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Who Benefits from Better Roads and Why?

Mixed Methods Analysis of the Gender-Disaggregated Impacts of a Rural Roads Project in Vietnam

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Abstract

The literature lends empirical support for the idea that improvements to transport infrastructure lead to economic development. How and why the benefits of better transport differ between genders is less clear. This paper attempts to answer this question by combining a nonexperimental impact evaluation of a large-scale rural roads project in Vietnam with qualitative data collection. The paper finds that roads improve economic opportunities for agricultural production and trade: all households increase agricultural trade. Yet only households headed by men capitalize on these opportunities, experiencing an increase in agricultural output and income. Production and income do not increase in households headed by women. The result seems to be driven by a lower level of household labor and access to capital in female-headed households, which constrains their ability to make up-front investments to increase production and income. Overall, the results indicate that female-headed households face constraints in taking advantage of newly created economic opportunities. Coordinating transport investments with complementary development programs addressing these constraints can improve the benefits of better transport for such households.

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1. Introduction

Transport infrastructure plays an important role in enabling economic development by facilitating access to markets, services, and information. Better roads can help farmers or entrepreneurs sell their output to larger markets. They can also enable workers to access job opportunities in labor markets that were previously inaccessible. Similarly, reducing the cost and time to travel to schools and hospitals can increase usage of the services provided by these facilities and have positive effects on human capital. A growing body of literature lends empirical support with a credible claim for a causal link between transport infrastructure and development through these and other channels.

Several studies have attempted to link transport to macroeconomic outcomes such as growth. Banerjee, Qian, and Duflo (2012) find limited impacts of proximity to historical transportation networks on the long-term growth rates of income in China. However, they find impacts on levels of income—counties closer to transportation networks have higher per capita GDP than those further away. Faber (2014), also in China, finds that highway expansion in fact led to a fall in GDP in peripheral regions that were "incidentally" connected by road networks between larger centers. This effect is driven by deindustrialization in these regions, which he plausibly argues could be due to the falling costs of trade with bigger centers and would thus be consistent with aggregate gains from trade.

In contrast to these studies, more of the existing literature focuses on the short-term impacts of improvements in rural transport infrastructure on household-level outcomes. These typically present an easier setting for identification for a few reasons: changes to rural roads have smaller network effects than changes to highways or railroads; there have been several large-scale rural transport programs in the recent past that have clear rules for selection and present an opportunity to work with larger samples in terms of numbers of roads.

Studying one such program in Bangladesh, Khandker, Bhakt, and Koolwal (2009) find that road pavement led to a decrease in the number of households living in poverty. Similarly, Dercon et al. (2009), studying a small program of road investments in rural Ethiopia, found evidence of both a decrease in poverty and an increase in consumption. Consistent with these studies is evidence from India in Aggarwal (2018), who observes changes in consumption linked to a national-level village feeder-road construction program.

Khandker, Bhakt, and Koolwal (2009) find that the impact on poverty comes through several channels, including an increase in the value of agricultural production caused partly by changes in prices. In Sierra Leone, Casaburi et al. (2013) find that there is heterogeneity in the response of prices to road rehabilitation—prices in fact fall in some markets. They find that price response is linked to local market characteristics and argue that this is consistent with a model of search frictions in these markets, thereby suggesting that roads helped lower these market frictions. A related result on the development of markets comes from Vietnam, where Mu and Van de Walle (2012) observe improvements in indicators of local market development, such as the availability and frequency of markets following the rehabilitation of rural roads.

Those results tie into changes observed in India by two other studies of the same program[1] studied by Aggarwal (2018). Shamdasani (2016) finds an increase in the number of households that sell their crop output and an increase in the cultivation of non-cereal crops, and interprets these as a sign of a transition from subsistence to commercial farming. Asher & Novosad (2017) find an increase in off-farm employment outside the village, suggesting that the same program also improved access to labor markets. Indeed, this effect on labor markets is consistent with evidence from a road rehabilitation program in Nicaragua studied by Garz and Perova (2014).

Notably, Garz and Perova also find signs of improved health outcomes and access to health facilities, in addition to an increase in enrollment at the primary school level. The finding that roads improve enrollment in educational institutions is consistent with some studies (Khandker, Bhakt, and Koolwal, 2009; Khandker and Koolwal, 2011; and Mu and Van de Walle, 2012) as well as two other studies from India (Mukherjee, 2012; Adukia et al., 2019).

Finally, there are indications in this literature that the impact of roads may vary by gender though this is less well established. For instance, Garz and Perova (2014) and Khandker and Koolwal (2011) find that enrollment impacts are stronger on girls in primary education, while Adukia et al. (2019) and Mukherjee (2012) detect no significant differences between the genders. Similarly, in the case of employment, Garz and Perova (2014) detect stronger impacts on likelihood of employment for men, while Asher and Novosad (2016) find no significant differences between the genders.

There is some ambiguity ex ante about which gender is likely to benefit more. Women's access to markets, services, and information tends to be weaker than men's (World Bank, 2012). Consequently, men may benefit more since roads address only one of the several overlapping constraints that women face (we will refer to this scenario as a complementary constraints hypothesis). On the other hand, because women face a greater time constraint in accessing economic opportunities,[2] the marginal value of their time may be higher and they could benefit more than men for an equivalent decrease in travel times (we will refer to this scenario as a tightness of constraint hypothesis).

If the tightness of constraint hypothesis is correct, road improvements may constitute an effective policy tool in achieving the EAP WDR 2012 recommendations of "increasing women's access to markets, factor inputs, locally available economic opportunities and services such as electricity, schools, hospitals and postal services." Conversely, if the complementary constraints hypothesis is true, improving road connectivity alone may not be sufficient to achieve these development outcomes and other interventions may be needed to ensure that the benefits of infrastructure improvements flow to both genders equally.

Knowing which of these hypotheses is true has the potential to inform policy and development programming at a large scale. Estimates of global investment in transport, which are not easy to compile,

[1] The Pradhan Mantri Gram Sadak Yojana or PMGSY.

[2] This is because women are typically responsible for a greater share of the household and child care burden than men. See World Development Report 2012 for a discussion of this literature.

point to a very large number, on the order of magnitude of US$1 trillion annually.[3] Furthermore, these lessons are also likely to be applicable to non-transport infrastructure investments such as electrification or Internet connectivity programs.

We study a rural roads improvement project in Vietnam using mixed methods analysis to assess whether the impacts of road rehabilitation differed across genders, and to better understand the underlying mechanisms. Specifically, we first measure causal impacts of road improvement on average and by gender applying a difference-in-differences framework to a combination of survey and administrative data. We then complement these results with qualitative data collection that aims to shed light on the mechanisms that may prevent either gender from fully benefiting from infrastructure improvements economically and socially.

The remainder of the paper is structured as follows: we describe the project interventions in more detail in Section 2. Sections 3 and 4 discuss the data and methodology, respectively. Results are discussed in Section 5. Section 6 provides conclusions.

2. Intervention Description

We analyzed rural road improvements carried out under a large-scale project, the Third Rural Transport Project (RTP3), in Vietnam[4] (World Bank, 2015) that was implemented between 2008 and 2015 (Table A.1). Under the project, approximately 3,100 km of rural roads were rehabilitated, and maintenance activities were implemented on over 19,000 km of rural roads spread across 33 provinces in Northern and Central Vietnam (Figure A.1).

The interventions under RTP3 cover activities classified as either rehabilitation or maintenance under the program and in the administrative data that we use for the analysis. Road maintenance is important since it receives a low level of investment despite being critical to sustaining road quality in the face of not only traffic impacts, but also severe weather.[5] Flooding, landslides, and slope and coastal erosion during the rainy season are common occurrences in many rural areas. Maintenance, particularly clearing drainage systems like culverts and side drains, can both reduce the chances of flooding of roads and the consequent deterioration in road quality after flooding. Maintenance was further categorized into two types of interventions based on the type and the periodicity of the activities, and who implements the activity. Overall, the project activities are classified into three types of interventions in the administrative data:

[3] The estimates range from US$900 billion in studies by the Institute for Transportation and Development Policy (ITDP) and EMBARQ (Sakamoto et al. 2010; Mahendra et al. 2013), between US$1.4 trillion and US$2.1 trillion in a World Resources Institute (WRI) study (Lefevre et al. 2014), and US$2.6 trillion in a study by the International Energy Agency (IEA) (Dulac 2013).
[4] The World Bank Group was one of the donors for this project.
[5] This is acknowledged in the development objective of the project, which is to "improve year-round access to markets, economic opportunities and social services for rural populations."

1. **Road rehabilitation:** In our data, this covers activities that might typically be classified as rehabilitation and upgrading. Rehabilitation would normally refer to the activities needed to bring a badly degraded road back to its original usable condition, while upgrading would refer to upgrading gravel roads to sealed or concrete roads (raising them to a higher management classification). These are intensive improvements which require mechanized equipment and workers skilled in using the equipment. Rehabilitation, therefore, is similar in nature to the rehabilitation studied in Garz and Perova (2014) and upgrading is similar to some types of road construction carried out under the Pradhan Mantri Gram Sadak Yojana in India evaluated in other studies.
2. **Routine road maintenance:** These activities ensure the daily passability and safety of existing roads in the short run and to prevent premature deterioration of the road. They are mostly manual activities carried out using simple tools, such as clearing side drains, culverts, and vegetation off-carriageway and filling potholes on-carriageway. Under the RTP3 project, these activities were carried out by Road Maintenance Groups (RMGs) and by contractors. In three provinces—Lào Cai, Quảng Bình, and Thanh Hóa—routine maintenance by RMGs was managed by the Vietnam Women's Union.
3. **Periodic road maintenance:** Major maintenance activities such as re-graveling (on unsealed roads) or resealing (on sealed roads) aim to preserve the structural integrity of the road. These activities require specialized equipment and tools. All periodic maintenance activities under the RTP3 project were carried out by contractors.

As these descriptions indicate, there is a significant amount of heterogeneity in not just the type and intensity of activity, but also in the expected duration of improvement. Rehabilitation lasts much longer than routine maintenance improvements. To tackle this heterogeneity, we treat each of these improvements as being time bound, with the length of improvement corresponding to the nature of the intervention. Section 4 provides more details on the definitions of the treatment, depending on the type of activity.

It is important to note that when routine maintenance was carried out by RMGs, these groups were composed of people living in the communes that benefited from the roads. However, in contrast to other projects,[6] which explicitly targeted employment generation, the objective of involving communities in these activities under RTP3 was to foster community awareness and maintenance. Accordingly, participation was prioritized, and a very large number of people participated in road maintenance jobs. In turn, the average remuneration per worker, where provided,[7] was low.[8] Consequently, we did not expect

[6] As in the case of the road improvements in Nicaragua studied by Garz and Perova (2014).
[7] In some communes, funds for road maintenance were used by the Vietnam Women's Union or Vietnam Farmer's Union (which implemented routine maintenance in some areas) for communal activities instead of paying wages.
[8] A report from 2014 estimates average payments to have been about US$9, and the work to have corresponded to two to three days of work for each member on average. Qualitative work carried out for this study suggests that the earnings were lower than at least some wage work opportunities that the worker could access. For example, one of the respondents states: "*this service* [RTP3 routine maintenance] *paid much less than the VND200,000 per working day as wage worker in district town or in the commune.*"

this component of RTP3 to have large effects on the labor market or income outcomes of participating households.

Finally, RTP3 followed the decentralized structure of the Government of Vietnam. Although the project was administered and supervised centrally, implementation was carried out by provincial and local government bodies. For instance, while the selection criteria for roads was developed centrally, provincial Departments of Transport (DoTs) were responsible for submitting lists of eligible roads. Provincial DoTs, in turn, invited local government bodies to apply for the project before shortlisting roads based on the eligibility criteria.

3. Data

As previously mentioned, we relied on a mixed methods analysis to provide evidence on whether men and women benefit equally from rural road improvements, and to explore reasons why they do or do not. Specifically, we used quantitative data to rigorously evaluate the gender-specific impacts of rural road improvements. Then, we collected qualitative data to understand the mechanisms behind these impacts. For the quantitative analysis, we combined administrative data on the rollout of the RTP3 activities with existing household-level data. We describe all three types of data in greater detail below.

Household data

For household data, we turned to the Vietnam Access to Resources Household Survey (VARHS) implemented by UNU-WIDER in collaboration with the Central Institute for Economic Management (CIEM). The VARHS consists of two questionnaires—a commune and a household questionnaire. The former covers information on the commune, recent economic shocks, infrastructure, access to services, and development programs at the commune level. The household questionnaire, which we used in our analysis, includes modules on household members, production and employment, use of inputs, income, and measures of social and political connectedness.

The VARHS was implemented in 2002, 2006, and every two years since 2008 in 12 provinces in Vietnam. From 2008, the survey included a panel component. We used data from the 2008, 2010, 2012, and 2014 rounds of the survey. As per this data, 99.5 percent of RTP3 road improvements occurred between 2009 and 2014 (Table A.1). Having a panel allows us to use household and individual-level fixed effects, which requires less stringent identification assumptions. The panel component of the VARHS is the main reason we chose it over another household-level data set from the same period: the Vietnam Household Living Standards Survey (VHLSS).

The sample in the VARHS was chosen in 2006 to be representative of the population in rural areas in the sampled provinces.[9] In 2008, this sample was expanded by 1,000 households in five additional provinces[10]

[9] Đắk Lắk, Đắk Nông, Điện Biên, Hà Tây, Khánh Hòa, Lai Châu, Lâm Đồng, Lào Cai, Long An, Nghệ An, Phú Thọ, and Quảng Nam.

[10] Lào Cai, Điện Biên, Lai Châu, Đắk Lắk, and Đắk Nông.

to facilitate the evaluation of the Danida-supported Agricultural and Rural Development Sector Program Support (ARD-SPS). In subsequent rounds, a part of the sample was replaced in each round to correct for aging of the original sample. In total, approximately 3,000 households were sampled in each round from 2008 onwards. We restricted our sample to households covered in all four rounds between 2008 to 2014, the latest round of VARHS to which we were able to gain access. Matching this with the administrative data left us with 509 households in each round of the VARHS spread across 73 communes in the RTP3 sample; a total of 2,036 observations in four consecutive rounds, spanning an eight-year period.

Administrative data

We used administrative data on road improvements at the level of each road. This data included: type of activities carried out under RTP3 (classified into rehabilitation, periodic maintenance, and routine maintenance), the dates when these activities were carried out, and the location of the road. We retrieved these data from project management units located within the DoTs in each province with significant assistance from the central project management unit located in the Department of Roads Vietnam (DRVN) in Hanoi.

The decentralized implementation structure both impeded easy access to administrative data and lowered the quality of data we were eventually able to retrieve. Although some project data were maintained centrally, including by the World Bank, they were not at the level of detail sufficient to carry out an impact evaluation. Data on locations of each road, activities, and timelines were only maintained in the provincial DoTs responsible for the implementation of the project. Collecting the data took several months and was an iterative process based on conversations with staff of the DRVN and provincial DoTs. We learnt in the process that data on non-RTP3 activities and GIS data on roads were prohibitively difficult to retrieve, if not nonexistent. The data on the pre-intervention quality of the road were not available either. In the end, we were able to collect data covering project activity, start and end dates, and details of the road segment improved from 17 of the 33 project provinces.

The resulting data set covered 1,369 road segments, which pass through 1,222 communes in 240 districts. Activities are classified into four types of improvements—road rehabilitation, periodic maintenance, routine maintenance, and repairs due to flood (Table A.2). Repairs due to flood are an emergency response. Including them in estimation of RTP3 impacts could conflate the impact of the flooding with the impact of response to the disaster. Consequently, we dropped RTP3 roads where these emergency repairs due to floods took place. This left us with 1,350 roads.

Qualitative data collection

We complemented these quantitative data with qualitative data collected from three RTP3 project sites. The objective of qualitative data collection was to understand the mechanisms through which better roads affected socio-economic outcomes. We placed specific emphasis on capturing gender-specific factors, which may facilitate or hinder benefitting from improved rural roads.

Our primary data collection took place between October 21 and November 2, 2018. We selected one RTP3 road in three provinces that were covered in VARHS: Lào Cai, Nghệ An, and Quảng Nam. We designed the survey instruments jointly with a local team of sociologists and anthropologists, who also administered the instruments, transcribed the interviews, translated them, and carried out their preliminary analysis.

In total, the team carried out 18 interviews with key informants, 42 interviews with project beneficiaries (26 women and 16 men), and 12 focus group discussions (FGDs) with beneficiaries in the three sites. Interviews with key informants focused on their perceptions of the effectiveness of the program, its impacts on the beneficiaries, and longer-term expectations of road quality following closure of the RTP3 project. The interviews and FGDs with beneficiaries were aimed at providing a better picture of the livelihood patterns in the communes affected by RTP3 and how these changed, if they did, during the project period. The qualitative data also asked about gender roles to see how these may have mediated changes in the outcomes we observed, and whether these roles were also affected by improved access to roads. The research instruments, field reports from each site, and transcripts, along with the final report, are available upon request.

4. Methodology

The key challenge in evaluating the impacts of the road improvements under RTP3 is to identify a valid counterfactual. Since an experimental approach is not usually feasible in evaluations of transport infrastructure, the existing literature has relied on quasi-experimental approaches that include comparing groups around eligibility thresholds (Asher and Novosad, 2016; Mukherjee, 2012), constructing comparable groups using matching techniques (Mu and Van de Walle, 2011), instrumental variables (Faber, 2014), or difference in differences framework (Shamdasani, 2016; Garz and Perova, 2014). These papers generally compare individuals, households, or communities in areas where roads were rehabilitated to comparable individuals, households, or communities in areas not reached by road improvement programs.

One of the limitations of our administrative data is that we only have information about RTP3-linked road improvements. They do not include road rehabilitation projects funded through other development agencies or from the national budget. Therefore, if we use a group of non-RTP3 communes as a comparison group, we would not know whether they received road improvements from a different program for which we do not have data. However, we do know based on discussions with the DRVN and Provincial Departments of Transport (PDoTs) that the rural communes that received RTP3 did not receive any non-RTP3 road improvements during our study period. This largely happened because the government tried to distribute infrastructure improvement funds equitably, and communes generally do not get funds for road construction and improvement from more than one source. Therefore, we restricted our sample to communes that benefitted from the RTP3 project and exploited variation in the timing of rollout. Essentially, we identified the impacts of the project by comparing welfare outcomes in the communes that received road improvements at the beginning of the study period with welfare outcomes in the communes which had not as yet.

Taking advantage of the panel data, we formalized this approach in the following regression:

$$Y_{hct} = HH_h + \sum_{t=2}^{T} \gamma_t \delta_t + \beta Treat_{ct} + \kappa(Treat_{ct} * FHH_{ht}) + \lambda X_{hct} + \varepsilon_{hct} \qquad \text{(Equation 1)}$$

where h, c, t denote household, commune, and time, respectively. δ_t denotes dummy variables for each year; HH_h is a household fixed effect,[11] and X_{hct} are time-variant household characteristics. FHH_h is a dummy variable equal to one if a household head is a woman, and zero otherwise. X_{hct} includes controls for the age of the household head, the number of dependents in the household[12] and the level of education of the household head.

Y_{hct} captures outcomes of interest, such as household production and trade of crops and livestock, the types of crops grown, and the inputs into production, as well as measures of welfare like income, quality of housing, and consumption at the household level. We also explore the impact on employment at the individual level. These outcomes represent the overlap between the outcomes where we expected changes based on the literature and the data available in the VARHS.

The parameter of interest in equation (1) is the coefficient on the dummy $Treat_{ct}$ which takes the value of one when the treatment is active. In contrast to the existing literature where road improvements are treated as permanent, given the nature of the RTP3 project, we treat improvements as temporary. Following consultation with transport specialists at the World Bank and corroboration by specialists from the DRVN and the Transport Development and Strategy Institute (TDSI) in Vietnam, we arrived at the following as an average estimate of the life span of each type of RTP3 activity:

- **Routine maintenance** leads to an improvement in road quality that lasts a maximum of one year since these activities typically prevent road quality from deteriorating during the rainy season. We use one year as the life span of a road improved with routine maintenance.
- **Periodic maintenance** leads to improvements that last longer, typically around two years.[13]
- **Rehabilitation** improves road quality[14] for longer than five years, the maximum length of the post-intervention period in our study, so we treated it as a permanent improvement *within our study period* (i.e., a road rehabilitated in 2009 remains "improved" until 2014). This is consistent with

[11] Since we had household-level fixed effects and the households in our sample did not move in the duration of the study, these absorbed a potential commune-level fixed effect.

[12] We controlled for number of dependents in the household rather than household size. The number of dependents likely correlated with the household size, but did not open up a channel for omitted variable bias arising from the fact that household size is affected by migration caused by road improvements.

[13] The administrative data do not distinguish between periodic maintenance on unsealed and sealed roads. The lifespan of this intervention on sealed roads is usually longer, up to six to eight years. Therefore, the average lifespan proposed by transport specialists at the World Bank, DRVN, and TDSI is a conservative estimate of the duration of improvement.

[14] As noted in Section 2, activities classified in the administrative data as "road rehabilitation" include rehabilitation and upgrading. The life span for upgrading is typically much longer than six years, whereas for rehabilitation, improvements are normally expected to last on average five years.

the current literature focused on rural roads rehabilitation (Garz and Perova, 2014; Khandker, Bhakt, and Koolwal, 2009; Khandker and Koolwal, 2011; Mu and Van de Walle, 2011).

Given that there is a degree of subjectivity in arriving at these definitions, we tested the robustness of our findings to alternative definitions of treatment length (described in greater detail further on). Equation 1 estimates treatment effects at the household level. In order to estimate treatment effects on men and women living in male- and female-headed households, we ran an identical regression at the individual level with controls for an additional interaction term between female and female-headed households.

$$Y_{ihct} = \theta_i + FHH_{ht} + \sum_{t=2}^{T} \gamma_t \delta_t + \beta Treat_{ct} + \kappa(Treat_{ct} * Female_{ihc}) + \rho(Treat_{ct} * Female_{ihc} * FHH_{ht}) + \lambda X_{ihct} + \xi_{ict}$$

(Equation 2)

where subscript *i* denotes individual, and θ_i is an individual fixed effect. $Female_{ihc}$ takes value of one for women and zero for men. Equations 1 and 2 estimate household and individual-level impacts of having been exposed to any road improvement activity (rehabilitation, periodic, or routine maintenance). We refer to this estimation as pooled treatment. We also estimated the impact of each of these interventions separately in the following regressions:

$$Y_{hct} = HH_h + \sum_{t=2}^{T} \gamma_t \delta_t + \beta_{RM} RM_{ct} + \kappa_{RM}(RM_{ct} * FHH_h) + \beta_{PM} PM_{ct} + \kappa_{PM}(PM_{ct} * FHH_h) + \beta_{RB} R_{ct} + \kappa_{RB}(R_{ct} * FHH_h) + \lambda X_{hct} + \varepsilon_{hct}$$

(Equation 3)

where RM_{ct} is a dummy that is equal to one when a road qualifies as improved through routine maintenance in commune *c* in year *t*. β_{RM} captures the change in outcome variable Y that we can attribute to a commune having received routine maintenance under RTP3. Similarly, PM_{ct} and R_{ct} are dummy variables which capture improvements due to periodic maintenance and rehabilitation, respectively. In most cases, for any given year only one of these treatment dummies is equal to one in a commune, but there are some cases where a commune received more than one type of road improvement.

In all of the regressions above we clustered errors at the commune level since the interventions under RTP3 were effectively delivered at the commune level.

Taking advantage of the panel data, we controlled for unobserved time-invariant factors that may be correlated with road rehabilitation at the commune and household level by including an individual or household-level fixed effect term. Since our data were restricted to households that did not move, the commune-level fixed effect was absorbed by the household or individual fixed effect.

At the commune level our identifying assumption is likely to be violated under two circumstances. First, if the placement of the program responds to changes in the outcome variables, our estimates will be biased. This will happen, for example, if there is commune-level dynamic targeting; for instance, if roads in the communes with declining unemployment get improved first. However, this assumption is an at least partially testable one. We cannot run traditional placebo tests as we do not observe all the roads for more than one period before the implementation of the program started. However, we can still carry out a placebo test in a subset of communities that were treated later. Specifically, we checked whether the changes in key outcomes between 2008 and 2010 differed in communities that received RTP3 in 2010 from changes in communities which received RTP3 later, in 2012. Tables A.5a, A.5b, and A.5c present the results for key outcomes of interest. Overall, we do not find evidence of differential trends. The one exception is the regression of income from common property resources on placebo treatment. However, as this is the only regression with a significant coefficient out of 21, we interpret the results of our placebo tests as consistent with our identifying assumption of parallel trends.

Second, our regressions will yield biased estimates if some unobserved changes at the community level are correlated with RTP3 rollout as well as the outcomes of interest. This can happen if the rollout of other social programs coincides with the rollout of RTP3. Although the assumption that such correlations are absent is not testable, it is quite plausible. Specifically, given the construction of our treatment term, the treatment variable switches on and off (may take value one and then again zero during the study period for maintenance activities). Consequently, any contemporaneous development program would need to not only be rolled out simultaneously, but also paused simultaneously, or at least be systematically correlated not just with the turning on date, but also the turning off date. This is a much more restrictive condition.

Our identifying assumption may also be violated if time-variant individual- or household-level factors are correlated with program rollout and the outcomes of interest. Households may act either in anticipation of or as a consequence of the program rollout. Since the rollout of RTP3 was centrally planned, we treat road improvement as an exogenous shock to households that is not anticipated. However, since we used a balanced panel of households, our sample excludes households that migrated during this period by construction. This may lead us to miss an important channel of effects associated with improved connectivity. Since migration affects estimates of employment and productivity, this could bias our estimates of treatment effects on these variables. It is usually more common that individuals within a household, rather than an entire household, move. In that case, we interpret our results as the effects on the population that stays behind.

Finally, it is worth pointing out that our estimation strategy involved treating RTP3 road improvements as local changes. In contrast, Donaldson (2018), for example, calculates changes in implied trading costs for all points in the network in response to a change in trading costs between one pair of points. A similar exercise is not feasible in the current setting given that it would require information on the entire road network. More importantly, the rural roads under RTP3 connected populations that previously lacked year-round road access. The network impacts of an improvement in this case are likely to be much more muted than, for instance, would be the case with a road like a national highway (or a railroad). If RTP3 roads did indeed improve rest-of-network connectivity, our estimates provide a lower bound of the full impact of road improvements.

5. Results

Sample characteristics

The selection of roads for RTP3 interventions was carried out at the start of the program and was strictly based on criteria linked to the development objective of the program: to *improve year-round access to markets, economic opportunities, and social services for rural populations*. The criteria included the number of poor and total population affected by the road, defined as the population living within 2 km of the road, and whether or not the commune previously had an all-weather road. Our study sample differs from the broader VARHS 2008 sample, which was constructed to be representative of the rural population in the provinces it covered, because we restricted our study to the communes that were selected to receive RTP3 interventions.

A comparison of households from the two sets of communes suggests that the program achieved its targeting objectives:[15] our study sample is poorer than the full VARHS sample and this difference is quite large in some measures. There are few statistically significant differences in terms of household size and household head characteristics (Table A.3), but there are significant differences in income, consumption, and indicators of wealth like assets and quality of housing. For instance, households in RTP3 communes are less likely to have a brick wall or a cement floor. Total incomes among the RTP3 sample are approximately 40 percent lower than in the full VARHS sample. The differences appear to come from wages, agriculture, and income from non-farm sources, all of which are suggestive of lower levels of economic opportunity in these villages. Indeed, considering land ownership, we see little difference in the size of land owned, but significant differences in the amount of land cultivated, and perhaps unsurprisingly, in the value of land (Table A.3).

Male- versus female-headed households

A second relevant comparison to make at the outset is between gender differences at baseline: mainly differences between male- and female-headed households since most of our regressions are at the household level. Anecdotal evidence suggests that the default head of household is a man, with the implication that female-headed households are likely those where women are widowed, separated, or divorced. In contrast, a very small percentage of male-headed households are unmarried. Therefore, it is likely that female-headed households have one working-age adult less on average, compared to male-headed households. This indeed appears to be the case in our sample. As Table A.4a shows, there appear to be only small differences between male- and female-headed households in VARHS 2008 in the education or literacy levels of the household heads, but statistically significant differences in the size of the household. Male-headed households are larger on average than female-headed households by close to one adult per household.

[15] Another reason these samples could differ is that the sampling unit that we draw data from is the commune whereas VARHS is intended to be representative at the province level. However, nothing in the sampling strategy of VARHS (described in Section 2) gives us a reason why we should expect the systematic differences we observe in Table A.3 based on the fact that the data are not representative at the commune level. Therefore, we interpret this largely as a result of RTP3 targeting.

The deficit of a working age adult can explain the lower agricultural income in female-headed households in our sample. Surprisingly, however, female-headed households report higher incomes from wage work. It could be that female-headed households where men are missing may also be more likely to suffer from a lack of access to land, making wage work or self-employment more important as means of income. It is interesting, however, that while we see limited signs of differences in wealth, we do not see differences in terms of assets or land ownership or value.

Pooled estimates

As we discuss, our choice of outcomes is based on the overlap between variables where the literature suggests possible effects and the data available in VARHS. Thus, we analyze RTP3 impacts on agricultural production patterns, employment outcomes, and household income.[16] In discussing impacts on agriculture, we estimate impacts on crops and livestock in both production and trade. Following Shamdasani (2016), we also distinguish between export and non-export crops. Unfortunately, our data do not allow for construction of reliable indicators of educational or health outcomes. To better understand mechanisms behind the observed results, especially when they vary by gender, we drew on the insights from qualitative work.

Agricultural production and trade

Our analysis suggests that the RTP3 project had statistically significant impacts on both crop production and the amount of crop production traded (Table A.6). Besides being statistically significant, the impact is large in magnitude. The size of the treatment effect on crop production is about 15 percent of the baseline mean for male-headed households, or the equivalent of about US$100 annually. However, for female-headed households, the impact is much smaller: less than 0.5 percent of the baseline mean.

A few factors could explain this difference. Since there are fewer working-age adults in female-headed households (Table A.4a), these households have less of one of the critical inputs into agricultural production: household labor. In the absence of market frictions, households should be able to flexibly hire labor from outside the household to compensate. But this is not the case in the presence of market frictions, which appears to be the case for most agricultural households (La Fave and Thomas, 2016). For female-headed households, missing income from a working age adult may result in additional liquidity constraints and borrowing may be impossible due to underdeveloped credit markets. Indeed, we did not find any evidence on the use of credit.[17]

Our qualitative data corroborate the access to capital channel. We found that the households that appeared to have benefited the most from improved roads were households that either increased productivity by hiring machinery for ploughing and processing crops and transporting them to market or that were able to switch from cropping paddy to trees like acacia or orange. Both of these changes required up-front payment, with returns on the investment following with a lag of a few months or in the

[16] We are restricted in the types of effects we can analyze because we rely on data from the VARHS for household outcomes and are restricted both by the choice of variables in this data set and the small number of observations for some variables (such as agricultural inputs).

[17] Results available upon request.

case of trees, several years. The majority of female-headed households in our qualitative study were liquidity constrained and could not make these investments.

Notably, lack of access to capital will only affect the households' ability to trade if trading, too, requires some up-front payments. Our qualitative work suggest that this is not the case. Quantitative results are consistent with the qualitative study: the coefficient on the interaction term is not significant, so there appears to be no discernable difference in the impact on amount of crop traded between male- and female-headed households. The size of the effect on crop trade is higher than on crop production, with the increase close to 50 percent of the annual baseline mean.

"*In the old days, we ploughed by buffaloes or oxen. Getting up at 5 a.m., leading the buffaloes and ploughing tools to the rice fields, we would finish ploughing 1 sáo*[18] *at 8 a.m. Nowadays* [with machines], *3 sáos takes 1.5 hours."* — Female (household head), 38, Phuc Thanh, Nghệ An Province

In part, the high magnitude of the effect reflects the low level of pre-intervention crop trade when less than a quarter of the crop output was traded. Respondents in our qualitative data reported primarily two ways in which roads enabled crop trade. First, roads made it easier to access farms by motorized transport, which facilitated transporting crops to the markets. Second, road improvements appeared to have strengthened trading networks, both within and outside the villages. In the villages, improved road infrastructure increased awareness of who was producing what. Outside villages, roads facilitated access of intermediaries and buyers. These changes equally affected households headed by women and by men.

"When the road had not [yet been] upgraded, I drove a bike to carry 20 kg rice to a market. I couldn't carry much more. It took 20 minutes to go to the market by bike. Sometimes I even had to push the bike or use a pole to carry 20 kg rice to the market. It might take a half of day to sell… Now I phone customers to come buy rice. I don't need to carry the product to the market." — Woman, Nghệ An Province

"Customers go to the hill to buy cinnamon, I needn't carry cinnamon to find the buyers... In the past, some households planted litchi trees and pineapples, but they could not sell these products, so they either consumed them or gave them away. Now, with the road, we can sell every product." — Male, 56, Phố Ràng, Lào Cai Province

The decision to trade is linked closely to the choice of crop. For instance, a majority of smallholder farmers in Vietnam cultivate paddy as a subsistence crop. Therefore, we checked whether road improvements triggered an increase in commercial crop farming, as Shamdasani (2016) finds in India. We used two classifications to capture such effects. First, we classify crops reported in the survey as cereal (rice and maize) and non-cereal (all other crops). Second, we divide the crops into Vietnam's common exports (coffee, cashew, pepper, rubber, tea, peanuts) and all other crops. We find significant impacts on the value of cereal crops traded (Table A.7), but not on the output of cereal crops or the amount of non-cereal crops produced or traded. The difference between male- and female-headed households is not significant.

[18] 1 sáo is about 500 sqm.

Our findings are similar when we use an alternative classification (Table A.8). There is an increase in the value of non-export crops that are traded, with no difference between male- and female-headed households. We also find evidence of decrease in non-export crop production among female-headed households.

Why is it that households do not switch towards more commercial crop production in response to the availability of more options for commerce, as Shamdasani (2016) finds in India? There are a few possibilities. First, it is worth remembering that the response of a farmer depends on the types of markets that are now newly accessible. If rural roads offer connectivity to local markets rather than export markets, there may not be as strong an incentive to switch to export crops. Emerging evidence from the trade literature on the high costs of intranational trade (Atkin et al., 2015) suggests that this may be the case: domestic markets may be better thought of as a collection of small fragmented markets rather than a homogenous single market. In that case, better roads improve the links between these fragmented local markets where the demand for export crops may not be very high.

Second, switching may take more time than our quantitative data allow us to capture. Several respondents in our qualitative data collection exercise told us that they did start to cultivate certain types of trees. However, since our study spans a period of six years, we would not expect to see impacts on crop production or trade associated with increased cultivation of acacia, orange, or cinnamon in the VARHS data: the cropping cycle for these trees is seven to eight or 10 years. The decrease in production of non-export crops among female-headed households may reflect this gap in production immediately after the switch to a more profitable crop in the long run.

"*I started planting acacia in 2012. First, I planted on 2 ha, and planted rubber on the remaining 1 ha. In 2016, I planted acacia on all 3 ha since rubber was not profitable.*" — Male, 63, An Bac, Quảng Nam Province

When analyzing production and trade of livestock, we find that access to roads is associated with reduction in both livestock production and trade for female-headed households only (Table A.6). Analysis of changes in household income patterns, combined with qualitative work, provide insights into the potential reasons why.

Changes in household income

Table A.9 presents estimates of impacts on household income. While we do not find significant impacts on total income, our results suggest that the composition of income has changed. Notably, these patterns differ for female- and male-headed households. We observe an increase in income from agriculture for male-headed households and a decrease, albeit smaller, in income from the sale of assets. For female-headed households, we observe the opposite pattern: a decrease in income from agriculture and an increase in income from the sale of assets.

The impact on household production, combined with qualitative work, provides some insights into the mechanisms behind these opposing trends. While improvements in road infrastructure offer better economic opportunities in agriculture, only some households can take advantage of these opportunities by increasing crop production in response (Table A.6). Male-headed households benefit from greater availability of one of the critical inputs into agricultural production: household labor. Female-headed households are predominantly households of widows or separated women and have on average one less working age adult compared to male-headed households.

Moreover, our respondents told us that the increased opportunities to trade agricultural products spurred two main types of changes: hiring machinery and switching to more commercially lucrative crops that also had longer cropping cycles. These changes required up-front investment, and in case of commercial crops, such as acacia trees, would not bring any returns in the short run. Such long-term or capital-intensive projects are easier to implement for households with greater availability of labor. In addition to serving as a resource for agricultural production, these projects may enable households to rely on multiple sources of income from different household members, while waiting for commercial crops with long growth cycles to yield the first crops.

While in theory female-headed households could substitute capital for labor and still make investments in agriculture, in the absence of well-developed credit markets it is hardly an option.[19] Increase in sales of assets may suggest an attempt by female-headed households to acquire capital for such investments. The decrease in income from agriculture may be indicative of the start of a transition process to longer growth cycle commercial crops.

Employment

Existing literature suggests that roads rehabilitation is associated with increased off-farm employment (Asher and Novosad, 2016; Garz and Perova, 2014). We take advantage of the fact that VARHS contains employment information for each individual living in a household. The questionnaire asks whether each household resident older than 10 years does any work for wages, works on the household farm, is self-employed, and does any work within the household or on common property resources. We estimate the impact of roads improvements on employment choice using Equation 2, with standard errors clustered at the village level. As our outcome variables are binary, we effectively estimate the probabilities of being employed in each type of work.

The baseline differences between men and women in employment are noted in Table A.4b—women are less likely to be working in wage work and more likely to be doing housework, and are marginally more likely to be self-employed. The main change in employment is an approximately 10 percent increase in the likelihood of working on common property resources for men (Table A.10). For women, the likelihood of increase depends on whether they live in a male- or female-headed household. For women in male-

[19] One constraint on crop switching that affects everyone is caused by the food safety policy. This restricts switching from paddy to non-paddy cultivation for both male- and female-headed households.

headed households, the likelihood of working on common property resources increases, but by less than for men. Whereas for women in female-headed households, the likelihood increases by more than for men. In our qualitative study, respondents suggested that one of the main benefits of improved roads was better access to forests, which made it easier and safer to transport any output from the forest home or to the market. Notably, we do not find a significant increase in income from common property resources. However, much of the common property resources may be destined for consumption rather than market sale.

"*We climb hills to look for firewood…. We need to travel carefully when driving with firewood. Before the road was improved, it used to be difficult to pass other vehicles in the opposite direction…. The road was dangerous when it rained and road got slippery…. You could fall down…. We only started collecting firewood after the new road.*" — Female, 54, Luong Son, Lào Cai Province

In contrast to the evidence from India and Nicaragua, we do not find a significant treatment effect on wage employment in Vietnam. The channels behind these effects are different in the two countries: in India, increase in employment is due to an improved labor market. In Nicaragua, an additional channel is at play: the intervention there was intended as an employment generation program, with residents laying cobble stones for wages higher than average in their villages (Garz and Perova, 2014). Although in some provinces road rehabilitation involved residents, as described earlier, it was set up with the objective to promote a culture of community road maintenance, rather than to provide competitive employment opportunities. In this respect, qualitative work suggests that the intervention succeeded.

"We worked for ourselves, this helped to keep road clean; better for environment. Even without payment, we should maintain our road regularly. We go on the road every day, especially our children." — Female (Household head), 34, Luong Son, Lào Cai Province

Road improvements could still hypothetically increase off-farm work through improved access to broader labor markets, the channel discussed in Asher and Novosad (2016). We do not find any evidence of this. On the contrary, we find an approximately three-percentage-point reduction in the likelihood of working for wages among female residents, in male- and female-headed households alike. This amounts to approximately 1 percent of the pre-intervention level of engagement in wage work among women. Qualitative data suggest that this decrease is also due to emerging specialization after road improvement. In male-headed households, greater opportunities in agriculture necessitate diverting more household labor to the fields. In some cases, increase in household labor in agriculture necessitates women's withdrawal from wage work either to also help in the fields or due to increased household burden.

"When I finish all the above tasks [housework, child care, cooking, shopping, and feeding the pets] then I can go to work. Also, I can go to harvest." — Female, 45, An Bac, Quảng Nam Province

In female-headed households, women may decrease wage work to engage in low-level commerce. Notably, the coefficient on self-employment for women is positive, and marginally significant (t-stat is at 1.67).

Separate estimates

As we discuss in Section 4, our treatment variable pools together all the interventions under RTP3, which correspond to different types of road improvements (rehabilitation, routine maintenance, and periodic maintenance).

Rerunning our analysis to estimate the impacts of each type of treatment (Equation 3) allows us to check whether these types of road improvements affect households differently. However, it is important to keep in mind ensuing differences in statistical power when interpreting our results. The pooled treatment effect offers us a considerably larger sample size and, therefore, more statistical power. When we switch to estimating separate treatment effects for each type of treatment, we are effectively working with smaller samples. Moreover, the sample size for each type of intervention varies substantially, as indicated in Table A.3, making the issue of statistical power all the more salient in interpretation of the results from this analysis.

We find that our main results are driven by road rehabilitation and routine maintenance (Tables A.11 to A.15). For instance, when we look at changes in household production in terms of output and trade of crops and livestock, we find that only coefficients on rehabilitation and routine maintenance replicate magnitude and significance of polled estimation. Periodic maintenance is not statistically significant. This is a pattern that is repeated throughout our results. For example, the treatment coefficients for cereal sales are again significant for routine maintenance and rehabilitation. We also find a positive and significant effect of routine maintenance on sale of non-export crops for men and women, and of rehabilitation for men only.

This may not be entirely surprising given the nature of the interventions. We expect rehabilitation, the most intensive of the three treatments, to have the strongest treatment effect. Similarly, although routine maintenance is the least intensive of the three types of treatments administered under RTP3, more than 60 percent of the roads covered under RTP3 received routine maintenance. In contrast, approximately 16 percent of roads received periodic maintenance. For the same effect size, we would, therefore, be much more statistically powered to detect changes caused by routine maintenance than periodic maintenance. Though the number of roads that receive periodic maintenance is similar to the number that receive rehabilitation, the latter is a much stronger intervention.

Notably, we see strong income effects associated with rehabilitation in particular on wage income, total income, and total non-transfer income. In contrast, the treatment effects of routine maintenance are only significant (and in the direction of the pooled treatment effect) in the case of income from the sale of assets.

Robustness checks

We carried out two types of robustness checks. First, we checked if our results are sensitive to the definition of length of treatment. Our approach in this study departs from the existing literature in an important way in that it treats road improvements as being time bound. This approach has some advantages: one, it presents a more accurate picture of the types of interventions we are studying. Two, it increases the likelihood that our identifying assumptions hold, as discussed in Section 4. However, there is indisputably some degree of arbitrariness in deciding how long the effects of road improvements last on average.[20]

In the case of rehabilitation, this definition (i.e., treatment lasting more than five years) is corroborated by broader literature. In the case of routine maintenance, the duration corresponds to the annual weather cycle. However, in the case of periodic maintenance, we rely solely on our own definition based on the judgment of transport experts on the project implementation team, DRVN, and TDSI. Given potential subjectivity, we test how robust our results are to modifications in the definition of treatment length for periodic maintenance. Increasing the length of treatment from one to two years does not result in any significant changes in the conclusions of our analysis.[21]

Second, we check if our results are robust to an alternative functional form specification. We reestimate Equation 1 using an inverse hyperbolic sine (IHS) transformation of our dependent variables, expressed in Vietnamese dong (crops and livestock amounts traded and sold, income). We prefer to use an IHS transformation rather than a logarithmic one to avoid losing observations where these outcomes are equal to zero, which constitutes a non-trivial proportion of our sample.

The results from the robustness checks for the main results with the pooled treatment term are presented in Tables A.16 to A.19. While the direction of the effect remains the same, we lose significance of most of our results with IHS transformation. Only in the equations with income from sales of assets as a dependent variable, coefficients remain statistically significant for both the treatment variable and its interaction with the female-headed household dummy. Thus, our results are not fully robust to modifications in functional form. However, use of levels remains our preferred specification because of our interest in changes in the right tail of the distribution. Our qualitative work revealed that better roads triggered productive changes in agriculture, such as the increased use of machinery and switch towards more commercially lucrative crops. However, these changes take time and happened in the households that were more likely to invest in improved production processes and planting new crops. However, these types of changes may substantially increase production rather than trigger change in the margin. Consequently, we would like our estimates to be sensitive to the changes in the right tail of the distribution, which are likely to be subdued when IHS transformation is used.

6. Conclusion

Although accurately estimating the magnitude of global investment in transport is fraught with challenges, the estimates that exist point to a very large number—on the order of magnitude of US$1 trillion annually. Recent studies demonstrate that such investments play an important role in improving development outcomes ranging from crop diversification (Shamdasani, 2016) to higher educational enrollment (Garz

[20] Our administrative data do not allow us to distinguish between activities carried out on sealed versus unsealed roads and the baseline conditions of roads, two data points which would narrow the range of life spans, we could reasonably expect. They also do not allow us to distinguish between upgrading and rehabilitation, but as we note in footnote 15, the impact of this is not as large given the short time frame of this study.
[21] Results are available upon request.

and Perova, 2014). Our study contributes to this literature in two ways. First, we explored whether there is heterogeneity in benefits by gender using quantitative methods: we rigorously evaluated the gender-specific impacts of a large-scale road rehabilitation and maintenance project in Vietnam. As discussed in the introduction, we tested two hypotheses that have distinct policy implications. Women may benefit less than men from better roads if road improvements address only some of the constraints that women face (complementary constraints hypothesis). Women may benefit more than men from road rehabilitation if for an equivalent reduction in travel time the marginal value of their time is higher (tightness of constraint hypothesis). In the latter case, rural road improvements may on their own be an investment towards the Sustainable Development Goal (SDG) of gender equality. In the former case, complementary interventions may be needed to avoid exacerbating existing inequalities between the genders.

Second, we complement our quantitative analysis with qualitative data collection to provide additional insights into what barriers prevent one gender from taking full advantage of improved roads. The analysis is based on in-depth interviews and FGDs carried out in October and November 2018 with women and men living in three project sites.

The combined quantitative and qualitative results suggest that better roads expanded economic opportunities, particularly in agricultural production and trade. However, our results also indicate that male-headed households are significantly more likely to take advantage of these opportunities.

Increasing agricultural production and trade required an increase in usage of labor or machinery. Male-headed households have one more working-age adult than female-headed households and are either able to increase the amount of labor on the farm or use the income from the extra adult to rent machinery. Female-headed households, suffering from a household labor deficit, are more constrained in increasing farm labor or renting machinery. Given the lack of efficient credit markets in our study areas, they are also not able to substitute capital for labor and borrow to make these investments. We find evidence of increased income from sales of assets among female-headed households—selling assets may be a strategy to access capital for agricultural investments.

Overall, our results point towards the validity of the complementary constraints hypotheses and suggest the need for complementary interventions to allow both genders to fully reap the potential benefits of better roads. This resonates with one of the main messages of a recent World Bank study on the Belt and Road Initiative, of which Vietnam is a part,[22] that complementary programs are required to "unlock" the full potential of investments in transport corridors not just to increase impacts and deepen inclusion, but also to mitigate their social and environmental risks (World Bank, 2019).

In our study context, facilitating access to credit combined with financial literacy training and business development skills would be one example of such complementary intervention. The impact of such an

[22] The upgrade to Vietnam's NH-5 connecting Hanoi to Hai Phong port, carried out with Japanese aid, is highlighted as an example of a project where complementary policies, including investments in human capital and improvements in business environment, led to successful economic development along the corridor.

intervention would go beyond female-headed households, since other vulnerable households may also be constrained in terms of credit or household labor. Our results also point to the importance of coordination among different governmental investments. For example, coordinating the implementation of a rural roads program with a financial literacy or agricultural credit program would likely lead to a multiplier effect, at least for more vulnerable households.

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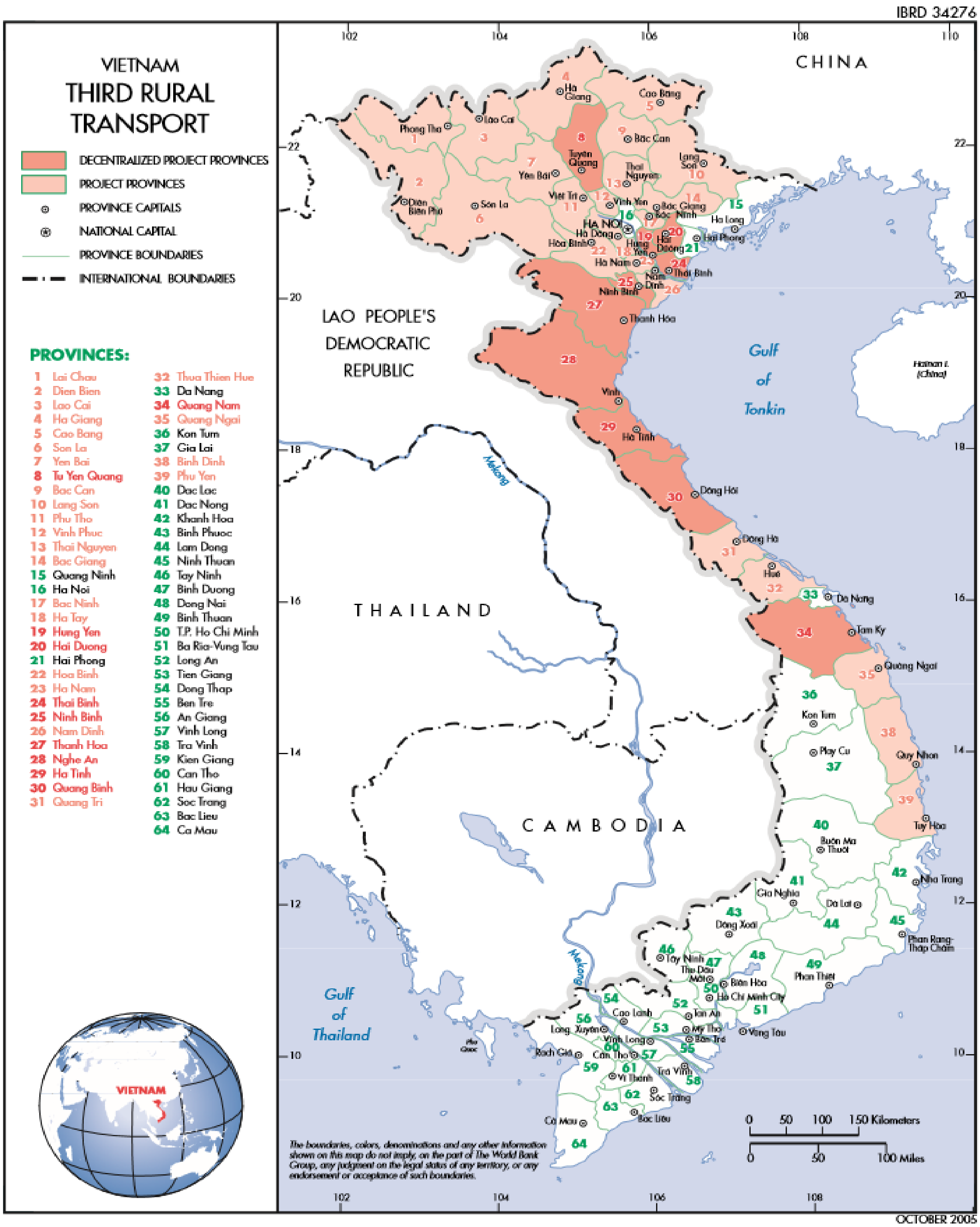
Appendix

Figure A.1: Map showing RTP3 provinces



Source: Project ICR document (see References).

Table A.1: Rollout of RTP3 activities by year

Year	No. Roads	(%)
2009	75	5.51
2010	201	14.78
2011	488	35.88
2012	234	17.21
2013	183	13.46
2014	173	12.72
2015	6	0.44
Total	1,360	100

Table A.2: RTP3 activities, by type of activity

(Note that "Repairs due to flood" were not included in the analysis)

Type of activity	No. Roads	(%)
Routine Maintenance	857	63.01
Periodic Maintenance	220	16.18
Repair Due to Flood	19	1.40
Rehabilitation	264	19.41
Total	1,360	100

Table A.3: Comparison of RTP3 households with VARHS households at baseline (pre-RTP3)

	Full Sample			*RTP3 Sample*				
	N	**mean**	**sd**	**N**	**mean**	**sd**	**diff**	**p-value**
Household								
Size	2,442	4.92	1.99	509	4.83	1.90	-0.09	0.35
Dependents (N)	2,442	2.39	1.52	509	2.32	1.34	-0.07	0.32
Literate (N)	2,442	0.76	1.00	509	0.71	0.91	-0.05	0.29
Household head								
Female	2,442	0.17	0.37	509	0.16	0.37	-0.01	0.61
Married? (Y/N)	2,442	0.86	0.35	509	0.85	0.36	-0.01	0.64
Education level	2,442	8.03	3.50	509	8.17	3.90	0.14	0.42
Literate? (Y/N)	2,442	0.16	0.37	509	0.19	0.39	0.03	0.10
Housing/Dwelling								
Size	2,437	64.31	34.98	508	66.77	33.35	2.46	0.15
Brick wall	2,442	0.54	0.50	509	0.44	0.50	-0.09	0.00
Cement floor	2,442	0.67	0.47	509	0.55	0.50	-0.12	0.00
Solid roof	2,419	0.50	0.50	507	0.47	0.50	-0.02	0.37
Non-compost toilet	2,442	0.28	0.45	509	0.25	0.43	-0.03	0.19
Water connection	2,442	0.07	0.26	509	0.14	0.34	0.07	0.00
Electricity	2,442	0.90	0.31	509	0.88	0.33	-0.02	0.24
Number of assets								
Motorcycles	2,240	0.90	0.71	439	0.74	0.66	-0.17	0.00
Bicycles	2,240	0.88	0.94	439	0.72	0.97	-0.16	0.00
Cars	2,240	0.01	0.12	439	0.01	0.12	0.00	0.80
TV	2,240	0.92	0.43	439	0.84	0.41	-0.08	0.00
Radio	2,240	0.13	0.35	439	0.11	0.32	-0.02	0.21
Fridge	2,240	0.17	0.46	439	0.10	0.35	-0.07	0.00
A/C	2,240	0.01	0.10	439	0.00	0.00	-0.01	0.09
Washing machine	2,240	0.04	0.19	439	0.02	0.13	-0.02	0.02
Computer	2,240	0.03	0.19	439	0.04	0.20	0.01	0.37
Land								
Total value	2,442	128,383.20	283,563.62	509	34,713.90	119,871.90	-93,669.30	0.00
Total size	2,442	10,974.87	17,131.53	509	9,254.37	37,523.53	-1,720.51	0.11
Unit value	2,442	37.61	135.06	509	24.70	101.71	-12.91	0.04
Income								
Wage	2,442	9,171.16	14,620.61	509	6,087.93	12,609.43	-3,083.23	0.00
Agriculture	2,441	16,561.36	22,762.33	509	10,012.48	9,827.97	-6,548.88	0.00
Common-property resources	2,442	871.75	1,648.45	509	1,086.96	1,611.59	215.21	0.01
Non-farm	2,442	5,749.82	16,757.43	509	2,797.14	10,919.26	-2,952.68	0.00
Rent	2,442	71.61	389.33	509	56.20	340.30	-15.40	0.41
Total	2,442	41,262.68	43,454.86	509	24,062.48	25,476.16	-17,200.20	0.00

Table A.4a: Pre-intervention differences between male- and female- headed households

	Male			*Female*				
	N	**mean**	**sd**	**N**	**mean**	**sd**	**diff**	**p-value**
Household								
Size	428	5.09	1.82	81	3.46	1.75	-1.63	0.00
Number of dependents	428	2.43	1.34	81	1.70	1.18	-0.73	0.00
Household head								
Married	428	0.98	0.15	81	0.17	0.38	-0.80	0.00
Widowed	428	0.01	0.11	81	0.77	0.43	0.75	0.00
Separated or divorced	428	0.00	0.05	81	0.04	0.19	0.03	0.00
Literate	428	0.18	0.38	81	0.23	0.43	0.05	0.25
Education	428	8.21	3.83	81	7.98	4.25	-0.23	0.63
Income								
Wage	428	5,642.04	12,394.23	81	8,646.44	14,492.18	3,004.40	0.05
Agriculture	428	10,876.49	10,179.51	81	5,447.06	5,929.43	-5,429.43	0.00
Common-property resources	428	1,869.75	10,379.72	81	487.78	1,084.67	-1,381.98	0.23
Non-farm	428	3,554.40	27,724.53	81	4,326.67	12,624.56	772.26	0.81
Rent	428	125.08	1,228.21	81	55.19	267.40	-69.90	0.61
Total	428	25,386.08	40,866.94	81	23,811.96	22,376.58	-1,574.12	0.74
Consumption								
Cereals	428	1.00	0.05	81	1.00	0.00	0.00	0.66
Tubers	428	0.28	0.45	81	0.38	0.49	0.10	0.06
Vegetables	428	0.98	0.14	81	0.96	0.19	-0.02	0.38
Fruit	428	0.31	0.46	81	0.46	0.50	0.15	0.01
Meat	428	0.35	0.48	81	0.43	0.50	0.09	0.14
Eggs	428	0.14	0.35	81	0.20	0.40	0.06	0.18
Fish	428	0.32	0.47	81	0.57	0.50	0.24	0.00
Pulses	428	0.29	0.45	81	0.23	0.43	-0.05	0.35
Dairy	428	0.07	0.26	81	0.21	0.41	0.14	0.00
Fats	428	0.82	0.38	81	0.91	0.28	0.09	0.05
Sugar	428	0.22	0.41	81	0.43	0.50	0.21	0.00
All crops								
Output	428	12,284.22	8,509.95	81	6,588.52	6,487.16	-5,695.70	0.00
Sold/bartered	428	3,963.92	6,219.30	81	2,625.21	4,192.37	-1,338.71	0.06
Cereal crops								
Output	428	8,996.31	6,303.06	81	4,468.75	4,877.16	-4,527.55	0.00
Sold/bartered	428	1,796.18	3,441.40	81	1,061.73	1,928.94	-734.46	0.06
Non-cereal crops								
Output	428	3,287.91	5,027.24	81	2,119.77	3,913.16	-1,168.15	0.05
Sold/bartered	428	2,167.74	4,721.02	81	1,563.48	3,717.13	-604.25	0.28
Export Crops								
Output	428	298.93	1,757.57	81	611.38	3,269.46	312.45	0.21
Sold/bartered	428	241.36	1,583.87	81	503.09	3,202.38	261.72	0.26
Non-export crops								
Output	428	11,985.29	8,266.64	81	5,977.14	5,638.23	-6,008.15	0.00
Sold/bartered	428	3,722.56	5,843.47	81	2,122.12	3,036.45	-1,600.43	0.02

Table A.4b: Pre-intervention differences between men and women

	Male			*Female*				
	N	**mean**	**sd**	**N**	**mean**	**sd**	**diff**	**p-value**
Employment								
Wage work (Y/N)	703	0.18	0.39	613	0.07	0.25	-0.12	0.00
Household production (Y/N)	703	0.71	0.45	613	0.73	0.44	0.02	0.54
Self-employment (Y/N)	703	0.06	0.23	613	0.08	0.28	0.02	0.08
CPR (Y/N)	703	0.46	0.50	613	0.41	0.49	-0.05	0.10
Household work (Y/N)	703	0.55	0.50	613	0.79	0.40	0.24	0.00

Table A.5a: Placebo test (estimating the effect of being treated in the period before a commune was actually treated) on household farm production (in ’000 VND)

	(1)	**(2)**	**(3)**	**(4)**
	Livestock		**Crop**	
	Value	**Traded**	**Produced**	**Traded**
Placebo treatment	1,144.0	-223.6	-1,517.2	10.1
	(2,928.2)	(487.7)	(5,399.9)	(1,442.8)
Constant	8,404.4***	753.3**	10,152.8***	2,296.9**
	(2,795.5)	(305.8)	(1,369.5)	(858.1)
N	376	376	376	376

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; controls: number of dependents in household, errors clustered at the commune level.

Table A.5b: Placebo test on cereal and export crop production and trade (in ’000 VND)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	Cereal		**Non-cereal**		**Export**		**Non-export**	
	Produced	**Traded**	**Produced**	**Traded**	**Produced**	**Traded**	**Produced**	**Traded**
Placebo treatment	-1,466.7	680.3	-50.6	-670.2	64.6	-183.6	-1,581.8	193.6
	(3,206.8)	(853.8)	(3,684.6)	(761.5)	(281.4)	(237.2)	(5,356.4)	(1,434.6)
Constant	7,509.4***	1,146.5	2,643.4***	1,150.4**	225.8	284.9*	9,927.0***	2,012.0**
	(1,137.8)	(702.9)	(725.5)	(433.2)	(277.4)	(158.6)	(1,310.8)	(805.4)
N	376	376	376	376	376	376	376	376

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; controls: number of dependents in household, errors clustered at the commune level.

Table A.5c: Placebo test (estimating the effect of being treated in the period before a commune was actually treated) on household income, by source (in '000 VND)

	(1) Wage	(2) Agriculture	(3) Common Property Resources	(4) Non-farm	(5) Rent	(6) Sales	(7) Other	(8) Total	(9) Non-transfer Income
Placebo treatment	117.8	-618.7	-662.2**	1231.9	-59.3	761.6	-289.9	4,538.7	-1,367.9
	(1,308.4)	(5,615.3)	(321.5)	(752.0)	(65.6)	(800.8)	(284.1)	(12,006.1)	(11,847.1)
Constant	6,555.0***	8,365.1***	906.9*	3,144.2**	19.7	1,036.4	-386.2	12,269.5*	20,206.6***
	(1,150.6)	(1,781.3)	(522.1)	(1,339.2)	(19.0)	(792.7)	(297.2)	(6,047.2)	(3,340.0)
N	376	376	376	376	376	376	376	376	376

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; controls: number of dependents in household, errors clustered at the commune level.

Table A.6: Pooled treatment effects on household production (in '000 VND)

	(1)	(2)	(3)	(4)
	Crop		Livestock	
	Produced	Traded	Produced	Traded
Treatment	2,437.1**	1,989.0**	-146.8	81.5
	(988.2)	(932.0)	(2,291.0)	(360.3)
Female-headed HH	349.1	172.6	965.6	237.7
	(2,606.0)	(2,085.0)	(4,055.4)	(592.9)
Treatment x female-headed HH	-2,629.3**	-1,219.1	-7,979.0**	-466.0
	(1,279.2)	(1,151.9)	(3,033.6)	(343.2)
Number of dependents	451.7	190.0	997.9	279.1
	(308.6)	(243.1)	(710.8)	(236.5)
Age of household head	-125.1**	59.0	-55.8	107.5
	(61.1)	(59.1)	(302.4)	(115.8)
Constant	18,444.2***	975.9	15,784.7	-5,740.1
	(4,175.9)	(3,190.2)	(13,641.1)	(6,179.4)
N	1,572	1,572	1,572	1,572

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.7: Treatment effects on the production on sale and trade of cereal and non-cereal crops (in '000 VND)

	(1)	(2)	(3)	(4)
	Cereal		Non-cereal	
	Produced	Traded	Produced	Traded
Treatment	184.1	951.3***	1,176.7	1,120.2
	(752.5)	(353.5)	(1,728.2)	(773.5)
Female-headed HH	-736.9	-514.0	-1,228.4	-317.2
	(1,955.1)	(1,300.6)	(1,210.6)	(634.1)
Treatment x female-headed HH	-1,020.6	690.4	-903.0	-698.0
	(786.0)	(1,134.2)	(1,046.1)	(657.5)
Number of dependents	310.3	-223.4	550.8	284.0*
	(194.5)	(153.5)	(607.7)	(156.2)
Age of household head	-60.3	45.3**	39.7	46.5
	(38.2)	(20.1)	(79.6)	(42.2)
Constant	13,611.0***	1,931.2	-1,787.7	-1,666.6
	(2,213.7)	(1,223.8)	(5,254.7)	(2,030.4)
N	1,873	1,873	1,873	1,873

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.8: Treatment effects on the production and sale of export and non-export crops ('000 VND)

	(1)	(2)	(3)	(4)
	Export		Non-export	
	Produced	Traded	Produced	Traded
Treatment	170.6	197.0	1,190.2	1,874.6**
	(218.9)	(270.0)	(1,572.7)	(888.3)
Female-headed HH	-324.8	-183.5	-1,640.5	-647.6
	(259.9)	(230.7)	(2,577.2)	(1,611.0)
Treatment x female-headed HH	-119.1	-104.6	-1,804.5	97.0
	(306.9)	(234.9)	(1,169.7)	(1,459.0)
Number of dependents	-106.3	-104.4	967.4	165.0
	(84.7)	(78.5)	(583.5)	(222.0)
Age of household head	-11.3	8.81	-9.36	82.9*
	(12.6)	(9.01)	(74.0)	(43.2)
Constant	961.5	-140.6	10,861.8**	405.2
	(762.0)	(696.3)	(5,211.9)	(2,228.8)
N	1,873	1,873	1,873	1,873

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.9: Treatment effects on Income (in '000 VND), by source

	(1) Wage	(2) Agriculture	(3) Common-Property Resources	(4) Non-farm	(5) Rent	(6) Sales	(7) Other	(8) Total	(9) Non-transfer Income
Treatment	1,347.5	1,311.1*	218.3	-323.9	18.6	-1,084.0**	-46.1	-2992.4	-3442.0
	(1,987.6)	(776.0)	(153.3)	(545.4)	(22.8)	(433.9)	(113.8)	(4474.2)	(5,116.5)
Female-headed HH	1,317.5	-1,847.9	-279.8	-951.5	-14.4	-1,244.1	395.9	-47.4	-11,580.1
	(5,435.1)	(2,001.3)	(233.1)	(1,198.7)	(33.6)	(752.1)	(325.3)	(9,114.7)	(10,805.9)
Treatment x female-headed HH	402.5	-3,798.5***	-182.9	-1,151.7	-21.3	1,473.1**	-39.6	-1,507.8	2,062.3
	(2,724.8)	(1,198.1)	(179.2)	(1,080.0)	(46.5)	(603.4)	(188.1)	(5,099.5)	(5,894.6)
Number of dependents	-1,289.7*	781.9**	144.9**	625.1*	-1.18	86.3	-28.9	704.0	1,020.0
	(707.4)	(308.1)	(55.4)	(343.5)	(12.4)	(168.8)	(31.5)	(1,403.0)	(1,356.1)
Age of household head	129.5	10.9	-17.4	2.96	2.26	6.83	10.1	-12.4	272.8
	(169.9)	(87.2)	(14.5)	(59.5)	(2.46)	(6.57)	(12.6)	(249.3)	(299.5)
Constant	2,539.5	9,860.9**	1,808.5**	-446.5	-44.2	86.6	-192.4	2,4063.1*	9,808.0
	(9,880.8)	(4,830.9)	(718.6)	(3,082.5)	(123.4)	(677.3)	(730.7)	(13,938.0)	(16,431.3)
N	2,033	2,033	2,033	2,033	2,033	2,033	2,033	2,033	2,033

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.10: Treatment effects on likelihood of being employed in each type of work

	(1) Wage Work	(2) Household Production	(3) Self-Employment	(4) Common Property Resources	(5) Household Work
Treatment	0.021	0.0044	-0.013	0.093**	0.066
	(0.033)	(0.021)	(0.012)	(0.037)	(0.047)
Treatment x female	-0.048	-0.016	0.017	-0.077***	-0.047
	(0.032)	(0.020)	(0.022)	(0.026)	(0.044)
Female-headed HH	0.22*	-0.14	0.033	-0.093	-0.097
	(0.12)	(0.17)	(0.046)	(0.13)	(0.20)
Treatment x female-headed HH	-0.053	-0.026	-0.019	-0.11	-0.063
	(0.062)	(0.11)	(0.023)	(0.072)	(0.13)
Female x female-headed HH	-0.16	0.11	0.12	-0.068	0.028
	(0.14)	(0.18)	(0.075)	(0.16)	(0.21)
Treatment x female x female-headed HH	0.019	-0.0032	0.011	0.14**	-0.043
	(0.065)	(0.12)	(0.040)	(0.066)	(0.14)
Number of dependents	-0.019*	-0.017**	0.0074*	0.011	-0.0063
	(0.0098)	(0.0070)	(0.0042)	(0.0089)	(0.0087)
Age of HH head	0.00081	-0.0029	0.00097	0.00039	0.00015
	(0.0048)	(0.0037)	(0.0012)	(0.0019)	(0.0028)
Constant	0.18	0.96***	-0.040	0.48***	0.83***
	(0.23)	(0.18)	(0.079)	(0.11)	(0.15)
N	4,642	4,642	4,642	4,642	4,642

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

a) SEPARATE (OLS): For all tables below, standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01"

Table A.11: Treatment effects by type of treatment on household production (in '000 VND)

	(1)	(2)	(3)	(4)
	Crop		Livestock	
	Produced	Traded	Produced	Traded
Routine maintenance	2,927.9***	2,474.5**	1,476.9	274.0
	(1,017.5)	(999.4)	(2,109.6)	(379.8)
Female-headed HH	619.9	327.3	806.2	137.9
	(2,778.6)	(2,232.7)	(4,038.6)	(625.2)
Routine maintenance x female-headed HH	-904.2	-325.5	-4671.3	-288.6
	(1,746.9)	(1,601.6)	(2,853.8)	(336.1)
Periodic maintenance	-40.1	-575.0	-2,554.3	-884.5*
	(2,086.3)	(1,805.0)	(4,806.8)	(524.7)
Periodic maintenance x female-headed HH	-5,009.9	-2,294.1	-3,972.3	532.8
	(3,061.2)	(2,887.8)	(5,255.5)	(592.0)
Rehabilitation	791.9	2,076.8	-5,772.6*	-383.4
	(1,401.8)	(1,262.9)	(3,424.0)	(475.3)
Rehabilitation x female-headed HH	-2,858.0	-1,714.6	-5,822.5	-120.1
	(2,009.8)	(1,656.4)	(4,475.2)	(647.8)
Number of dependents	423.1	172.6	881.1	259.4
	(295.2)	(235.2)	(732.8)	(239.3)
Age of HH head	-127.3**	56.9	-59.9	107.3
	(61.8)	(60.7)	(308.5)	(116.4)
Constant	18,178.4***	728.7	16,310.5	-5,682.9
	(4,059.9)	(3,169.4)	(14,263.5)	(6,217.2)
N	1,572	1,572	1,572	1,572

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.12: Treatment effects by type of treatment on production and trade (in '000 VND) of cereal and non-cereal crops

	(1)	(2)	(3)	(4)
	Cereal		Non-cereal	
	Produced	Traded	Produced	Traded
Routine maintenance	664.6	1,367.2***	1,291.4	1,249.1
	(691.8)	(400.3)	(1,701.6)	(904.0)
Female-headed HH	-409.2	90.9	-1,436.6	-303.6
	(2,016.5)	(1,507.4)	(1,198.3)	(610.1)
Routine maintenance x female-headed HH	-693.6	1,188.5	-4.92	-303.9
	(968.6)	(1,236.7)	(1,454.2)	(737.5)
Periodic maintenance	-2,152.6*	1,500.0	3,419.2	-244.0
	(1,184.8)	(1,775.0)	(3,136.6)	(1,017.6)
Periodic maintenance x female-headed HH	674.0	2,231.2	-2,995.7	-1,190.6
	(1,045.1)	(5,620.0)	(1,853.2)	(1,308.6)
Rehabilitation	1,123.4	3,085.2*	-1,364.5	847.3
	(1,196.8)	(1,712.8)	(1,683.8)	(676.9)
Rehabilitation x female-headed HH	-2,625.1**	-3,651.0	-531.6	-618.0
	(1,213.5)	(2,376.5)	(865.6)	(622.4)
Number of dependents	283.2	-164.5	579.2	273.1*
	(184.6)	(162.5)	(588.7)	(146.4)
Age of HH head	-62.8	43.9*	36.2	41.7
	(37.7)	(26.2)	(79.9)	(42.7)
Constant	13,513.7***	1,614.7	-1,562.3	-1,576.0
	(2,156.2)	(1,285.8)	(5,288.6)	(2,022.9)
N	1,873	1,873	1,873	1,873

Note: * p<0.1 ** p<0.05 *** p<0.01; Standard errors in parentheses; Additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.13: Treatment effects by type of treatment on production and trade (in '000 VND) of export and non-export crops

	(1)	(2)	(3)	(4)
	Export		Non-export	
	Produced	Traded	Produced	Traded
Routine maintenance	189.9	252.0	1,766.2	2,364.3**
	(230.6)	(287.3)	(1,572.0)	(927.8)
Female-headed HH	-421.0*	-231.9	-1,424.9	19.2
	(248.5)	(229.0)	(2,639.3)	(1,798.4)
Routine maintenance x female-headed HH	-318.8	-303.7	-379.7	1,188.3
	(350.1)	(262.3)	(1,676.4)	(1,634.7)
Periodic maintenance	1,331.4	1,435.7	-64.9	-179.7
	(1,135.8)	(997.3)	(2,430.1)	(1,837.2)
Periodic maintenance x female-headed HH	-701.6	-926.9	-1,620.1	1,967.6
	(1,216.0)	(1,165.0)	(1,620.9)	(5,590.6)
Rehabilitation	-598.2	-582.4	357.1	4,514.9**
	(462.2)	(416.6)	(1,530.2)	(1,835.4)
Rehabilitation x female-headed HH	553.1	431.1	-3,709.7**	-4,700.1*
	(342.5)	(311.4)	(1,430.7)	(2,447.9)
Number of dependents	-94.3	-90.1	956.6	198.8
	(79.8)	(72.5)	(576.1)	(213.8)
Age of HH head	-11.7	7.64	-14.9	78.0
	(12.0)	(7.51)	(74.7)	(49.0)
Constant	1,076.1	-11.9	10,875.3**	50.7
	(711.2)	(619.8)	(5,279.1)	(2,407.6)
N	1,873	1,873	1,873	1,873

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.14: Treatment effects by type of treatment on income (in '000 VND) by source

	(1) Wage	(2) Agriculture	(3) Common-Property Resources	(4) Non-farm	(5) Rent	(6) Sales	(7) Other	(8) Total	(9) Non-transfer Income
Routine maintenance	1,303.8	897.9	-49.7	-183.2	10.7	-537.8*	-112.3	-2,516.4	-2,602.5
	(1,808.4)	(805.2)	(177.5)	(407.2)	(23.0)	(302.7)	(112.5)	(3,733.0)	(4,455.2)
Female-headed HH	2,173.9	-1,980.1	-111.6	-573.4	-3.65	-676.7	443.3	5,112.1	-6,373.5
	(5,330.1)	(1,967.0)	(243.7)	(1,252.0)	(27.5)	(629.6)	(339.2)	(8,701.9)	(10,667.9)
Routine maintenance x female-headed HH	672.1	-3,485.4***	0.92	-2,274.3**	-21.1	1,167.0	120.7	-6,194.0	-1,705.2
	(2,872.4)	(1,185.2)	(212.2)	(1,012.2)	(50.5)	(883.4)	(188.7)	(3,969.3)	(4,738.9)
Periodic maintenance	2,039.2	-248.9	393.8*	1,304.8	80.1	-1,733.0***	339.3*	6,725.8	4,221.7
	(2,970.3)	(1,813.5)	(198.4)	(1,523.8)	(61.2)	(524.0)	(202.6)	(7,644.0)	(9,483.9)
Periodic maintenance x female-headed HH	-2,068.3	5.02	-518.8*	1,218.8	-158.8**	569.3	-944.5**	-2,698.0	-4,440.5
	(5,263.3)	(1,895.2)	(278.0)	(2,247.8)	(69.1)	(1,546.0)	(386.9)	(11,749.3)	(12,476.9)
Rehabilitation	6,959.6**	809.0	832.4**	2,435.7**	79.8*	-345.2	-43.4	19,207.1***	18,999.6***
	(3,483.9)	(1,395.4)	(352.6)	(1,108.6)	(44.1)	(443.6)	(164.8)	(6,722.3)	(6,379.7)
Rehabilitation x female-headed HH	-3,224.9	-3,020.8	-926.9***	-1,996.8	-8.64	-804.7	-69.7	-17,774.7**	-14,909.5
	(3,706.3)	(1,897.1)	(347.6)	(1,312.8)	(60.1)	(937.2)	(309.0)	(8,065.7)	(9,747.9)
Number of dependents	-1,151.6*	769.3**	168.6***	701.7**	1.47	63.1	-20.4	1,264.7	1,519.2
	(689.3)	(307.2)	(55.6)	(351.2)	(11.9)	(163.2)	(31.8)	(1,382.1)	(1,298.8)
Age of HH head	122.2	16.3	-16.7	6.99	2.11	1.90	9.84	-13.2	259.5
	(168.4)	(84.5)	(14.1)	(60.4)	(2.50)	(6.06)	(12.3)	(249.4)	(293.4)
Constant	2,075.6	9,625.0**	1,629.3**	-753.0	-48.0	143.9	-220.2	21,519.2	7,660.7
	(9,630.2)	(4,711.2)	(676.1)	(3,046.7)	(125.0)	(662.6)	(726.7)	(14,423.0)	(16,200.0)
N	2,033	2,033	2,033	2,033	2,033	2,033	2,033	2,033	2,033

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.15: Treatment effects by type of treatment on likelihood of being employed in each type of activity

	(1) Wage work	(2) Household production	(3) Self-employme nt	(4) Common property resources	(5) Household work
Routine maintenance	0.026	0.031	-0.014	0.093***	0.10**
	(0.028)	(0.021)	(0.015)	(0.033)	(0.041)
Female-headed HH	0.12*	-0.096	0.10*	-0.14	-0.091
	(0.070)	(0.080)	(0.053)	(0.087)	(0.094)
Routine maintenance x female-headed HH	-0.014	0.021	-0.038	0.041	-0.036
	(0.054)	(0.046)	(0.029)	(0.049)	(0.053)
Periodic maintenance	-0.0042	-0.066**	0.0090	-0.045	-0.13***
	(0.030)	(0.026)	(0.025)	(0.055)	(0.033)
Periodic maintenance x female-headed HH	-0.11	0.049	0.017	-0.0012	0.030
	(0.072)	(0.052)	(0.036)	(0.081)	(0.040)
Rehabilitation	-0.10***	0.028	-0.028	0.11**	0.051
	(0.035)	(0.038)	(0.018)	(0.050)	(0.054)
Rehabilitation x female-headed HH	0.030	-0.13***	0.0054	-0.22***	-0.23***
	(0.074)	(0.044)	(0.021)	(0.062)	(0.079)
Number of dependents	-0.021**	-0.018***	0.0075*	0.011	-0.0095
	(0.0098)	(0.0068)	(0.0042)	(0.0084)	(0.0083)
Age of HH head	0.0010	-0.0029	0.0012	0.00029	0.00018
	(0.0048)	(0.0037)	(0.0013)	(0.0018)	(0.0028)
Constant	0.18	0.95***	-0.045	0.46***	0.81***
	(0.23)	(0.18)	(0.083)	(0.10)	(0.15)
N	4642	4642	4642	4642	4642

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

a) Robustness check (OLS) on Inverse Hyperbolic Sine of dependent variables.

Table A.16: Pooled treatment effects on household production (IHS of dependent variable)

	(1)	(2)	(3)	(4)
	Crop		Livestock	
	Produced	Traded	Produced	Traded
Treatment	-0.046	0.13	0.0061	0.066
	(0.068)	(0.40)	(0.11)	(0.35)
Female-headed HH	-0.12	-0.39	-0.25	0.39
	(0.16)	(0.86)	(0.26)	(0.90)
Treatment x female-headed HH	-0.18	-0.41	-0.092	-0.40
	(0.15)	(0.76)	(0.22)	(0.60)
Number of dependents	0.039**	-0.088	0.16***	0.28***
	(0.018)	(0.14)	(0.047)	(0.083)
Age of household head	-0.010	0.051**	0.015*	-0.0066
	(0.0095)	(0.024)	(0.0079)	(0.029)
Constant	10.3***	5.08***	9.08***	0.54
	(0.43)	(1.43)	(0.49)	(1.75)
N	1572	1572	1572	1572

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.17: Treatment effects on the production on sale and trade of cereal and non-cereal crops (IHS of dependent variable)

	(1)	(2)	(3)	(4)
	Cereal		Non-cereal	
	Produced	Traded	Produced	Traded
Treatment	-0.20	0.058	0.34	0.29
	(0.16)	(0.27)	(0.25)	(0.42)
Female-headed HH	-0.27	-0.87	-0.27	-0.68
	(0.18)	(0.66)	(0.68)	(0.75)
Treatment x female-headed HH	0.033	-0.27	-1.07**	-0.32
	(0.27)	(0.45)	(0.51)	(0.64)
Number of dependents	0.059	-0.068	0.11	0.099
	(0.059)	(0.14)	(0.092)	(0.12)
Age of household head	-0.0062	0.030*	-0.012	0.032
	(0.0049)	(0.018)	(0.025)	(0.026)
Constant	9.45***	3.82***	7.13***	3.86**
	(0.32)	(1.28)	(1.29)	(1.46)
N	1873	1873	1873	1873

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.18: Treatment effects on production and sale of export and non-export crops (IHS of dependent variable)

	(1)	(2)	(3)	(4)
	Export		Non-export	
	Produced	Traded	Produced	Traded
Treatment	0.0046	0.048	-0.012	0.25
	(0.15)	(0.12)	(0.065)	(0.37)
Female-headed HH	-0.44	-0.37	-0.18	-0.86
	(0.52)	(0.44)	(0.15)	(0.71)
Treatment x female-headed HH	-0.39	0.11	-0.13	-0.30
	(0.37)	(0.24)	(0.12)	(0.58)
Number of dependents	-0.00055	-0.0079	0.055**	-0.045
	(0.087)	(0.069)	(0.023)	(0.13)
Age of household head	-0.045**	-0.023	-0.00021	0.042*
	(0.018)	(0.015)	(0.0039)	(0.023)
Constant	2.94***	1.83**	9.72***	5.61***
	(0.78)	(0.78)	(0.20)	(1.59)
N	1,873	1,873	1,873	1,873

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.

Table A.19: Treatment effects on income (HIS of dependent variable) by source

	(1) Wage	(2) Agriculture	(3) Common-Property Resources	(4) Non-farm	(5) Rent	(6) Sales	(7) Other	(8) Total	(9) Non-transfer Income
Treatment	0.54	0.22	0.87***	0.041	0.047	-0.44***	0.014	-0.024	0.075
	(0.38)	(0.26)	(0.21)	(0.24)	(0.094)	(0.16)	(0.22)	(0.058)	(0.074)
Female-headed HH	-0.56	0.048	-1.48***	-0.033	-0.0054	-0.24	0.77	0.096	-0.44
	(0.99)	(0.45)	(0.55)	(0.60)	(0.37)	(0.30)	(0.47)	(0.14)	(0.39)
Treatment x female-headed HH	-0.71	-0.87*	0.077	-0.75**	-0.037	0.46**	-0.028	-0.13	-0.14
	(0.63)	(0.47)	(0.38)	(0.32)	(0.33)	(0.21)	(0.25)	(0.093)	(0.26)
Number of dependents	-0.072	0.19***	0.10	0.22**	-0.025	0.0066	-0.079	0.029	0.047*
	(0.12)	(0.068)	(0.076)	(0.11)	(0.058)	(0.057)	(0.058)	(0.020)	(0.025)
Age of household head	0.024	0.0070	0.018	0.018	0.0043	-0.0014	0.023	0.00071	0.0059
	(0.028)	(0.013)	(0.017)	(0.021)	(0.013)	(0.0028)	(0.019)	(0.0036)	(0.0085)
Constant	2.83*	8.11***	4.04***	-0.24	0.22	0.38	-0.55	10.4***	9.93***
	(1.61)	(0.69)	(0.82)	(1.30)	(0.62)	(0.27)	(1.09)	(0.20)	(0.45)
N	2,033	2,033	2,033	2,033	2,033	2,033	2033	2033	2033

Note: * p<0.1 ** p<0.05 *** p<0.01; standard errors in parentheses; additional controls for level of education of household head and household, year fixed effects. Errors clustered at the commune level.