each commune's socio-economic groups.

The household survey does not attempt to measure household income or consumption expenditures. However, using extensive information on household characteristics common to the SIRRV and the nationally representative Vietnam Living Standards Survey (VLSS) of 1998, we use regression techniques to predict consumption expenditures for SIRRV households in 1997.[13] This variable is then aggregated to form a commune level welfare indicator which we use in Figure 1 (Section 3.3) and to divide communes into those below and above median mean predicted consumption, which we will refer to as poor and non-poor communes, respectively.[14]

Finally, a project level database detailing what the project did, when and how, was also constructed for each surveyed project area. Project differences can then be taken into account in determining impacts.

3.3 Initial conditions of poor and non-poor communes

Pre-project, 48 percent of all sample communes had a market whose frequency averaged once a week. Figure 1 shows how the initial presence of a commune market was related to both the commune's distance to the closest central market town and its average living standards as measured by mean predicted household per capita consumption in the baseline.[15] [16] Panel (a) plots the relationship between having a market (vertical axis) and

[13] The consumption model includes 80 explanatory variables (not counting 58 province dummies) and has an R^2 of 0.687. Mean consumption for the 1998 VLSS rural sample is 2515.605 thousand dongs (with a standard deviation of 1467.065), and mean predicted consumption for 1997 SIRRV households is 2332.896 (with a standard deviation of 1110.707). Full details are available from the authors.

[14] This is the only variable used in the paper that is built up from household level information.

[15] Distance to the closest market town is defined as the distance to the closest large town.

commune mean consumption on the horizontal axis for communes classified into three equal groups based on distance to the closest large market town ─ within 7 kilometers ("close"), between 7 and 15 km ("middle") and further than 15 km ("far"). Panel (b) places distance on the horizontal axis instead and plots the relationship separately for communes above ("non-poor") and below ("poor") median consumption.

Figure 1 suggests a clear relationship between these three variables, corroborating elements of the theoretical model outlined in Section 2.[17] Local markets are most often present at middle distances (Figure 1, Panels a and b). They are an increasing function of predicted consumption except at very close distances and high consumption levels (Panel a). For better-off communes the relationship with distance is a pronounced inverted U, while it is much flatter for poor communes although starting out at a somewhat higher level for those at very close distances (Panel b). Poorer communes are less likely to have markets than better-off communes at all distances beyond short distances (Panels a and b).

Table 1 examines how communes below and above median consumption expenditures differ in their initial characteristics ─ including (in the bottom half of the table) the market and market-related development outcome indicators that we will focus on.[18] The table reveals considerable and highly significant differences in attributes across communes dissaggregated in this way. Poorer communes are associated with characteristics that are typically assumed to be disadvantageous, including higher illiteracy, worse access to transportation and credit, larger distances to the closest city and far lower market presence. They have generally lower levels of population and road

[16] These are non-parametric regressions, using locally weighted smoothed scatter plots, in which the unit of observation is the commune.

[17] The best fit for these data was obtained from the product of two quadratics ─ in consumption and in distance ─ which gave uniformly significant (at the 5% level) coefficients and an R^2 of 0.27.

densities, larger minority populations, and are more likely to be in mountainous areas.

Focusing specifically on the baseline values of the outcomes variables, we see that in addition to having lower market presence, poorer communes typically have significantly fewer commercial businesses, inferior access to services, less diversified income sources and worse schooling indicators. For example, only 32% had any kind of market, and small shops or stalls which typically sell a few basic necessities such as salt, rice and soap, were present in only 39%. The probabilities that better off communes had markets and shops were 63 and 57%, respectively. In 1997, an overwhelming majority of households in these communes relied primarily on agriculture for their livelihoods (90%) but the lack of income diversification was even more pronounced in the poorer communes where 94% did so compared to 86%. Finally, less than a quarter of children completed primary school by age 15 in the poor communes and only three quarters of these continued on to secondary school. In the non-poor communes it was 36 and 92% respectively.

These differences again raise the crucial policy question of whether road placement in poor areas with poor initial conditions will handicap or stimulate TILD. The rest of the paper explores whether the project had impacts on these outcome indicators and how differences in initial conditions may have interacted with road improvements to affect those impacts.

4 Evaluation methodology

The official project selection criteria detailed in Section 3.1 clearly allow provinces considerable freedom in choosing communes and road links. Some may aim to

[18] The variables are defined in the notes to Table 1 when they are not self-explanatory.

direct the project to poorer communes with important rehabilitation needs, while others may aim for communes with greater economic potential. Either way, the placement of the project is unlikely to have been random and may well have been influenced by factors that also determine outcomes.

A potentially important source of endogeneity bias in this context is that initial conditions are likely to determine project placement as well as to influence the subsequent growth path and prospects of the communes (as emphasized by Jalan and Ravallion 1998). Our evaluation methodology corrects for these potential sources of selection bias.

We combine a difference-in-difference (DD) with propensity score methods (PSM). A conventional DD gives unbiased estimates based on the assumption that the selection bias is constant over time. However, if there are time varying factors that influence placement, then road placement is still correlated with the error term in the differenced equation. To allow for the possibility of time variant selection bias due to initial observables, we use the predicted probability of participating in the road project (the propensity score) to match the comparison communes in the DD estimate. PSM is implemented using a logit that includes initial conditions that may affect subsequent commune trajectories as explanatory variables. Our impact estimates are then constructed by comparing the before and after project change in outcome measures for the project communes with those for the matched comparison communes.

Specifically, the average impact for project communes (DD) can be written as

$$DD = \sum_{N_P} DD_i / N_P \qquad (3)$$

where

$$DD_i = (Y_{i1}^{\ P} - Y_{i0}^{\ P}) - \sum_j W_{ij}(Y_{j1}^{NP} - Y_{j0}^{NP}) \quad (4)$$

is the impact estimate for commune *i*, *P* and *NP* denote project (treatment) and non-project (comparison) communes respectively, $Y_{i1}^{\ P} - Y_{i0}^{\ P}$ is the change in the outcome measure for project commune i, $Y_{j1}^{NP} - Y_{j0}^{NP}$ is the change in the outcome measure for comparison commune j, and W_{ij} is the weight given to the j^{th} commune in making a comparison with the i^{th} project commune. N_P in equation (3) is the total number of project communes. We apply nonparametric kernel matching in which all the non-participants are used as comparison communes and weights are assigned according to a kernel function of the predicted propensity score following Heckman, Ichimura, and Todd (1997). This technique ensures valid bootstrapped standard errors (Abadie and Imbens 2006). As a robustness check, we also construct a PS-weighted DD (Hirano, Imbens and Ridder 2003; Hirano and Imbens 2002).[19]

The key assumption of PS-matched or weighted DD in this context is that the selection bias is conditional on the observed placement covariates in the baseline. The estimates will be biased if there are unobservables that affect both project placement and outcome changes. Since all project communes were selected prior to the project start date based on initial conditions as reflected in our baseline, we need not worry about latent factors that might influence changes both in road placement and outcomes over time. In the logit model used to calculate the propensity scores, we control for an array of initial conditions that may subsequently affect changes in the communes. However, we can

[19] For the theory of propensity score matching and propensity score weighting, see Rosenbaum and Rubin (1983) and Hirano et al. (2003), respectively. For an empirical application in the same setting, see van de Walle and Mu (2007).

never rule out the possibility of omitted initial conditions that are correlated with placement and outcome changes over time.

To explore whether and how initial commune conditions affect impacts we use a simple OLS regression of the estimated commune specific impacts against certain key initial commune characteristics. For this exercise we use the PS matched estimates since these can be estimated for each specific commune.

5 Impacts on local market development and their heterogeneity

5.1 Participation in the project

The probability of a commune's participation in the project is estimated using a logit model. The detailed results, including a list of the initial commune characteristics included in the logit are reported in an Appendix available from the authors and in van de Walle and Mu (2007), so we only summarize them here. We find a number of significant explanatory variables for program placement. Consistent with official selection criteria, communes with a higher total population and a larger share of ethnic minority population were more likely to participate in the project. Communes in Thai Nguyen, Nghe An, and Binh Thuan were more likely to get the project than communes in Tra Vinh. A few characteristics that may indicate higher living standards or local development had a significant negative effect on the probability of participation ─ namely, the share of the adult population working in private enterprises, the school enrollment rate and having an Agricultural Bank branch. Yet, other proxies for income had no effect ─ including, the presence of a market and predicted average commune consumption expenditures. Finally, among measures of transport and accessibility, a national road passing through the

commune, the presence of passenger transport, a higher density of roads, and a higher distance to the province center all reduced the probability of participation, while a railroad passing through the commune improved it. As there is imperfect overlap in the estimated propensity score for project and non-project communes, we limit the sample to the common support, ending up with 94 project and 95 non-project communes for the rest of the analysis. Using the predicted propensity scores to match communes, we achieve a close balancing of the initial observed commune characteristics for the two samples.[20]

5.2 Average treatment effects

We assess impacts of the road project on a set of outcome variables (introduced in Table 1) that we deem relevant to local market development and to testing TILD. In addition to the presence and frequency of local markets, we examine whether the presence of other commercial establishments ─ namely shops, bike repair shops, pharmacies, and restaurants ─ was affected. Such impacts could both be direct or via impacts on local markets. To test whether there are signs of a process consistent with lower transport costs and market development stimulating a more diversified local economy we also examine whether there are effects on the availability of various services and signs of livelihood diversification, such as away from agriculture and towards trade and service activities. Finally, we check to see whether school enrollments are affected, as might be the case if the perceived returns to education have been altered.

[20] Following Rosenbaum and Rubin (1985), we carried out a balancing test using the standardized mean difference ─ the difference in covariate means in project and non-project communes as a percent of the standard deviation in the full sample. This drops significantly from 14% before to 9% after matching.

Table 2 displays the mean values of these indicators across project and non-project communes in the baseline and for subsequent survey rounds.[21] These generally moved in the expected direction over time, with a tendency to increase over the period in both project and non-project communes. The key question then is whether there was a differential impact attributable to the road improvements in the project communes.

Table 3 presents DD estimates of the mean impacts using the PS-based kernel matching and weighting methods discussed in Section 4, as well as simple DD estimates. The estimates are given for two time periods ─ namely, 1997 to 2001 and 1997 to 2003, referred to as the short and medium term. Under our assumptions, these estimates reflect causal effects of the road improvements. One or two stars indicate whether each change is significantly different from zero at the 10 and 5 percent significance levels respectively.

By the start of data collection for the 2001 round, 27 months had elapsed on average since the project work ended.[22] How long it takes for impacts to emerge is an issue that often arises in discussions of road impacts and planning for their evaluation. Here we are able to ascertain whether local area impacts were different in 2001 from those in 2003, after two more years had elapsed.

Focusing on the PS-based estimates, and starting with impacts by 2001, we see that across the examined indicators there is no sign of statistically significant mean impacts in the short term. The only exception is for the primary school completion rate which rose by 15 to 25 percent, according to the kernel matched and PS-weighted DD respectively. Why would better roads affect primary school completion rates? Although

[21] With the exception of market frequency, the employment and the school enrollment variables, other variables are dichotomous so that the numbers are interpretable as probabilities that communes have the outcome.

all communes have primary schools, secondary schools are considerably rarer. It is plausible that a road improvement now allows children to more readily reach a secondary school which will encourage both primary school completion and post primary enrollments.

The results change when we track impacts through to 2003. A number of outcome indicators now exhibit significant impacts. As a result of the road improvements, markets became newly available in close to 10 percent more project than non-project communes over the 7 years, and their frequency increased. However, despite small positive impacts on commercial establishments, none are statistically significant.

By 2003, we also discover significant impacts of the road project on the services for which we have data ─ the availability of tailoring and hairdressing services. The weighted DD show that the probability of men and women's hair dressing services being available in the communes rose by 14 and 20% respectively in 2003. Consistent with effects on market and services availability, we find evidence of impacts on employment and livelihood patterns. Improved roads resulted in a small but significant 2 percent decline in households relying on farming as their main source of income. A significant increase in the share of households mainly relying on the service sector (1.7%) hints at what alternative livelihoods these households may have switched to. This is not a trivial impact given that only one percent of households were employed in the service sector in the baseline. The impact on households engaged primarily in trading activities is also positive but small and statistically insignificant. Finally, impacts on the primary school

[22] The 2001survey was fielded about 4 months after all projects were completed. About 11% of project communes had finished their road project less than one year before.

completion rate are sustained over time and have even risen slightly. Moreover, small effects on secondary school enrollments also appear to be emerging.

In sum, we find some support for TILD. Our results indicate significant average impacts on the development of local markets, both their presence and frequency. The project resulted in households switching from agriculture to non-agricultural, mostly service-related activities, and tailoring and hairdressing services became more commonly available. These impacts were not sharp and short-lived; they took time to emerge, only appearing in 2003, and are thus rising over time. This is all we can say based on our two data points. Of note too are the quicker, sustained and robust impacts on primary school completion rates.

5.3 Heterogeneity in impacts

As implied by our theoretical model, the average treatment effects may hide significant heterogeneity across communes. Using the PS-matched DD method, we can calculate the individual treatment effects for each of the 94 project communes. Eyeballing these confirms that they vary substantially across communes. Furthermore, calculating mean impacts separately for the 47 communes below and above median predicted household consumption reveals pronounced differences in impact estimates between relatively poorer and less-poor project communes. Particularly striking is that impacts are generally larger for the poorer communes. Normalizing impacts by each group's mean value of the variable in the baseline, we find that for 10 out of the 14 outcomes the impacts for the relatively poorer communes exceed those for the better off ones.[23]

[23] Khandker et al. (2008) also find larger impacts for the poor although their analysis is carried out at the household level.

The characteristics associated with whether a commune is poor or not are likely to interact with roads to influence their impacts. One popular hypothesis is that benefits are highly dependent on local human capital endowments needed to take advantage of the opportunities afforded by new roads. But, our finding that impacts are larger in poorer communes where, as we saw in Table 1, illiteracy is also typically higher, appears to contradict this common argument. Other hypotheses can be suggested, such as that historical discrimination against certain social and economic groups makes it harder for them to adopt more outward economic orientation, as required to take advantage of new roads. Our result of generally higher impacts in consumption poor communes that also tend to have worse attributes begs for analysis of the role of initial conditions in determining road impacts.

To explore the covariates of road impact estimates, we use OLS regressions where the dependent variables are the commune level impact estimates and the explanatory variables are initial pre-project commune characteristics for the sample of 94 treatment communes. Potentially important, mediating physical, social and economic commune conditions, that we also observe, include most of the variables listed in the top half of Table 1. To these we add location in the country's north ─ which has had a far shorter experience with the market economy. We include the initial value of the dependent variable/outcome measure, as well as whether the commune had a local market pre-project, as a test of the virtuous cycle idea. Finally, to represent heterogeneities in the actual treatment we also include quadratics in the number of months since project

completion and in the length of improved road.[24] In principle one can imagine all sorts of relationships and non-linearities between these project attributes and impacts. Time may enhance impacts as local providers take time to set up or it may reduce them as customers come to value access to outside providers. Under increasing returns to scale, one would expect cumulative impacts with more time leading to higher impacts.

The interpretation of road length is a bit unclear though it is still probably better to control for it as it represents an important difference between the sub-projects. Typically, the project rehabilitated what was necessary to make the road link functional. Length is thus likely to reflect some omitted characteristic about how bad road access was prior to the project. It is probably not interpretable as road length per se but most likely proxies for the road's initial condition and omitted attributes of remoteness.

Tables 4 through 8 report the results.[25] For each outcome variable we present two regressions: one with a full set of the same initial conditions (model 1) and one the result of a cumulative pruning of the highly insignificant variables (t-statistics below one), starting with the lowest t-ratio (model 2). This serves to sharpen the picture somewhat, given multicollinearity.

There are significant interaction effects, indicating that impacts are the result of how the attributes of places and people interact with what the project does. Some attributes consistently raise or reduce impacts, while a few are both complements and substitutes to better roads in inducing local market development.

[24] We leave out transportation access and road density as they are highly correlated with other explanatory variables that we judge more important and we are limited in degrees of freedom. We also exclude measures of social services as there is little variance across communes.

[25] Note that the fact that the dependent variables are estimated does not invalidate the parameter estimates or their standard errors. The estimated impact is the true impact plus an error term that ends up in the composite regression error. The overall predictive power falls but the estimates are still valid.

We note first that impacts are consistently and significantly reduced for communes with a higher initial value of the outcome variable.[26] These are some of the largest effects both in terms of the magnitude of the coefficients and of their statistical power. This strongly suggests decreasing impacts ─ whereby marginal returns are higher when outcomes are initially lower. This is consistent with our earlier finding that impacts tend to be higher in poorer communes.

As anticipated, several commune attributes that are widely deemed to be disadvantageous, consistently dampen the impacts of improved roads, although not significantly across all outcomes. For example, as we would expect, higher adult illiteracy rates reduce the impacts of road improvements on a number of market related outcomes ─ the presence of commercial establishments, the availability of services and secondary school enrollments ─ consistent with human capital and infrastructure being complements. On the other hand, illiteracy strengthens road impacts on the share of households who remain farmers.

A greater distance to the closest market town significantly lowers impact on the availability of pharmacies, tailoring and women's hair dressing services, specialization of households into the service sector and secondary school enrollments. The last probably reflects the fact that distance to secondary schools is closely correlated with distance to the market town. As expected, impacts are also generally lower for communes located in the North where entrepreneurship and markets have been less developed historically.

[26] Given the number of commune attributes and outcomes, the discussion here focuses on the estimated coefficient signs rather than their magnitudes. The coefficients indicate how each attribute affects the road project's impact on the probability of having a market or a related indicator (in the case of dichotomous variables), or its impact on the percentage change in employment or enrollments. For example, in the markets regression (Table 4), the coefficient on the initial value is -0.27 ─ meaning that the probability across communes that better roads lead to new local markets is reduced by 27% by having a market in 1997.

A high concentration of ethnic minority households, controlling for a mountainous location and education levels, results in significantly lower impacts on many of the same outcomes including markets and their frequency, the availability of services and continuation on to secondary school. This too may reflect the fact that many minorities have less of a tradition of using markets or relying on public services due to a culture molded by past discrimination; this is broadly consistent with the arguments and evidence of van de Walle and Gunewardena (2001) on the sources of ethnic inequality in Vietnam.

Other commune characteristics have almost exclusively positive effects on the impacts of improved roads. The initial presence of a market in the commune typically significantly enhances road impacts on other market related development consistent with a story of external benefits to local markets and the hypothesis of TILD. Unsurprisingly, initial market presence particularly enhances impacts on the establishment of retail and other small firms, and trading activities. It also significantly increases impacts on primary school completion rates.

Population density is typically a project placement criteria as indeed it was for RTP1. Impacts and marginal returns are expected to be higher in more densely populated communes. We find supportive evidence for this with respect to impacts on shops and women's hair dressing services. More households with motorcycles indicate the degree to which households can rapidly take advantage of the road for their transport needs, although it may also capture an income effect. Plausibly, we find that it enhances project impacts on the development of off-farm activities and secondary school enrollments.

A number of other commune attributes interact with road improvements to both raise and reduce impacts depending on the outcome indicator. An often cited bottleneck

to development is lack of credit. We find evidence for this with respect to the development of local markets. However, credit availability appears to reduce road impacts on household diversification into trade and service sector activities. Credit has been found to be more readily available to landed households engaging in agricultural pursuits in rural Vietnam (Ravallion and van de Walle 2008, chapter 7). Its availability may well coincide with other discouragements to trade and service sector activities.

A high prevalence of weather shocks and presumably a higher incidence of episodes of commune inaccessibility significantly reduce the impacts of road improvements on the availability of shops and school enrollments at the secondary level. Against this, it raises impacts on primary completion rates and on the share of households relying on the service sector for their livelihoods. Location in mountainous areas also reveals ambiguities in its impacts across outcomes. It significantly increases road impacts on local market development and the availability of tailoring services, reinforcing our intuition that, holding other attributes constant, poor road conditions represent a key constraint to market development in mountainous areas. Yet, mountainous location also interacts with the project to reduce the percentage of households who derive their livelihoods from farming and services as well as the primary completion rate.

The number of months since project completion has both positive and negative impacts on a number of service-related indicators. Restaurants are more likely to develop as more time elapses. More months also have a positive though decreasing impact on the share of households relying on the service sector. On the other hand, the longer the period, the lower the impact on the availability of tailoring services. Road impacts on women's hair dressing are also first negatively affected by more time passing but this is

reversed after around 50 months have gone by. Finally, the length of improved road is significant in a number of cases but, as anticipated earlier, its interpretation is unclear.

6 Conclusions

We have studied the impacts of rural road improvements on local markets and market-related development at the commune level in Vietnam. In particular, we have endeavored to test whether impacts are consistent with a hypothesis of "transport-induced local market development (TILD)." A simple theoretical model is first proposed that suggests that impacts on local markets are a priori ambiguous and will depend on commune level characteristics. Our empirical methods then combine a double difference estimator with propensity score matching on pre-intervention covariates. We examine average impacts, including the time it takes for them to emerge and whether they rise or fall over time, but also the cross-commune differences in impacts, and the nature of those differences, including interactions with initial geographic, community and household characteristics. In this context, we focus on two specific questions that are vitally important from a policy view point, to see what implications there might be for future project design. Are road impacts enhanced or weakened by initially poor local market development as is typical in poor areas? Are the covariates of road impacts congruent across outcomes? These issues have tended to be ignored by the recent literature on assessing rural road impacts.

There are indications of significant average impacts on the development of local markets and related indicators. Few outcomes responded rapidly to the new and improved roads. Most impacts are not apparent 27 months (on average) after project completion,

and only emerge in data collected two years later. We find significant average impacts on the presence and frequency of markets and on the availability of various services. The project also resulted in households switching from agriculture to non-agricultural, mostly service-based, activities. Perhaps most notable, the project had significant, early and sustained impacts on primary school completion rates. These results give qualified support for the hypothesis of TILD.

However, it is clear from our findings that TILD oversimplifies the process. Our findings point to substantial heterogeneity in the effects on market development. The circumstances of a project's location influence its impacts. On the whole, poor communes tend to experience higher impacts on many indicators of market development. This is the outcome of two broad sets of attributes of poor areas that tend to work in opposite directions to influence the impacts on local markets of road improvements. On the one hand, poor areas are less likely to have markets and market-related institutions and services and this alone means more scope for road improvements to help develop those same institutions and services. On the other hand, poor areas have various other attributes that tend to discourage TILD. For example, poor communes in Vietnam are more likely to have a high share of ethnic minorities and high illiteracy rates which are both uniformly negative in their effects. They are more isolated and have lower population densities, attributes that also tend to lessen road impacts. They are less likely to initially have a local market which impedes development of other market-related institutions and services in response to road improvements (separately to the fact that markets are more likely to develop in places where they do not exist initially). Hence, we find signs of a virtuous

cycle effect whereby the impacts on small businesses, service availability, trade activities and primary school completion rates are enhanced by the initial presence of a market.

Our results thus suggest that, on balance, the road project tended to have larger impacts on market development in poorer communes due largely to the initially lower market development in these places. This was strong enough to outweigh the fact that poorer communes have other attributes (besides low initial market development) that reduce impacts of road improvements.

The structure of the cross-commune heterogeneity in outcomes is driven by the initial state of market development tempered by a number of commune attributes in a way that tends to follow distinct and predictable patterns across outcome indicators. Distance to central markets, low population density and high minority populations, high adult illiteracy and location in the North all consistently dampen road impacts.

These findings can be exploited by project design to promote larger development impacts. They suggest that small road improvement projects such as RTP1 could have vastly larger impacts on local market development if they were targeted to places with initially lower market development, and equally important, accompanied by complementary social and economic policies aimed at improving certain attributes (e.g. adult literacy) or reducing the disadvantages of others (policies to reverse the effects of historical discrimination towards ethnic minority groups) that interact with roads to reduce their impacts.

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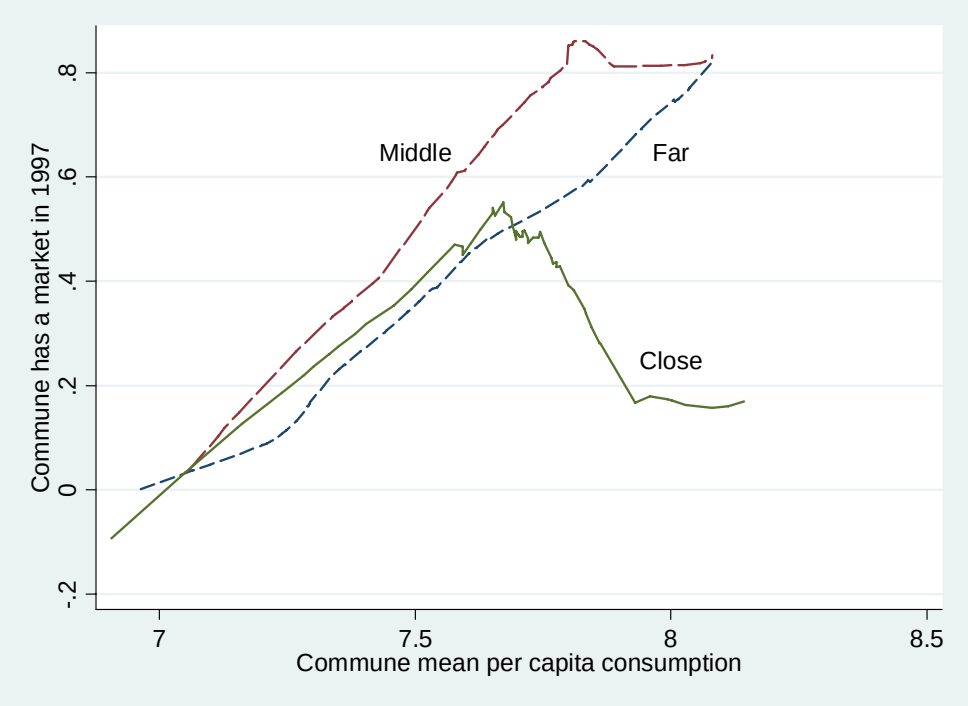
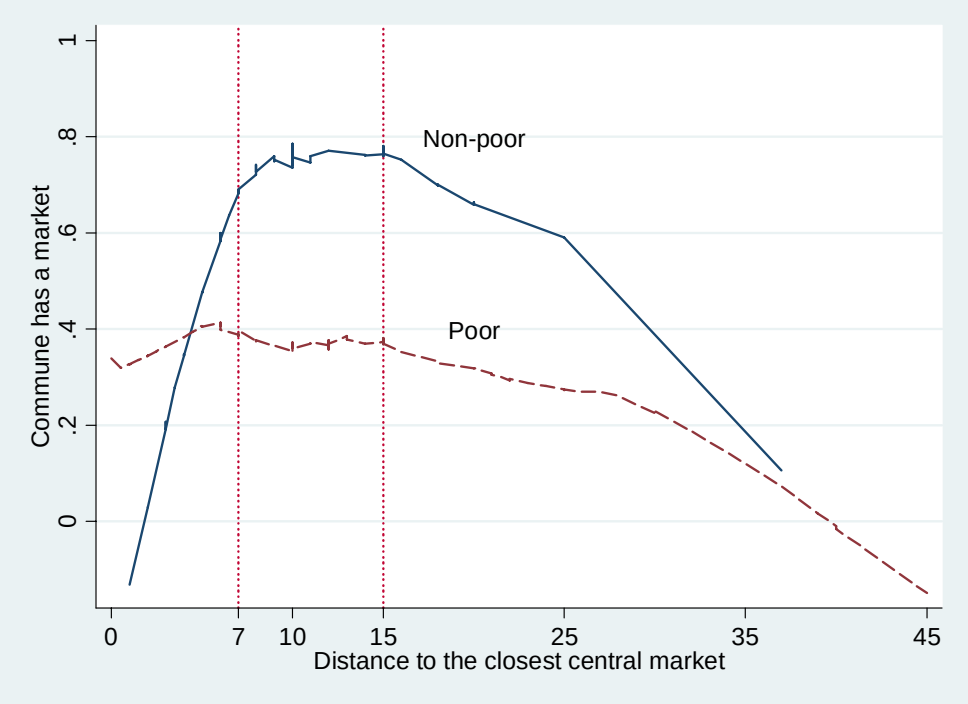
Figure 1: Presence of a commune market in the baseline

(a) By distance to the central market



(b) By poor and non-poor communes



Note: These are non-parametric regressions, using locally weighted smoothed scatter plots. The unit of observation is the commune. One third of all communes are 'close' or within 7 kilometers of a central market; the 'middle' distance third are between 7 and 15 km from the market; while the 'far' communes are more than 15 km from the market. Non-poor and poor communes are defined as those above or below the sample median commune per capita consumption based on aggregated predicted household consumption.

Table 1: Mean baseline characteristics and outcome variables for communes classified by median household per capita consumption (log)

	Below median (1)	Above median (2)	Difference (1-2)	t-ratio
Baseline commune characteristics				
Typology: mountain	0.70	0.33	0.38**	5.55
Distance to closest central market (km)	15.53	9.39	6.14**	4.64
Share of households owning motorcycles	0.06	0.09	-0.03*	-2.77
Population density	2.01	5.50	-3.48**	-6.67
Ethnic minority share	0.66	0.20	0.47**	10.03
Adult illiteracy rate	0.25	0.04	0.21**	7.34
Flood and storm prevalence	0.60	0.62	-0.03	-0.35
Credit availability	0.01	0.07	-0.06**	-2.17
North provinces	0.54	0.68	-0.14**	-2.01
Transportation accessibility	0.23	0.31	-0.08*	-1.76
Road density	0.01	0.03	-0.01**	-3.47
Baseline market related outcome variables				
Market availability	0.32	0.63	-0.31**	-4.50
Market frequency	0.72	1.45	-0.73**	-4.12
Shop	0.39	0.57	-0.18**	-2.59
Bicycle repair shop	0.53	0.88	-0.36**	-6.03
Pharmacy	0.34	0.74	-0.40**	-6.12
Restaurant	0.23	0.44	-0.21**	-3.21
Women's hair dressing	0.32	0.48	-0.16**	-2.27
Men's barber	0.42	0.75	-0.32**	-4.92
Men and women's tailoring	0.51	0.81	-0.30**	-4.71
% farm households	93.94	86.27	7.67**	3.59
% trade households	1.16	1.69	-0.53*	-1.74
% service sector households	0.71	1.05	-0.33	-1.10
Primary school completion (<15)	0.24	0.36	-0.12**	-4.40
Secondary school enrollment rate	0.75	0.92	-0.17**	-4.71

Note: The sample consists of all 200 communes. ** significant at 5% level or higher; * significant at 10% level. Flood and storm prevalence summarizes the average incidence between 1997 and 2003; Credit availability averages dummy variables for the availability of credit from the following sources: the Agricultural Bank, commercial banks, the Bank for the Poor, credit coops/ people's credit funds, government programs, mass organizations, international projects and NGOs; Transportation accessibility averages dummy variables for the presence of provincial and national roads, railways and waterways. Many outcome variables are dichotomous referring to whether the outcome is present in the commune. The exceptions are: market frequency which takes the values 0 for no market, 1 for once per week or less, 2 for more than once a week, 3 for permanent market; the % of households in various occupations refers to their main source of income; the primary completion rate is defined as the share of children 15 and under who completed primary school; the secondary school enrollment rate is the share of children who graduated from primary school in the previous year who are enrolled in secondary school.

Table 2: Outcome variable means

	1997		2001		2003	
	project	non-project	project	non-project	project	non-project
Local market development						
Market	0.51	0.44	0.57	0.51	0.62	0.46
Market frequency	1.13	1.05	1.29	1.20	1.43	1.16
Shop	0.63	0.59	0.82	0.80	0.84	0.77
Bicycle repair shop	0.76	0.65	0.80	0.78	0.87	0.81
Pharmacy	0.62	0.58	0.73	0.62	0.69	0.52
Restaurant	0.35	0.33	0.50	0.41	0.52	0.44
Services availability						
Women's hair dressing	0.38	0.39	0.46	0.51	0.66	0.53
Men's barber	0.59	0.58	0.72	0.68	0.85	0.75
Men and women's tailoring	0.65	0.66	0.82	0.72	0.84	0.77
Employment: *% households whose main occupation is:*						
Farming	89.53	90.67	89.65	91.07	87.02	90.15
Trade	1.45	1.41	1.73	1.75	3.17	2.56
Services	1.12	0.54	1.42	1.52	3.20	1.60
School Enrollments						
Primary school completion(<15)	0.31	0.31	0.32	0.32	0.39	0.35
Secondary school enrollment	0.80	0.88	0.91	0.94	0.92	0.91

Notes: The sample consists of the 94 project and 95 non-project communes on common support as determined by propensity score matching. Many outcome variables are dichotomous referring to whether the outcome is present in the commune. The exceptions are: market frequency which takes the values 0 for no market, 1for once per week or less, 2 for more than once a week, 3 for permanent market; the % of households in various occupations refers to their main source of income; the primary completion rate is defined as the share of children 15 and under who completed primary school; the secondary school enrollment rate is the share of children who graduated from primary school in the previous year who are enrolled in secondary school.

Table 3: Impact of road rehabilitation/building

	2001						2003					
	DD	t-ratio	PS kernel matched DD	t-ratio	PS weighted DD	t-ratio	DD	t-ratio	PS kernel matched DD	t-ratio	PS weighted DD	t-ratio
Markets												
Market	0.00	0.02	0.03	0.88	0.04	1.27	0.09*	1.93	0.08*	1.85	0.09**	2.37
Market frequency	0.01	0.10	0.08	0.75	0.10	1.06	0.19	1.61	0.23*	1.69	0.25**	2.23
Shop	-0.02	-0.23	0.01	0.01	0.08	0.50	0.03	0.43	0.08	0.57	0.14	1.12
Bicycle repair shop	-0.08*	-1.83	-0.06	-1.01	-0.04	-0.78	-0.04	-0.91	0.02	0.37	0.03	0.60
Pharmacy	0.08	0.99	0.04	0.32	-0.06	-0.31	0.14*	1.65	0.12	0.94	0.16	1.36
Restaurant	-0.03	-0.97	-0.01	-0.30	-0.01	-0.28	0.05	0.62	0.01	0.08	0.05	0.55
Services availability												
Women's hair dressing	-0.04	-0.70	-0.07	-0.72	-0.07	-0.72	0.14*	1.83	0.18**	2.19	0.20**	2.61
Men's barber	0.03	0.49	0.01	0.11	0.01	0.11	0.10	1.53	0.11	1.20	0.14**	2.15
Men and women's tailoring	0.12	1.60	0.11	1.42	0.10	1.26	0.09	1.19	0.10	1.12	0.12*	1.69
Employment: *% households whose main occupation is:*												
Farming	0.04	0.62	0.05	0.72	0.03	0.38	-1.99	-1.26	-2.04*	-1.67	-2.06**	-1.89
Trade	-0.05	-1.21	0.03	0.42	0.03	0.53	0.57	1.27	0.36	0.71	0.58	1.35
Services	-0.06	-0.14	-1.54	-1.15	-1.03	-0.95	1.01**	2.51	1.68**	2.43	1.72**	3.10
School Enrollments												
Primary school completion(<15)	0.00	-0.09	0.15**	2.58	0.25**	2.82	0.04	0.91	0.17**	2.48	0.30**	2.31
Secondary school enrollment	0.06	1.53	0.10	1.47	0.25	1.33	0.10**	2.88	0.05	1.41	0.07*	1.70

Notes: The sample consists of the 94 project and 95 non-project communes on common support as determined by propensity score matching. T-ratio of kernel matching is obtained from bootstrapping (100 repetitions). ** significant at 5% level or higher; * significant at 10% level. Standard errors of weighted DD estimations are robust to heteroskedasticity and serial correlation of communes within the same district.

Table 4: Impact heterogeneity: Market and market frequency

	Market		Market frequency	
	model 1	model 2	model 1	model 2
1997 value	-0.26**	-0.27**	-0.30**	-0.30**
	(-4.85)	(-4.81)	(-4.92)	(-4.86)
Distance to central market/100	0.09		-0.54	
	(0.19)		(-0.48)	
North province	-0.04		-0.35*	-0.44**
	(-0.68)		(-1.86)	(-2.87)
Typology: mountain	0.19	0.18**	0.43	0.37
	(1.57)	(2.27)	(1.23)	(1.58)
Flood and storm prevalence	-0.03		-0.31	
	(-0.20)		(-0.65)	
Population density/100	0.01		-0.25	
	(0.01)		(-0.08)	
Ethnic minority share	-0.35*	-0.27**	-1.20**	-0.94**
	(-1.86)	(-2.28)	(-2.22)	(-2.50)
Adult illiteracy rate	0.15		0.54	
	(0.91)		(1.04)	
Share of h'holds owning motorcycles/100	0.82	0.85	0.68	
	(1.46)	(1.69)	(0.49)	
Credit availability	0.39**	0.36**	1.16**	1.01**
	(2.48)	(2.11)	(2.36)	(2.08)
Length of road rehabilitated	-0.02*	-0.02**	-0.04	-0.01
	(-1.86)	(-2.25)	(-1.22)	(-1.20)
Length squared/100	0.04	0.05*	0.08	
	(1.50)	(1.92)	(0.93)	
Months since project completion	0.02		0.03	
	(0.71)		(0.42)	
Months squared/100	-0.02		-0.04	
	(-0.82)		(-0.49)	
Constant	-0.13	0.22**	0.39	0.85**
	(-0.19)	(2.23)	(0.18)	(3.65)
R-squared	0.37	0.35	0.34	0.30

Note: Based on 94 observations. Standard errors are clustered at the district level of which there are 29. T-statistics are given in parentheses. ** significant at 5% level or higher; * significant at 10% level. Market is a zero/one dummy for whether a market exists in the commune. Market frequency takes the value 0 for no market; 1 for once a week or less; 2 for more than once a week and 3 for permanent market.

Table 5: Impact heterogeneity: Retail and other commercial establishments

	Shop		Bicycle repair shop		Pharmacy		Restaurant	
	model 1	model 2	model 1	model 2	model 1	model 2	model 1	model 2
1997 value	-0.96**	-0.98**	-0.84**	-0.86**	-0.71**	-0.72**	-0.66**	-0.63**
	(-10.02)	(-11.30)	(-6.05)	(-6.06)	(-7.03)	(-7.63)	(-5.11)	(-5.98)
Distance to central market/100	0.55		-0.79	-0.87	-0.76	-0.77*	-0.70	
	(0.94)		(-1.15)	(-1.61)	(-1.39)	(-1.75)	(-1.11)	
North province	-0.32**	-0.32**	-0.01		0.04		0.07	
	(-3.04)	(-2.90)	(-0.08)		(0.38)		(0.53)	
Typology: mountain	0.19	0.21	0.04		0.01		0.08	
	(1.28)	(1.65)	(0.49)		(0.13)		(0.63)	
Flood and storm prevalence	-0.38*	-0.39*	0.05		-0.11		-0.01	
	(-1.83)	(-2.02)	(0.41)		(-0.84)		(-0.04)	
Population density/100	3.18*	2.79*	0.26		0.30		-0.57	
	(1.90)	(1.83)	(0.36)		(0.21)		(-0.30)	
Ethnic minority share	0.21	0.17	-0.09		-0.02		0.09	0.15
	(1.30)	(1.24)	(-0.57)		(-0.11)		(0.67)	(1.41)
Adult illiteracy rate	-0.52**	-0.53**	-0.50*	-0.63**	-0.40	-0.42**	-0.37	-0.37*
	(-2.14)	(-3.42)	(-1.76)	(-2.50)	(-1.60)	(-2.21)	(-1.57)	(-1.74)
Share of h'holds owning motorcycles/100	0.40		0.45	0.43	0.67	0.69	0.10	
	(0.73)		(1.21)	(1.20)	(0.97)	(1.15)	(0.13)	
Credit availability	-0.02		-0.06		0.16		-0.22	
	(-0.07)		(-0.32)		(0.75)		(-0.70)	
Commune has a market in 1997	0.22**	0.22**	0.10*	0.10	0.34**	0.36**	0.32**	0.32**
	(2.44)	(2.57)	(1.72)	(1.58)	(3.81)	(4.30)	(3.29)	(3.86)
Length of road rehabilitated/100	-0.48		-1.29		-1.75	-1.45	2.23	2.39
	(-0.33)		(-0.87)		(-1.61)	(-1.67)	(1.45)	(1.67)
Length squared/10^4	1.21		2.87		3.57	0.03	-4.56	-0.05*
	(0.38)		(0.63)		(1.18)	(1.09)	(-1.34)	(-1.70)
Months since project completion/100	0.27		1.50	-0.30	1.03		-0.33	1.13**
	(0.07)		(0.55)	(-1.15)	(0.32)		(-0.09)	(3.49)
Months squared/10^4	-0.07		-1.69		-1.09		1.31	
	(-0.02)		(-0.64)		(-0.35)		(0.38)	
Constant	0.48	0.70**	0.54	0.94**	0.36	0.59**	-0.43	-0.70**
	(0.53)	(4.20)	(0.75)	(4.50)	(0.45)	(3.17)	(-0.46)	(-3.61)
R-squared	0.58	0.57	0.56	0.54	0.50	0.48	0.49	0.48

Note: Based on 94 observations. Standard errors are clustered at the district level of which there are 29. T-statistics are given in parentheses. ** significant at 5% level or higher; * significant at 10% level. All outcomes refer to availability in the commune.

Table 6: Impact heterogeneity: Service availability

	Women's hair dressing		Men's barber		Clothes making	
	model 1	model 2	model 1	model 2	model 1	model 2
1997 value	-0.75**	-0.72**	-0.82**	-0.82**	-0.76**	-0.78**
	(-7.03)	(-7.56)	(-14.67)	(-13.87)	(-12.50)	(-11.17)
Distance to central market/100	-0.87*	-0.74	-0.80	-0.72	-0.48	-0.63*
	(-1.71)	(-1.67)	(-1.56)	(-1.65)	(-1.09)	(-1.82)
North province	-0.26**	-0.23**	-0.15*	-0.13*	-0.14	-0.09
	(-2.53)	(-2.49)	(-1.71)	(-1.95)	(-1.48)	(-1.31)
Typology: mountain	0.21	0.18	0.09	0.09	0.26**	0.21**
	(1.50)	(1.33)	(1.48)	(1.24)	(2.32)	(2.08)
Flood and storm prevalence	-0.14		-0.05		-0.18	-0.16
	(-1.01)		(-0.50)		(-1.40)	(-1.19)
Population density/100	3.68*	3.79**	0.03		1.26	
	(1.99)	(2.14)	(0.04)		(1.12)	
Ethnic minority share	-0.09		-0.30**	-0.30**	-0.29*	-0.30*
	(-0.64)		(-2.38)	(-2.63)	(-1.75)	(-1.83)
Adult illiteracy rate	-0.42*	-0.44**	-0.61**	-0.57**	-0.51*	-0.54*
	(-1.87)	(-2.78)	(-2.66)	(-2.69)	(-1.76)	(-1.99)
Share h'holds owning motorcycles/100	0.44		-0.15		0.50	0.57*
	(0.97)		(-0.44)		(1.48)	(1.81)
Credit availability	-0.11		0.15		0.13	
	(-0.47)		(1.11)		(0.76)	
Commune has a market in 1997	0.23**	0.23**	0.05	0.05	0.09	0.09
	(2.78)	(2.76)	(1.14)	(1.23)	(1.23)	(1.31)
Length of road rehabilitated/100	0.77		1.15		0.88	
	(0.79)		(0.88)		(0.67)	
Length squared/10^4	-1.49		-2.23		-2.46	
	(-0.64)		(-0.53)		(-0.62)	
Months since project completion/100	-8.13**	-7.71**	-1.78	-0.31	0.02	-0.60**
	(-2.13)	(-2.22)	(-0.79)	(-1.46)	(0.01)	(-2.73)
Months squared/10^4	8.09**	7.69**	1.40		-0.68	
	(2.20)	(2.30)	(0.65)		(-0.28)	
Constant	2.39**	2.24**	1.35**	1.05**	0.81	1.10**
	(2.54)	(2.57)	(2.33)	(9.50)	(1.36)	(8.64)
R-squared	0.55	0.54	0.75	0.74	0.69	0.68

Note: Based on 94 observations. Standard errors are clustered at the district level of which there are 29. T-statistics are given in parentheses. ** significant at 5% level or higher; * significant at 10% level. All outcomes refer to availability in the commune.

Table 7: Impact heterogeneity: Employment

	Farming		Services		Trade	
	model 1	model 2	model 1	model 2	model 1	model 2
1997 value	-0.15**	-0.16**	-0.42	-0.30	-0.14	
	(-4.58)	(-4.22)	(-1.66)	(-1.48)	(-0.44)	
Distance to central market	-0.02		-0.07*	-0.07**	-0.04	
	(-0.25)		(-1.74)	(-2.16)	(-0.91)	
North province	-1.45		1.98**	2.48**	-2.10**	-1.76**
	(-0.99)		(2.30)	(3.00)	(-2.57)	(-3.29)
Typology: mountain	-3.37	-4.55*	-1.48	-1.89**	1.72	1.39
	(-1.55)	(-1.96)	(-1.49)	(-2.73)	(1.49)	(1.30)
Flood and storm prevalence	-2.95		5.31**	5.16**	-1.47	
	(-1.08)		(3.20)	(3.08)	(-0.57)	
Population density	-0.41	-0.51**	0.25		0.23	0.22
	(-1.37)	(-2.10)	(0.75)		(1.20)	(1.40)
Ethnic minority share	2.01	3.11	1.31		-0.90	
	(0.90)	(1.66)	(0.92)		(-0.78)	
Adult illiteracy rate	5.01*	4.64**	-1.10		0.83	
	(1.87)	(2.08)	(-0.45)		(0.27)	
Share of h'holds owning motorcycles	-0.05		0.16**	0.15**	0.11*	0.11*
	(-0.37)		(3.07)	(2.91)	(1.84)	(1.92)
Credit availability	0.04		-4.69**	-5.22**	-3.85	-4.18**
	(0.01)		(-3.78)	(-4.52)	(-1.51)	(-2.19)
Commune has a market in 1997	-1.90	-2.12	-0.79	-1.02	1.60*	1.68**
	(-1.09)	(-1.38)	(-0.95)	(-1.30)	(1.99)	(2.05)
Length of road rehabilitated	-0.10		-0.01		0.02	
	(-0.39)		(-0.08)		(0.16)	
Length squared/100	0.10		0.20		-0.06	
	(0.17)		(0.51)		(-0.27)	
Months since project completion	0.46		0.46	0.49	0.19	
	(1.09)		(1.27)	(1.52)	(0.53)	
Months squared/100	-0.45		-0.56	-0.59*	-0.21	
	(-1.11)		(-1.53)	(-1.76)	(-0.59)	
Constant	6.31	15.14**	-8.28	-7.37	-3.29	-0.56
	(0.53)	(3.01)	(-0.89)	(-0.97)	(-0.37)	(-0.52)
R-squared	0.27	0.25	0.31	0.28	0.17	0.15

Note: Based on 94 observations. Standard errors are clustered at the district level of which there are 29. T-statistics are given in parentheses. ** significant at 5% level or higher; * significant at 10% level. The % of households in various occupations refers to their main source of income.

Table 8: Impact heterogeneity: Schooling

	Secondary school enrollment		Primary school completion	
	model 1	model 2	model 1	model 2
1997 value	-1.08**	-1.09**	-1.16**	-1.24**
	(-13.75)	(-14.62)	(-6.53)	(-9.21)
Distance to central market/100	-0.28*	-0.32**	-0.32	
	(-2.01)	(-2.38)	(-0.60)	
North province	-0.02		0.03	
	(-0.53)		(0.41)	
Typology: mountain	-0.00		-0.06	-0.11*
	(-0.04)		(-0.82)	(-1.85)
Flood and storm prevalence	-0.20**	-0.20**	0.48**	0.45**
	(-2.13)	(-2.38)	(3.47)	(3.60)
Population density/100	-0.71	-0.90	0.65	
	(-0.76)	(-1.23)	(0.47)	
Ethnic minority share	-0.12*	-0.13**	0.07	
	(-2.03)	(-2.35)	(0.58)	
Adult illiteracy rate	-0.41**	-0.40**	-0.06	
	(-2.27)	(-2.36)	(-0.30)	
Share of h'holds owning motorcycles/100	0.47**	0.54**	1.01	0.89
	(3.88)	(4.09)	(1.67)	(1.59)
Credit availability	0.04		-0.18	
	(0.49)		(-0.81)	
Commune has a market in 1997	0.02		0.15	0.15**
	(0.91)		(1.66)	(2.16)
Length of road rehabilitated	-0.01	-0.01	0.02*	0.02*
	(-1.25)	(-1.48)	(1.91)	(1.81)
Length squared/100	0.01	0.02	-0.04*	-0.04*
	(1.12)	(1.25)	(-1.85)	(-1.83)
Months since project completion/100	0.44		-3.44	
	(0.65)		(-1.14)	
Months squared/10^4	-0.57		3.02	
	(-0.72)		(1.07)	
Constant	1.07**	1.17**	1.07	0.20**
	(5.42)	(12.41)	(1.24)	(2.19)
R-squared	0.76	0.75	0.50	0.47

Note: Based on 94 observations. Standard errors are clustered at the district level of which there are 29. T-statistics are given in parentheses. ** significant at 5% level; * significant at 10% level. The primary completion rate is defined as the share of children 15 and under who completed primary school; the secondary school enrollment rate is the share of children who graduated from primary school in the previous year who are enrolled in secondary school.