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Contracting the road to development: Early impacts of a rural roads program

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Abstract

We study here the early impacts of the Peruvian Rural Roads Program (RRP), characterized by a decentralized mechanism that contracts private local firms for the rehabilitation and maintenance of rural roads with local supervision by community leaders setting incentives that favour prevention activities and a sustainable and timely maintenance of rural roads. The analysis is based on a quasi-experimental approach through which control roads are defined prior to the intervention and based on key observable characteristics of the road and the villages they connect. Diff-in-Diff estimates are reported to control for biases associated with time-invariant unobservables. We find that this institutional innovation improved road transitability, which in turn led to significant changes in employment patterns and increased investments in education and health. Income effects are not significant on average, but they appear strong in villages with pre-existent endowments of key productive infrastructure, favouring the notion that road improvements need to be complemented with additional investments to effectively contribute to the reduction of rural poverty. Most of these results, though, are concentrated on interventions in motorized roads, although the inclusion of non-motorized tracks is supported by the empowering of women through their participation in farm activities. Thus, the results of this early evaluation are encouraging in terms of program impacts, as these indicate that the Peruvian RRP has been able to control local capture and corruption threats.

JEL codes: H54, H70, L33, O12

Key words: rural roads, provision of public services, contracting, Peru

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1. Introduction

The economic literature has been increasingly reporting mechanisms through which improved roads can create opportunities for economic growth and poverty reduction in rural economies (Binswanger, Khandker and Rosenzweig, 1993; among others). Through the reduction of transportation costs, improved roads can increase productivity and demand for labor in farm and non-farm activities, thus leading to increased income and consumption. Although often ignored until recently, improved roads can also have meaningful social impacts, in particular those associated with household investments in health and education (van de Walle, 2002).

Nevertheless, macroeconomic adjustments and local governance issues have led to underinvestment in this kind of infrastructure (World Bank, 2005). Moreover, rural transport projects have focused on building new roads or upgrading their condition, while disregarding the need to establish an institutional arrangement to guarantee timely rehabilitation and maintenance of roads (Malmberg Calvo, 1998). In that sense, the thrust of the Peruvian Rural Roads Program (RRP) as an institutional innovation that focuses on the rehabilitation and permanent maintenance of already existing rural roads, for which local private firms are contracted, makes it particularly important to be analyzed. That is, public funds are provided not only for one-time rehabilitation but also for permanent maintenance of treated roads, and payments to contracted local firms require a satisfactory report from PROVIAS and community supervisors. To my knowledge, there is no current study that carefully evaluates the impacts of a road program with such a similar institutional innovation.

Analyzing this kind of intervention is particularly relevant given the current wave of decentralization in infrastructure provision in the developing world. The latter initiative, combined with community participation, can increase accountability of providers and lead towards a quality increase in service provision (World Bank, 2004). However, more recent studies have been more cautious about the ultimate effects of decentralization and community participation on the quality of infrastructure provision. Local capture and corruption can make provision of infrastructure worse under decentralized mechanisms (Bardhan and Mookherjee, 2006; Olken, 2007). More empirical evidence is needed to see which of the trends ends up dominating under different contexts.

Focusing on the Peruvian RRP, this paper attempts to contribute to the literature by evaluating the impacts of such a unique program that focuses on an institutional innovation to improve road rehabilitation and permanent maintenance. The study tries to see whether we can define a decentralized mechanism or contract that can improve the quality of rural roads in

developing countries, and whether that would lead to increased income and human capital investments. With respect to the former, one point is whether including permanent road maintenance alters the nature of the contract enough, making local capture and corruption more complicated, and increasing the likelihood of improved quality of rural roads. With respect to the welfare effects of improved roads, a key issue is to analyze whether the factor of time is enough for effects to materialize, or whether complementary investments are required[1]. In addition, it is relevant to see whether a program that focuses exclusively on rehabilitation and maintenance of rural roads, excluding any new road construction or road upgrading, can generate sizable welfare effects. Most of the interventions reported in the literature, especially those in Africa and Asia, include building new roads or upgrading them (for instance, by paving them) while disregarding regular maintenance. Indeed, the Peruvian RRP does not include pavement upgrades as in the Bangladesh case analyzed by Khandker et. al. (2006), nor includes building new roads as in the Vietnamese case studied by Mu and van de Walle (2007).

Methodologically, we use a quasi-experimental approach that allows controlling for time-invariant unobserved characteristics of villages and households. Although we define a control group based on a rich set of observables, road rehabilitation and maintenance activities by other agencies are not banned in control roads, so that the impacts we report here are associated with an improved efficiency in road rehabilitation and maintenance as a result of the RRP, rather than with the absolute lack of these efforts on the part of other public agencies such as local governments, or others. To my knowledge, there is no published study that focuses on such institutional innovation. We use a longitudinal dataset that enables us to measure impacts on a wide variety of socio-economic, institutional, and environmental characteristics. Furthermore, we also explore the heterogeneity in the impacts by individual, household and village characteristics, as well as the conditioning community factors for realizing benefits. In particular, we analyze the extent to which poorer households, smaller communities, rural women, and other especially marginalized groups, benefit from the enhanced economic environment resulting from the Peruvian RRP. Policy makers would greatly benefit from identifying a conditional factor - either at the level of the community or the household - that spurs the impact of improved rural roads. However, if the key conditional factor varies too much by outcome so that no general pattern can be identified, targeting policy implications would be less clear.

[1] Although the Peruvian RRP has been operating since 1998, this study focuses on the impact of the cohort of interventions that started in 2004, and evaluates its impacts after only two years. That is, the estimated impacts we are presenting here need to be interpreted as the very early impacts of the improvement in rural roads generated by the institutional innovation.

This paper is organized in five sections including this introduction. The second section presents the key features of the intervention and discusses its expected effects. Section 3 describes the characteristics of the data and the methodology used for estimating the impact of the Peruvian RRP. Section 4 presents the estimated impacts on the quality of the roads and its effects on household income and expenditures, employment, as well as investments in education and health. Section 5 summarizes the results and discusses its limitations as well as some of its potential policy implications.

2. The program and its expected effects

The Peruvian RRP is a large program that has been operating since 1995 and run by the PROVIAS RURAL, a unit of the Vice-minister of Transport. The program intends to improve transport conditions in rural villages by contracting private local firms to manage and sustain the maintenance of rural roads in the poorest areas of Peru[2]. The first phase of the RRP was carried out during 1995-2000 in 12 departments that ranked highest in rural poverty within the country[3]. During that first phase, the project improved rural accessibility in 314 districts, contracting with 495 local firms in charge of rehabilitating and maintaining about 12,000 kilometers of rural roads and key secondary roads and about 3,000 km of non-motorized tracks (Escobal, et. al., op. cit.)[4].

2.1 The intervention

The RRP is based on an institutional innovation that focuses on setting the right incentives for all agents while also strengthening local governments and firms to improve rehabilitation and maintenance of already existent rural unpaved roads and non-motorized tracks. Rural roads in Peru are the responsibility of provincial and district governments since the enactment of the Law of Municipalities of 2004[5]. However, ambiguities, overlaps in responsibilities of different levels of government, and the lack of financial and institutional resources at the local level have allowed for

[2] Currently, the unit running the program is called PERU DESCENTRALIZADO, an indication of the increased role of local governments in the planning and execution of the program, as part of the decentralization process being carried out within the Peruvian state.

[3] See Figures 1-4 for photos with examples of the type of roads intervened.

[4] The system of district-level rural roads in Peru is estimated at 70,000 kilometers. In the 12 departments the system of rural roads is estimated in 28,000 kilometers.

[5] Typical of a centralized government, all roads were traditionally under the responsibility of the Ministry of Transport and Communications (MTC). The Regionalization Law of 2004 transferred all roads to regional and local governments. The mandate was partially reversed in 1991, as MTC was reassigned to the national road

avoidance of accountability in maintaining rural roads (World Bank, 1995). When a road is blocked due to floods or other weather shocks, local governments start rehabilitation with technical and financial support from the regional or central government, although the process tends to be slow. Responsibility is even less clear for regular maintenance; for instance, it is not clear where users can complain to for excessive potholes and stones in the roads, which in turn increase travel time as well as maintenance costs for public and private vehicles.

Implementing the Peruvian RRP is a clear example of the decentralization process that has been developing in Peru over the last two decades. It commits financing from the central government, works with local governments in the planning of activities, and assigns the responsibility of performing quality rehabilitation and permanent maintenance of selected rural roads to local private firms through contracts that connect regular payments to the quality of the road as periodically assessed by officials from both the program and local governments, as well as community organizations. This assessment is not limited to checking the materials the local firms use in the rehabilitation activities, as it can also use observable final outcomes such as travel time to go from startpoint to endpoint of the road segment, the number of months the road is blocked due to landslides during rainy season, or the 'bumpiness' of the road as this increases maintenance costs for private and public motorized vehicles. Observability of these outcomes helps to make local authorities and contracted firms accountable for the quality of maintenance. Thus, in principle, incentives are set for local contractors to implement maintenance works more regularly, including maintenance of road drainage systems as these could prevent blockages, or other activities that reduce rehabilitation costs when weather shocks hit transitability of the road.

Nevertheless, the incentive structure can be damaged if the program is captured by local elites as the supervision by local authorities is reduced to a mere formality. Olken (2007) reports the case of the Indonesian rural road program affected by corruption, as measured by the discrepancies between reported budgets and the budgets estimated by special supervisors based on an analysis of materials and labor used. However, it is important to notice that the Indonesian RRP, as opposed to the Peruvian RRP, does not include regular maintenance so that incentives cannot be set based on observable qualities of the road, and only by costly monitoring of the actual materials used during the construction, upgrading or rehabilitation. This evaluation allows us to see whether the program's

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network, although departmental and rural roads remained at the level of the regional and local governments, respectively.

incentive structure has so far been able to control local capture and corruption threats, after almost a decade at work.

The institutional innovation in the Peruvian RRP depends critically on the quality of local institutions, including local authorities and firms (Malmberg, 1998). Thus, the RRP promotes local institutional development by providing technical assistance to local governments and small and medium local enterprises for improved planning and management of rural roads and for the development of micro-enterprises formed by beneficiary groups for road maintenance. The program has a local office in every department, which starts by identifying the provinces in which they will operate in each stage. Once a province is identified, the program then forms a Provincial Road Institute (PRI) which signifies increasing participation of the provincial municipality and other local authorities. The program's departmental office coordinates with the PRI to select the specific road segments to be rehabilitated and maintained at each stage, with other local institutions participating through open consultations in different districts.

Once a road has been selected for intervention, local officials from the program and local government authorities coordinate to initiate the intervention with an open call for individuals interested in becoming members of the local microenterprise for road maintenance (MEMV is its acronym in Spanish) that is going to be in charge of the periodic rehabilitation and maintenance of the selected road (Escobal, et. al., 2005). They are then selected based on their previous experience in road maintenance, time of residence in the locality, as well as characteristics such as education, age, etc. The selected individuals are trained in microenterprise management and road maintenance, and the MEMV is legally formed. Next, the program's local officers elaborate the annual plan of activities using a program that calculates the number of individuals and time required to rehabilitate and maintain the selected road as well as the cost per kilometer[6]. These estimates are based on the characteristics of the selected road such as its location, length, width, traffic, and weather conditions. The MEMVs then sign a contract with PROVIAS RURAL through which they receive monthly payments, based on the estimated costs and a quality certification issued monthly by PROVIAS and community supervisors[7]. As mentioned above, these output-based contracts set

[6] Escobal et. al., op. cit., reports that average costs are US $ 17,000 per kilometer rehabilitated and US $ 2,800 per kilometer for periodic maintenance. Technical standards suggest rehabilitation is required every 10 years while periodic maintenance is on average required every four years, In addition, the program funds US $ 700 per kilometer-year in regular maintenance.

[7] In case of unsatisfactory maintenance, supervisors give time to the MEMV to repair the deficiencies. If the situation is not solved, the local office applies discounts to the monthly payments, and the contract is dissolved if the deficiencies occur over three consecutive months.

clear incentives for the local MEMV to invest in prevention activities and provide a sustained, timely maintenance of the contracted rural road (Benavides, 2003).

In terms of the kind of rural roads targeted by the program, it is important to point out that, unlike previous cases recently analyzed in the literature, the Peruvian RRP does not include road paving or the building of new roads. Second, the program not only considers unpaved motorized roads but also non-motorized tracks. The gradual inclusion of non-motorized tracks aims at promoting gender equity in distributing the impacts of the intervention, as these tracks were identified as the ones women use most[8].

2.2 Expected effects

Setting the right incentives for contracted local firms should improve the quality of rehabilitation and maintenance of rural roads treated by the program. Increasing the regular removal of bumps and stones would, in turn, reduce the time required to travel across the different points connected by the selected roads or the time they remain blocked when large weather shocks lead to landslides or flooding. Thus, we can expect the program to better integrate poorly accessible zones to regional economic centers, reducing transport costs and raising the reliability of vehicular access to expand markets for agricultural and non-farm products and enhancing a more diversified set of employment opportunities for rural households. Improved transportation will also reduce time to access basic social services such as health, education and justice. In turn, this improved transitability may lead to an increase in traffic and the availability of public transport services, but these may take longer as they require supply adjustments.

However, it is important to clarify here that our counterfactual is not complete inaction with respect to the rehabilitation and maintenance of rural control roads. Such roads may not have guaranteed financing for rehabilitation and maintenance, nor a specific agent with the clear responsibility and incentives to perform the actual physical works. Thus, control roads may take longer to be rehabilitated after a flood, or have bumps and stones that increase travel time and vehicle maintenance costs. Still, local governments and other offices of the Ministry of Transport and Communications (MTC) as well as public agencies such as FONCODES (the Peruvian social investment fund) may have performed related activities for control roads, especially when weather

[8] The program identified this fact when it collected the opinions of potential beneficiaries through gender-based focus groups organized in several rural communities (see Fort and Menendez, 2005). Additional focus

shocks blocked these roads. Thus, rather than assessing the impacts of rehabilitating and maintaining a rural road, this study evaluates the effects associated with the improved efficiency in these rehabilitation and maintenance activities as a result of the reallocation of incentives due to output-based contracts that favor prevention and sustained and timely maintenance by local contractors[9].

Many papers have shown the different mechanisms through which improved rural roads benefit the welfare of households and individuals associated with beneficiary roads (Mu and van de Walle, 2007; Khandker, et. al., 2006; Levy, 2004; Escobal y Ponce, 2002; Jacoby, 2000; among others). We briefly summarize the most important findings of these literature, with some extra comments regarding the sequence of effects as they may affect the time needed for some of these effects to materialize. The most direct effects of the RRP are associated with the transitability of rural roads, which are often estimated through the travel time needed to go from the initial to end points of the segment in reference and the time (weeks or months in a year) a road stays blocked due to a climatic shock or related event. Levy (2004), for instance, reports such effects in Morocco, emphasizing the importance of the number of months the road remained blocked (in the context of rural roads). Other subsequent effects are reduced time that individuals residing in the connected villages take on average to go to key markets, schools, health facilities, depending on the nature of the role of the segment on the local road network. At the same time, the improved transitability may eventually lead to an improved public transportation service that can be measured in terms of the increased frequency of buses or reduced prices for transporting individuals and cargo. The latter effects are clearly a function of the improved transitability of treated roads, and thus they are likely to take longer to materialize.

The improved rural roads activate a series of mechanisms that transform traditional productive patterns, both agricultural and non-agricultural, in the villages associated with the rehabilitated segments. First, reduced travel times help individuals have access to extra off-farm employment opportunities (both agricultural and non-agricultural) within and outside the village. Escobal and Ponce (2002) find such a result in the first round of interventions by the Peruvian RPP,

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groups after the intervention have confirmed that a large proportion of women see the program's road intervention as enabling them to travel farther and more safely, and has also led to increased income.

[9] This issue is particularly important in the case of the Peruvian RRP, as local governments have seen a substantial increase in their budgets as a result of the decentralization process. Note that the RRP intervention does not include road upgrading as in the Bangladesh case analyzed by Khandker et. al. (2006) nor building new roads as in the Vietnamese case studied by Mu and van de Walle (2007).

especially in terms of non-agricultural wage employment for more educated individuals[10]. Jacoby (2000) also argues for such effects as he finds a negative correlation between agricultural and non-agricultural wages and the distance from the village to the key markets in Nepal.

Farm productivity and income can also receive a boost as a result of reduced post-harvest crop losses, lower input prices, higher output prices or improved access to financial and non-financial agricultural services (Biswanger, Khandker and Rosenzweig, 1993). Improved accessibility to markets increases small farmer's bargaining power with local traders. Access to credit and agricultural extension services may take longer and come first for less poor farmers or in villages closer to larger markets, as they tend to require extra conditions such as mechanisms for agricultural risk management and organization of small local farmers. Access to these services is seen as crucial for small farmers to switch towards high-value crops.

However, these productivity and income effects have not been found in all cases and are often concentrated on less poor farmers, consistent with the fact that complementary investments are required for them to materialize. Moreover, income effects may at least initially be perceived as temporary, and consequently households may decide to increase savings through increments in livestock rather than increased consumption (Escobal and Ponce, 2002). More important for this study is the fact that many of these effects are conditioned on adjustments in the supply of key agricultural services such as extension and credit, which may take longer to materialize. Thus, it would not be that surprising if we do not find income effects in this study, especially if we consider that the follow up in which this study is based comes only two years since treated roads started being served by the program.

Improved rural roads can spur not only productivity and income but also household investments in the human capital of their children. As travel times are reduced, it is less costly for parents to send their younger children to school as they would need to devote less time traveling with them to the school location. In turn, older children would be able to attend school while at the same time being able to help with housework or at the family farm. Levy (2004), for instance, finds increased school attendance especially among girls, which may imply that improved travel security may also be an important factor for rural girls. These demand-side effects are likely to show up early. But supply-side effects may also increase household investments in schooling as quality can

[10] One can think of a more direct employment effect associated with the maintenance work performed by the local firm. However, such effects are not likely to be important in this context, as these firms have on average

improve as a result of more effective attendance by teachers or even improved recruiting as a result of reduced travel times to larger villages or the district capital. However, the teacher recruiting effect may be expected to take longer to show up.

Similar mechanisms can be cited to explain improved access to health services. With improved roads, visits to health facilities may take less time for the ill individual or the family member in charge of their care. The attendance and recruiting efforts can be raised for doctors and other health professionals, in the same way they were mentioned for school teachers. In addition, improved roads can also help bring social programs based on health facilities closer to the associated villages, increasing access to preventive health programs that can reduce sickness events among children and adults. Qualitative studies in Sub-Saharan Africa and Asia have reported that individuals identify improved access to health services as the key benefit obtained from improved roads (see, for instance, Porter, 2002 and Hettige, 2006).

All these positive effects may significantly alter the socio-economic context in the villages associated with the improved roads so that migration of individuals in search of better employment and education opportunities may be reduced. At the same time however, permanent and temporary migration costs are reduced. Thus, the net effect of improved roads on permanent and temporary migration may go either way.

In sum, we have seen a wide variety of potential impacts of the Peruvian RRP. However, not all of them are likely to show up in this early evaluation after just two years. It is also likely that the size and time lags of these effects may vary across households and villages depending on the initial endowments of private and public assets. Poverty in developing countries is strongly concentrated in rural areas, but still there is significant heterogeneity that can lead to differentiated impacts and have important implications for project design. If higher or faster impacts are found in less endowed households and villages initially, policy makers will face a much desired win-win situation. However, if higher impacts concentrate among the initially better endowed, targeting for higher impacts may lead to increased inequalities within rural economies. Khandker et. al. (2006) and Mu and van de Walle (2007) explore the nature of these heterogeneities, finding that road improvements tend to be pro-poor in rural Bangladesh and Vietnam, respectively, which is a very encouraging result. However, peculiarities of the Peruvian RRP require us to analyze whether such a trend is sustained

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only between 10-15 permanent workers and we observe a representative sample of villages that have on average 900 inhabitants (see Table 3).

when the intervention does not include road upgrades, but instead includes a permanent maintenance component for both unpaved motorized roads and non-motorized tracks.

3. Design, data and methodology

3.1 Quasi-experimental design

For this intervention, treatment and control roads are not chosen randomly from a set of *eligible* roads. Instead, treatment roads are first selected by a departmental committee (program officials and local authorities) that chooses the provinces to be intervened. Then, the PRI and the local program officials select the specific road to be intervened at a particular round. For this treatment group, a control group was selected prior to any intervention based on similarities in key observable variables such as the longitude and type of road (rural road or non-motorized track), and characteristics of the villages involved such as population size, access to basic public services and infrastructure, and altitude[11].

Another important matched variable is the hierarchy of the villages involved, so that if a district capital was involved in the treated road, the control road also connected a district capital. In addition, control roads are also required to have no intersection with a treated road or track to minimize the probability that benefits on treated villages spill over the control villages. Actually, control roads were selected within the same province but from different districts to minimize the possibility that they belonged to the same road network as the treated ones This effort was based on information provided by three key databases: the 1999 Pre-census database (INEI), the Population Census of 2005 (INEI) and the Geo-referenced Road Map (MINTRA-MINEDU), which is rarely available in a digital format for use in economics research. Table 3 shows the pre-treatment means for treatment and control groups for many observable variables, showing that there are almost not statistically significant differences between these two groups[12].

The selection process described for this intervention has important implications for the interpretation of the impact estimates we present here. First, it implies that our indicator would estimate a treatment on the treated effect. The relationship between our estimates and the average

[11] Control roads were selected by researchers in charge of impact evaluation, although some information was confirmed by program officials. The program was then informed to remain away from these road segments, which was not a major problem for the program as it was not likely for them to treat several road segments in a province, at least in the same round. Treated and control roads are associated with villages by defining the origin and the end of the road.

[12] For the outcomes analyzed in this study, Table 4-Table 12 show treatment-control comparisons at baseline. No significant differences are found there.

treatment effects would depend on the nature of the prioritization. If the PRI-selected roads are associated with the poorest and most remote villages, and those would be the ones for which the RRP impacts are smallest, then we would be underestimating the program's average effects. On the other hand, if roads where selected so that impacts would be largest, and these officials were right in their ex-ante assessments, then we would be overestimating its average treatment effect.

Second, the selection may affect our ability to identify a proper control group. The selection may be so acute that the likelihood of identifying a road similar in all characteristics to the treated ones is rather low. We argue, though, that the size of the intervention in any province and department and the measures taken by our team helped contain such a potential problem. A key issue is to avoid choosing roads that are systematically located at different points of the road network as control roads. For that, besides similarities in access to key infrastructure, altitude, and population, we argue that the hierarchy of the towns is crucial. That is, if a district's capital is associated with the treated road, we look for another road that connects another district capital to a similar ending town. In general, for each treated road, we restrict the search to different districts within the same province. However, when one of the towns was sensibly different from the rest of the province, we looked for roads in the adjacent provinces[13]. Although the described selection process for the control group attempts to maximize the probability that the control group will be equivalent to the treatment group of roads, we cannot discard the existence of certain time-variant unobservable data that can affect our estimates.

3.2 Data requirements and sources

The impact evaluation presented in this paper refers to the cohort of interventions defined for 2004 and uses the last two rounds (2004 and 2006) of a specialized household and community-level survey that includes a wide variety of socio-economic, institutional and environmental indicators[14,15]. For the most part, the survey questionnaires were the same for the two rounds, and

[13] That was the case, for instance, when a district capital was involved. Recall that treated roads needed to be unpaved, so capital of provinces has generally not been directly associated with treatment roads.

[14] The Peruvian RRP also applied a baseline survey in 2000 that would allow the analysis of the impacts of that cohort of interventions, also providing valuable information about the dynamics of the RRP's effects. That is, we would be able to verify the time lags and sustainability of effects. However, such an analysis is postponed for the project's second stage, as a very time consuming effort will be required to generate a consistent panel across the three rounds (2000, 2004 and 2006).

[15] The 2004 round of the survey was applied by the firm *Cuánto* while the 2006 round was applied by GRADE. Both surveys were done in coordination with the Rural Roads Program as part of the program's impact evaluation strategy.

they were all applied in the fourth quarter of the corresponding years so that consistent comparisons are allowed. The household survey includes information about the characteristics of the dwelling, health and education of all household members, farm and non-farm entrepreneurial activities, commercialization channels, etc[16]. The community-level survey is applied to key local informants and includes information about the characteristics of the villages in terms of access to public infrastructure and basic services, distance to nearest markets, and other key public facilities. It also includes the roads' characteristics such as the time required to travel from the initial to the final point of the road by the different means, the number of public transportation units that use the roads, the number of months the road remain closed over the past year, number of car accidents, and maintenance and operation costs for public transportation units traversing the road. The survey also considers the number of students in primary and secondary schools, number of health services offered by public health facilities, judiciary and police crime records, use of associated roads, among many other variables.

Recall treated and control roads are associated with villages at the origin and the end of the road. In the case of small roads or tracks (less than 20 kms.), six households were randomly selected within each of the initial and end villages. In the case of large roads, an extra, intermediate village is included in the sample. The 2004 sample cohort of interventions involved 92 treated road segments in 13 of the poorest departments in the country. At baseline, we interviewed a total of 2,457 households in 387 villages associated with treatment and control road segments[17]. In 2006, we were able to re-interview 2,167 of them, that is, we had an attrition rate of 11.8percent[18].

3.3 Methodology

The study uses the Double Difference (DD) estimate to determine the impact of the rural roads program on a wide variety of indicators at the level of the household and the localities involved. A basic regression-based DD estimate can be obtained from the following regression:

$$Y_{ijt} = \beta_0 + \beta_1 \cdot D_t^{AD} + \beta_2 \cdot D_j^{TC} + \beta_3 \cdot D_t^{AD} \cdot D_j^{TC} + \varepsilon_{ijt} \qquad (1)$$

[16] See Table 1 and 2 below for a list of the main indicators available in all survey rounds.

[17] In 2000, a baseline was established for a sample of 2,000 households associated with the road segments that were treated during 2000-2001. That sample was also followed in the 2004 and 2006 round of surveys.

[18] When a household was not initially identified, the field procedures to address this included asking the neighbors, relatives and community leaders. Although there were a few rejections, most of the missing households corresponded to cases in which the nuclear family had moved outside the province.

where Y_{ijt} denotes the value of an indicator of interest for household i that resides in village j at period t (t=0 is the baseline; t=1 is the follow-up survey). D^{TC} is a categorical variable that takes value one if the household resides in a treated village and zero if it resides in a control village. D^{AD} is a categorical variable that takes value one if the observation is from the follow-up survey and zero if it comes from the baseline. Finally, ε_{ijt} denotes the error term which is assumed to be independent across villages but not necessarily within them[19]. In that setting, β_3 is the DD estimator of the impact of the program on variable Y, and is often called an average effect as it refers to all beneficiaries without distinction.

If we identify systematic differences between the treatment and control groups in observable variables, we would need to include some controls in expression (1) to check the robustness of our DD estimate. Furthermore, we cannot assure that there are non-observables that can establish systematic differences between treatment and control groups, but the DD estimate can help control for any time-invariant systematic non-observable difference by including household fixed effects[20]. Thus, a full version of the average DD estimate can be obtained from the following expression:

$$Y_{ijt} = \beta_0 + \beta_3 \cdot D_t^{AD} \cdot D_j^{TC} + \lambda_t + \upsilon_{ij} + \varepsilon_{ijt} \qquad (2)$$

where λ_t and υ_{ij} denote the year and household fixed effects, respectively. As we plan to analyze the heterogeneity of the effects depending on the characteristics of the roads and the beneficiary villages, the associated econometric analysis will use the following formulation:

$$Y_{ijt} = \beta_0 + \beta_3 \cdot D_t^{AD} \cdot D_j^{TC} + \gamma_3 \cdot D_t^{AD} \cdot D_j^{TC} \cdot X_{ij} + \lambda_t + \upsilon_{ij} + \varepsilon_{ijt} \qquad (3)$$

where X is another dichotomic variable that takes value 1 if the household or village has the characteristic of interest or concern. In that case, β_3 comes to be the DD estimator of the program's impact for those households or villages that do not have the characteristic of interest X,

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[19] Thus, we use the Huber-White covariance matrix estimator to obtain the standard error of our coefficients of interest.

[20] Since we do not have a randomized control trial, we cannot discard that some time-variant unobservable effects may bias the DD estimate. One way we could argue against such a bias is to show that trends prior to the intervention are similar in both treatment and control groups (see Galiani, Gertler and Schargrodsky, 2005). Such could be done for schooling variables as we have a series of school censuses, but not for most of the variables analyzed here.

and $\beta_3 + \gamma_3$ denotes the impact for those that do have it. The impact evaluation proposed here will pay special attention to differentiated impacts by gender, education, ethnicity and village size.

4. Results

Table 4 Table 11 present the results obtained for road transitability, income, expenditures, poverty, employment, school attendance, and access to health services. In each table, we first report the number of households or individuals involved in the estimation. The first two numbered columns present the averages for each outcome for the treatment and control groups at baseline, while column (3) reports the difference[21]. Columns (4) to (6) do the same for the follow-up survey. Column (7) reports the DD estimate that resulted from assessing expression (1) in the previous section, while column (8) reports the DD estimate when controlling for household fixed effects as specified in expression (2). Results are always shown separately for motorized roads and non-motorized tracks as they may play different roles in connecting rural households to basic services.

4.1 Impacts on transitability of roads

The first important verification is that the program generated a significant reduction in the average time required to travel from the start point to the endpoint of the road in reference (Table 4). In the case of motorized roads, the reduction is 28 minutes from an initial travel time of 100 minutes. In the case of non-motorized tracks, the reduction is 37 minutes from an initial travel time of 173 minutes.

As suggested from the discussion in the previous section, it would have been very interesting to measure the effect in terms of number of months a year the road stays closed as a result of climatic shocks. Unfortunately, such information was only collected for treated roads in the 2004 round; hence, we cannot assess the DD estimator for such variable. We can only verify that such blockages were even more problematic in 2006 than in 2004. However, table 5 also shows that community leaders and household heads tend to report an increased level of satisfaction with rehabilitation work in treated localities. In the case of rehabilitation of motorized roads, community leaders in treated villages reported adequate work in 81 percent of the cases by the time the follow up survey was done, up from 62 percent at baseline. Improved satisfaction is similarly observed among households as they increased the reports of positive benefits out of the rehabilitated road.

This increased satisfaction among household heads is also found in the case of non-motorized tracks. However, an initially puzzling result was that community leaders reported a deterioration in the quality of the rehabilitation and maintenance work in non-motorized tracks within the program. Discussions with PROVIAS officers suggest that such reports may be a result of dissatisfaction with the unfulfilled expectation of the track being upgraded to a motorized road, rather than an evaluation of the quality of the rehabilitation work performed by the contracted MEMV[22].

These results are non-trivial for the program. First, the positive results on travel time and in the perception of the quality of the program intervention provide evidence against local capture or corruption of the program's mechanism by maintaining payments to MEMVs despite significant reductions in the quality of the rehabilitation and maintenance. Moreover, considering the program's age (recall that it started in 1995), positive impacts on the 2004 cohort of interventions indicate that the program has been resilient to such threats. Second, positive impacts are sustained despite the fact that many local governments have seen their budgets increase during the period of economic growth and progress in the decentralization process. Indeed, the number of other roads associated with treatment and control villages that were treated during the observation period has been important (Table 4). In the case of motorized roads for instance, villages associated with treated (control) roads had 0.92 (0.73) roads rehabilitated during the previous two years at baseline, and that number increased to 1.72 (1.57) by the follow up survey in 2006[23]. Thus, these positive impacts indicate that the difference with the program would likely go beyond the extra money spent on road rehabilitation and maintenance, emphasizing on the clear incentives provided by the contracts with MEMVs.

In the following sub-sections, we analyze the implications of the improved transitability upon income and expenditure patterns, employment decisions, and household human capital investments by type of road.

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[21] Notice that for almost all analyzed outcomes, differences between treatment and control groups are not significant, and this is also the case for the variables reported in Table 3.

[22] Also, recall that monthly payments to local MEMVs are contingent on a satisfactory report from program supervisors, and consecutive negative reports lead to a cancellation of the contract.

[23] Although, road rehabilitation also increased in control roads, it is clear that there is no observed bias in the quantity of rehabilitated roads between treatment and control groups, so that no strong evidence is found for a contamination bias. There could be a difference in the quality of rehabilitation work in favor of treated villages, but such difference would be rightly assigned to the program's impact if associated with the transmission of the program's methodology to the local governments involved.

4.2 Impacts on labor income, employment, expenditures and poverty

Table 6 reports the average effects of the Peruvian RRP on household labor income (farm and non-farm), expenditures and poverty. We do not find significant effects in any of these variables. A natural first explanation would be the time variable, as two years may not be sufficient for changes to materialize[24]. Although markets could become closer as a result of improved roads, key agents may need time to adjust to new conditions. Regarding farm income for example, farmers may take more time to recognize that it has become less convenient for them to sell their crops by the field or adjacent road than in local fairs or regional markets. Even if they have already noticed it, it may not be that easy for farmers to break the long-term relationship with local merchants[25].

However, before going any further trying to explain the absence of these income effects, we may want to explore whether some sub-groups might present some positive impacts. Interventions that enhance farmers' productivity tend to initially benefit those that were better off before the program, as they tend to have all the other conditions required to benefit from improved roads. However, it is also feasible to find a pro-poor bias if the less poor are less constrained by bad roads because they may have other assets to compensate. Indeed, recent studies evaluating rural roads programs in developing countries have reported encouraging pro-poor biases in their impacts. For instance, Khandker et. al. (2006) find that some of the effects of a rural roads program on household expenditures accrue among the poorest households in Bangladesh. Mu and van de Valle (2007) also find that the impacts of the Vietnamese rural roads project concentrate in the country's poorer communes. Still, it would be important to check whether this bias also works in the case of the Peruvian RRP, considering that the results we are reporting here ought to be considered as early impacts, and also because of the peculiarities of the Peruvian program with respect to the other cases discussed here, namely that it does not include pavement upgrades or building new roads. On the other hand, it does include financing of permanent maintenance of treated rural roads[26].

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[24] Recall that the interventions in the round of treated roads we are analyzing started in 2004, while the follow up survey was done in 2006 (see discussion in section 2).

[25] See Escobal (2005) for a discussion of the complex decision process associated with the selection of markets by Peruvian rural farmers in Huancavelica. The author argues that local merchants establish more personal relationships with local farmers as they tend to be their first alternative to sell. Such sales provide the farmer with the cash necessary to afford taking chances at more profitable but farther and riskier markets such as local fairs or regional markets. Huancavelica is part of the area targeted by the Peruvian RRP.

[26] Although, the Peruvian RRP is already focused on some of the poorest provinces, they likely still hide large inequalities across households and villages.

In particular, we first explore these hypotheses by checking for heterogeneous impacts by schooling and ethnicity of the household head, village size, and altitude. The analysis by village size may be particularly important in the case of the Peruvian RRP. Fieldwork for the 2006 survey showed that in many cases, treated roads were connecting a relatively large village with a very small one, with many other small villages along the road. If one thinks that some of the relatively large villages already have key markets and public services available, then we could expect that larger impacts would concentrate on the smaller villages as these would be the ones for whom transaction costs would be reduced most. Table 7 shows that the RRP did have effects on labor income for households residing in villages above 3,400 meters of altitude for which a motorized road was treated. Households with more educated heads and residing in larger villages (more than 850 inhabitants) also present positive impacts but they fall short of being statistically significant. On the other hand, treated non-motorized tracks show even weaker average effects and more variability, with no specific group presenting any significant positive income effects.

Table 7 also shows positive and significant income effects for households residing in villages with better initial endowments of productive infrastructure such as electricity, local markets and communications, at least in the case of motorized roads. These results support the argument that the rehabilitation and maintenance of rural roads need to be complemented by key infrastructure to lead to higher incomes.

The positive changes implied by the RRP are further supported when we observe effects on employment decisions by individuals. Table 8 shows that individuals residing in villages associated with treated motorized roads increase their dedication to waged employment (both agricultural and non-agricultural) by 10 days a year and reduce their participation in the family farm as unpaid family workers. These effects are small with respect to total days worked a year by an individual (171), which could explain why the program does not lead towards significant increases in household income, but remain important with respect to the time dedicated to waged employment at baseline. On the other hand, residents near non-motorized tracks increase their dedication to the farm as a non-remunerated family worker by 16 days a year. Those 16 days a year represent a 30 percent increase from the number of working days they dedicated to this kind of labor at baseline.

In table 9 we analyze the changes in employment patterns generated by the RRP intervention by age, gender, and mother tongue. As observed in motorized roads, the switch towards wage employment seems to be led by adults in the peak of their productive years; that is, between 25 and 50 years old. At the same time, though, females seem to increase their participation in agricultural jobs while males focus on non-agricultural jobs. Notice that in the case of

females, they seem to be abandoning work at the farm where they were participating as non-remunerated family workers. In the case of non-motorized tracks, the opposite switch towards farm work is also concentrated among females. Another important result is that employment effects seem to accrue among individuals reporting *quechua* or *aymara* as their mother tongue.

The important gender effects on employment are very relevant, especially in the case of non-motorized tracks, as they were specifically included in the program for their relevance to women. If further income effects materialize later, it can be said that women have been economically empowered within the household by the Peruvian RRP as they increase their participation in income-generating activities with respect to their male counterparts[27].

Thus, employment effects support the hypothesis that economic opportunities may have indeed changed with the RRP, but these are not large enough to imply income effects, except when focusing on households residing in high-altitude villages or with pre-existent endowments of key productive infrastructure, at least in the case of motorized roads. Next, we analyze effects on household investments in the education and health of their members.

4.3 Impacts on household investments in human capital

With respect to household investments in human capital, we find a strong effect in school attendance for children in villages associated with treated motorized tracks, as well as in morbidity and use of local health facilities for both types of roads. School attendance effects are clearly differentiated by gender and age (

[27] It is important to mention that women increase their participation in productive activities without affecting the time they dedicate to household chores. We do not report those results here but they can be available from the author upon request.

Table 10)[28]. Attendance increased by about 7 percentage points among older boys (12-18 years old), an important effect considering that attendance by such a group at baseline was only 84 percent. Considering the age group, it is possible that this effect may imply that with the program, boys are better able to attend secondary school while continuing to live within the nuclear family, rather than permanently migrating to a larger city[29]. For the younger girls (6-11 years old), school attendance increased by 6 percentage points from an initial 93 percent attendance rate for this group at baseline. That is, these young girls are reaching perfect attendance in primary school, eliminating a previously negative gender bias.

The lack of effects on younger boys may not be of concern, considering that this group's level of attendance was already very high (95%) at baseline. On the other hand, the lack of effects among older girls is worrisome as this group had a lower attendance level at baseline, and indicates that gender inequalities are still affecting girls in the higher levels of primary school or at the entrance to high school. If such is the case, it would be useful to identify whether the reason is associated with a lower value parents give to higher education of girls, or if it is instead explained by the higher vulnerability girls face with respect to the level of insecurity when traveling longer distances.

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[28] The attendance reported here refers to the period prior to the survey, and not the current one. Luckily, ENAHO has both variables. Current attendance is much lower at around 50% for high school level students, but the reports on attendance in the previous period in ENAHO are similar to those reported here.

[29] This hypothesis will be further evaluated using the individual migration data that has not been included in this version of the study.

Finally, table 11 reports the Peruvian RRP's impact on morbidity and use of health services by adults and children under five. We find a reduction in the incidence of illnesses and accidents in the four weeks prior to the date of the survey, especially for children under five and in the villages with treated motorized roads. In this case, the morbidity rate falls almost 4 percentage points among all members, but the reduction is almost 9 percentage points when looking only at children under five. The effect on the use of health services (consultations) is also negative, which is somewhat puzzling. An explanation could be that improved rural roads may allow the health system to work for the population in remote areas not by attending to them when they are sick but rather by providing them with useful health information that helps prevent illness and thus the need for consultations at the health center. Notice that the consultation effect is also higher for children under five, and in that case we also need to consider that more accessible health facilities help them reach children with nutritional supplements. Such hypothesis is indeed consistent with the finding that households with children under five in these localities report having benefited more (6-8 percentage points) from early childhood development programs, considering that most of the work of the corresponding nutritional and health programs is made off the health post or center (see Table 12).

On the other hand, a somewhat puzzling result is found among those that were treated through non-motorized tracks, as the use of consultations at health facilities for children under five drops by 12 percentage points, even though the reduction in morbidity is not found to be statistically significant. However, we should be careful with these results as the sample size for children under five in these localities is rather small, which is also true for the educational outcomes reported in table 10 (see Table 13)

5. Summary and discussion

The study looked at the early impacts of a rural roads program that is based on an institutional innovation characterized by the contracting of private local firms for the rehabilitation and maintenance of rural roads with local supervision by community leaders setting incentives that favour prevention activities and a sustainable and timely maintenance of rural roads. We find that this institutional innovation, promoted by the PROVIAS DESCENTRALIZADO of the Ministry of Transport and Communication, quickly improved road transitability which in turn led to significant changes in employment patterns and increased investments in education and health. Income effects are not significant on average, but they appear strong for certain groups, especially in villages with pre-existent endowments of key productive infrastructure. These results, though, are concentrated on interventions in motorized roads, although there are significant changes in employment patterns

in the case of non-motorized tracks that seem to indicate an increased participation of women in farm activities.

The impacts on road transitability are positive for the Peruvian RRP, and more generally, for the contracting of local private firms for the rehabilitation and maintenance of rural roads in developing countries. Considering that this study focuses on the cohort of interventions that started in 2004, nine years after the program began, the positive effects indicate that the intervention has been able to control local capture and corruption threats. Although it may still be the case that some money is diverted and/or that some special families benefit more from employment by local maintenance firms, it seems that the output-based contracts have helped the program to still present improvements in road transitability after almost a decade of interventions.

On the other hand, observed income effects support the notion that road improvements need to be complemented with other key infrastructure, although it is still possible that more time may be needed for income effects to spread to other villages, considering that the follow up survey we analyze here was done only two years after the intervention began. Indeed, employment changes on all treated households would support the idea that important changes in economic conditions already occurred with road improvements, although they may take more time to materialize in less endowed environments.

Also, the differences in employment opportunities by type of road indicate that the latter plays different roles in connecting rural people to key markets. Motorized roads seem to play the more recognized role of connecting rural households to larger cities where product and job markets are more developed and schools and health facilities are available. On the other hand, non-motorized tracks play a more important role in moving individuals from their houses to the farms, especially for adult women. These changes are particularly more significant for women who increase their participation in economic activities, which likely empower them within the household. The inclusion of treatments to non-motorized tracks is supported as we find that the increased participation of women in economic activities at the family farm is particularly stronger in such interventions.

The Peruvian RRP also had early effects on school attendance and morbidity in the case of treated motorized roads underscoring the importance of this type of intervention for household investments in human capital. However, the school attendance effects are not found significant for older girls (12-18 years), for which the attendance problem was more worrisome to begin with, and suggest the need for further interventions to promote gender equity in schooling investments by

rural households. The morbidity effects in turn are especially significant for children under five. These results would indicate the need to consider availability of rural roads when analyzing the capacity of the Juntos program to enforce the conditionalities on school attendance and health checkups by mothers and children.

Finally, considering that the analysis presented here is based on a follow up survey applied after only a year or two from the beginning of the intervention, it would be important to continue the analysis of this cohort of interventions by the RRP so that we could elucidate whether, for instance, the lack of income effects is because these effects need more time to show up, or whether complementary interventions are required. More generally, following interventions over time would allow us to explore deeply into the dynamics of RRP's effects, that is, which impacts need more time to mature, and also whether earlier impacts are sustained in time.

References

Ahmed, R. y Hossain, M. (1990). "*Developmental Impact of Rural Infrastructure in Bangladesh*". Washington D.C.: International Food Policy Research Institute.

Bardhan, Pranab; Dilip Mookherjee (2006). "Decentralization and accountability in infrastructure delivery in developing countries". *Economic Journal* 116: 101-127, January.

Benavides, Juan (2003). "*Infraestructura y pobreza rural: coordinación de políticas e intervenciones en países de América Latina y el Caribe*". Manuscript IADB, Sustainable Development Department, December.

Bertrand, Marianne; E. Duflo; S. Mullainathan (2004). "How Much Should We Trust Differences-in-Differences Estimates?". *Quarterly Journal of Economics* 119 (1): 249-275, February.

Binswanger, H. P.; S. R. Khandker; M. R. Rosenzweig (1993). "How infrastructure and financial institutions affect agricultural output and investment in India". *Journal of Development Economics* 41: 337-366.

Escobal, Javier (2005). "¿Cuan complicado es vincularse con los mercados? El caso de los pequeños productores de papa en Huancavelica". *Economía y Sociedad* 55, CIES, Marzo.

Escobal, Javier; Marisol Inurritegui; Juan Benavides (2005). "*Infraestructura rural: Guías para diseñar intervenciones y lecciones aprendidas de PROVIAS Rural (Perú)*". IADB Series of Technical Reports, Sustainable Development Department, February.

Escobal, Javier; Carmen Ponce (2002). "*The Benefits of Rural Roads: Enhancing Income Opportunities for the Rural Poor*". GRADE Working Paper # 40, Lima, November.

Fort, Lucia, Aurelio Menéndez (2002). "*Making Rural Roads Work for Both Women and Men: The Example of Peru's Rural Roads Program*". The World Bank, Promising Approaches to Engendering Development.

Fort, Ricardo; Fernando Aragón (2006). "Impacto de los Caminos Rurales sobre las Estrategias de Obtención de Ingresos de los Hogares". En Iguiñiz, Escobal y Degregori (eds.) *SEPIA XI, Perú: El Problema Agrario en Debate*, Lima.

Gannon, C.; Z. Liu (1997). "*Poverty and Transport"*. The World Bank, INU/TWU Series Transport Publications. TWU-30, Washington, D.C.

Hettige, Hemamala (2006). "*When do Rural Roads Benefit the Poor and How?: An In-Depth Analysis Based on Case Studies*". Asian Development Bank, Operations Evaluation Department, Philippines.

Instituto Cuánto (2004). "*Evaluación Económica, Social, Ambiental e Institucional del Provias Rural Fase I*". Final Report, November.

…….. (2000). "*Evaluación económica, social, ambiental e institucional del Programa Caminos Rurales*". Final Report.

Jacoby, H. C. (2000). "Access to markets and the benefits of rural roads". *Economic Journal 110* (465): 713-737.

Khandker, Shahidur R.; Zaid Bakht; Gayatri B. Koolwal (2006). "*The Poverty Impact of Rural Roads: Evidence from Bangladesh*". World Bank Policy Research Working Paper # 3875, April.

Levy, Hernan (2004). "*Rural Roads and Poverty Alleviation in Morocco*". Banco Mundial, Manuscrito preparado para la conferencia Scaling Up Poverty Reduction: A Global Learning Process, Shanghai, May 25-27.

Liu, Z. (2000). *Economic analysis of a rural basic access road project: the case of Andhra Pradesh, India*.: Infrastructure Notes: Transport Sector, (Transport No. RT-5). The World Bank.

Lucas, K., Davis, T., & Rikard, K. (1996). *Agriculture transport assistance program: impact study*. Dar es Salaam: Project Number 621-0166. USAID/Tanzania.

MacDonald, Charles L. (2001) "*Ecuador: Programa de Infraestructura Rural de Transporte, valuación Económica de los Proyectos de Rehabilitación de Caminos*". Development Ideas, INC.

Malmberg Calvo, Christina (1998). "Options for Managing and Financing Rural Transport Infrastructure". World Bank Technical Paper # 411.

Mu, Ren; D. van de Walle (2007). "*Rural Roads and Poor Area Development in Vietnam*". World Bank Policy Research Working Paper # 4340, August.

Olken, Benjamin (2007). "Monitoring Corruption: Evidence from a Field Experiment in Indonesia". *Journal of Political Economy* 115 (2): 200-249, April.

Oré, María Teresa (2001). "El impacto socio-cultural del programa caminos de herradura 1995-2000". The World Bank.

Porter, G. (2002). "Living in a walking world: rural mobility and social equity issues in Sub-Saharan Africa". *World Development* 30 (2): 285.300.

van de Walle, D. (2002). "Choosing Rural Road Investments to Help Reduce Poverty". *World Development* 30 (4): 575-589, April.

Windle, J.; R. A. Cramb (1996). "*Roads, remoteness and rural development: social impacts of rural roads in upland areas of Sarawak Malaysia".* Department of Agriculture, University of Queensland, Agricultural Economics Discussion Paper 3/96, Brisbane, Australia.

World Bank (2005). "*Infrastructure and the World Bank: A Progress Report*". Report presented to the Development Committee Meeting, September 25, Washington DC.

…… (2004). "*World Development Report: Making Services Work for Poor People*". Washington DC.

…… (1995). "*Peru Rural Road Rehabilitation and Maintenance Project: Staff Appraisal Report*". Infrastructure and Operations Division manuscript. Washington DC, November.

Table 1: Key indicators available in household and community-level surveys

Indicators	Description of variables	Source [a/]
Transport		
Travel time	Time in minutes needed to go from the initial to the final point of the road	CLS
Traffic intensity	Average number of public and private transportation units using the road, and frequency of public units	CLS
Cost of public transportation	Ticket prices for transporting people and cargo	CLS
Usability of the road	Number of months the road was closed over the past 12 months	CLS
Access to health and education		
Schooling	Maximum level of schooling attained by each individual	HLS
School attendance	Proportion of children currently attending school	HLS
School accessibility	Means of transport used to go to school and travel time	HLS
School availability in the locality	Number of schools available in the locality, by level	CLS
Illness	Number of days individuals were sick/disabled, incidence of diarrhea among children	HLS
Use of health care	Number of individuals that consulted with doctors	HLS
	Pregnancies with birth control consultancies, institutional births over the last two years	HLS
Accessibility to health care	Means of transport used to go to the nearest health facility and travel time	HLS
Availability of health facilities	Number of health facilities available in the locality, by level	CLS
Access to other services		
Public telephone	Availability of public phone in the locality	CLS
Internet	Availability of internet in the locality	CLS
Radio	Availability of radio in the locality	CLS
TV signal	Availability of public TV signal in the locality	CLS
Income and employment		
Income	Total monthly labor income, by individual and household	HLS
Diversification	Proportion of income coming from agricultural, livestock and non-agricultural activities	HLS
Wages	Average agricultural and non-agricultural wages for unskilled labor in the locality	HLS
Time use	Time dedicated to domestic activities, by age and gender	HLS

(continued …)

Table 2: Key indicators available in household and community-level surveys (… continuation)

Indicators	Description of variables	Source
Productive activities		
Agricultural land	Size of the plots owned and managed by household members	HLS
Land use intensity	Land cultivated by household members	HLS
Productivity	Yields of main products and value added per hectare	HLS
Livestock	Number of heads by type of animal	HLS
Productive assets	Number and value of key equipment and machinery	HLS
Trade	Proportion of production destined to the local and regional markets	HLS
Market accessibility	Means of transport used to go to the main market (local fair) and travel time	HLS
Access to agricultural services	Number of households with access to credit and technical assistance	HLS
Expenditures and poverty		
Household expenditures	Total per capita monthly expenditures	HLS
Poverty rate	Proportion of households with expenditures under the poverty and extreme poverty lines	HLS
Unmet basic needs	Proportion of households without at least one of the basic needs unmet (treated water, sewage, type of roof, children in school age not attending school, large dependency ratio)	HLS
Social capital		
Migration	Number of permanent and temporary migrants and immigrants	HLS
Social organizations	Number of social organizations in the locality	CLS
Presence of public programs	number of public programs that operated in the locality over the past two years, and number of beneficiaries in the locality	HLS
Participation	Number of households with individuals that are active members of local social organizations	HLS
Opinion of the program		
Performance of the program	Perception of the quality of rehabilitation and maintenance of roads	CLS
Impact	Perception of the types of benefits brought by the rehabilitation and maintenance of the road	HLS / CLS
Distribution of benefits	Proportion of households that report having benefited with the rehabilitation and maintenance of road	HLS

CLS - community-level survey; HLS – household level survey

Table 3: Pre-treatment differences for 2004 cohort

Variables	Control	Treatment	Difference	T-stat	
Household variables					
Age groups					
[0-8]	26.8	28.1	-1.4	-1.52	*
[9-18]	25.1	24.5	0.6	0.70	
[19-35]	23.5	23.5	0.0	-0.05	
older than 36	24.7	23.9	0.8	0.92	
School attainment (3 years or older)					
None	15.6	15.4	0.2	0.20	
Pre - school	8.6	9.5	-0.9	-1.56	*
Primary	48.5	48.5	0.0	0.04	
Secondary	24.1	23.7	0.4	0.46	
Superior	3.2	2.8	0.3	0.93	
Access to water (%)	52.7	52.2	0.5	0.20	
Female head (%)	11.1	10.9	0.2	0.15	
Head with indigenous mother tongue (%)	62.5	60.0	2.5	1.15	
Per Capita Expenditure (monthly soles)	87.0	91.8	-4.8	-1.21	
Per Capita Income (monthly soles)	91.1	92.3	-1.3	-0.24	
Poverty					
Extreme (%)	51.8	50.5	1.3	0.57	
No extreme (%)	30.4	30.4	0.0	0.02	
Village level variables					
Population size (# individuals)	874.7	1023.4	-148.7	-0.76	
Altitude (meters above sea level)	2722.6	2799.0	-76.4	-0.55	

Source: 2004 Household and Community-level Baseline Surveys

Table 4: Baseline - Follow-up statistics and impact of rural roads on transportation

Dependent variable [a/]	Nº of villages	Baseline				Follow-up				DD		DD (FE)	
		Treated	Control	Diff		Treated	Control	Diff					
		(1)	(2)	(3)		(4)	(5)	(6)		(7)		(8)	
Motorized roads													
Roads rehabilitated in past 2 years	235	0.92	0.73	0.18		1.72	1.57	0.15		-0.03		-0.03	
				(0.14)				(0.15)		(0.20)		(0.22)	
Road of reference													
Travel time	235	101.45	99.55	1.90		69.55	84.71	-15.16		-17.06		-28.07	*
				(11.26)				(13.01)		(14.70)		(16.51)	
# months road remains blocked		1.97	n.a.	n.a.		2.60	n.a.	n.a.		0.63	***	0.59	***
										(0.16)		(0.18)	
Non-Motorized tracks													
Roads rehabilitated in past 2 years	74	1.14	0.39	0.75	***	1.31	1.03	0.28		-0.47		-0.44	
				(0.23)				(0.25)		(0.34)		(0.38)	
Road of reference													
Travel time	74	172.87	180.34	-7.46		137.27	162.97	-25.70		-18.24	*	-37.04	***
				(5.45)				(37.35)		(12.69)		(9.55)	
# months road remains blocked		2.125	n.a.	n.a.		2.852	n.a.	n.a.		0.73	*	0.64	
										(0.40)		(0.46)	

Notes: Each row in the table is from a separate regression. Double difference (DD) estimates are reported as measures of impact. Standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviations in column 8 control for household-level fixed effects. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Baseline - Follow-up statistics and impact of rural roads on transportation

	Motorized roads			Non-motorized tracks		
Variables	2004	2006		2004	2006	
Perception of quality of intervention by community leaders						
Rehabilitation (=1 if considered adequate)	62.1	80.6	***	84.1	60.0	**
Maintenance (=1 if considered adequate)	67.9	75.0		70.5	47.1	**
Perception of quality of intervention by households						
Both (=1 if hh benefited from road intervention´)	60.1	73.9	***	47.4	65.0	***
Reasons						
Improved access to:						
Health care	48.9	64.2	***	33.3	63.2	***
Schools	38.1	57.3	***	21.8	54.2	***
Markets	85.1	69.3	***	74.4	65.3	
Job opportunities	40.6	57.3	***	14.1	56.3	***
Reduced prices of processed goods	21.1	30.0	***	5.1	11.1	
Other	15.8	20.4		20.5	17.4	

*** significant at 0.01, ** significant at 0.05, * significant at 0.1.

Table 6: Baseline - Follow-up statistics and impact of rural roads on household labor income, expenditures and poverty

Dependent variable [a/]	Baseline				Follow-up				DD	DD (FE)
	Treated	Control	Diff		Treated	Control	Diff			
	(1)	(2)	(3)		(4)	(5)	(6)		(7)	(8)
Motorized roads										
Household monthly income	358.31	365.17	-6.87		339.62	340.07	-0.45		6.42	6.18
			(18.51)				18.55		(19.36)	(19.63)
Household monthly expenditure	407.01	388.55	18.47		443.82	427.98	15.84		-2.63	-2.63
			(24.49)				24.49		(29.51)	(29.51)
Poverty rate										
Extreme	61.25	59.55	1.69		62.80	65.62	-2.82		-4.51	-4.91
			(2.52)				2.54		(3.04)	(3.07)
No extreme	20.04	23.41	-3.38	*	16.18	16.20	-0.02		3.36	3.68
			(2.04)				2.05		(2.81)	(2.85)
Non-poor	18.70	17.06	1.65		20.99	18.26	2.73		1.08	1.24
			(2.04)				2.05		(2.39)	(2.44)
Non-Motorized tracks										
Household monthly income	322.06	330.81	-8.76		291.14	262.46	28.67		37.43	31.86
			(27.96)				28.09		(32.59)	(32.97)
Household monthly expenditure	372.62	371.45	1.18		393.15	349.08	44.07		42.90	42.90
			(37.19)				37.19		(47.29)	(47.29)
Poverty rate										
Extreme	62.58	58.71	3.87		69.79	69.03	0.76		-3.11	-2.26
			(4.42)				4.43		(5.82)	(5.88)
No extreme	20.43	24.03	-3.60		12.99	19.57	-6.58	*	-2.98	-2.63
			(3.65)				3.66		(5.17)	(5.29)
Non-poor	16.97	17.20	-0.23		17.26	11.51	5.76	*	5.99	4.89
			(3.38)				3.39		(4.35)	(4.41)

Notes: Each row in the table is from a separate regression. Double difference (DD) estimates are reported as measures of impact. Standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviations in column (8) control for household-level fixed effects. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Heterogeneities in the impact of the RRP: Household labor income

	Motorized roads				Non-motorized tracks			
	Nº of households	Treated at baseline	DD (FE)		Nº of households	Treated at baseline	DD (FE)	
Base Model	1493	358.31	6.18		470	322.06	31.86	
			(19.63)				(32.97)	
Household head´s schooling								
Lower	1908	308.40	-8.25		599	306.99	40.90	
			(24.45)				(41.13)	
Higher	1070	433.57	32.01		336	344.05	15.60	
			(32.93)				(55.43)	
Village size								
Small	500	347.00	35.82		187	312.13	6.37	
			(34.42)				(52.71)	
Medium	472	357.32	-14.13		126	298.66	62.09	
			(35.57)				(66.02)	
Large	337	375.45	47.72		107	413.73	-79.08	
			(41.45)				(71.45)	
Altitude								
Low	393	347.40	-34.26		87	265.88	65.52	
			(38.16)				(78.36)	
Medium	399	384.28	21.97		120	368.37	-8.77	
			(37.65)				(68.86)	
High	441	311.55	78.40	**	169	326.27	2.99	
			(35.69)				(57.53)	
Infrastructure								
Power infrastructure								
Without	748	348.06	-5.59		208	328.60	-7.03	
			(27.68)				(50.33)	
With	561	371.88	64.02	**	212	351.74	8.33	
			(32.20)				(50.04)	
Marketplace								
Without	1195	359.95	0.91		390	343.60	22.59	
			(21.75)				(36.68)	
With	110	348.25	269.88	***	30	241.52	-227.67	
			(72.38)				(142.03)	
Public telephone								
Without	683	355.75	2.56		261	307.00	13.65	
			(28.75)				(45.06)	
With	626	362.34	50.53	*	159	374.77	-31.68	
			(30.49)				(60.02)	
Institutional presence								
Technical Assistance								
Without	804	355.20	45.17	*	328	335.18	4.21	
			(26.78)				(40.17)	
With	505	364.46	-6.42		92	350.67	-11.37	
			(33.76)				(77.13)	
Credit								
Without	1134	357.02	36.39		365	334.65	4.34	
			(22.52)				(37.74)	
With	175	373.50	-62.06		55	376.17	44.35	
			(57.60)				(99.14)	

Notes: Each group of rows of the same category is from a separate regression. Coefficient and standard deviations control for household-level fixed effects. Double difference estimates are reported as measures of impact. * significant at 10%; ** significant at 5%; *** significant at 1%. Heterogeneous categories are defined as follows. Schooling: Lower is for household head with primary or no education; Higher, with secondary or higher education. Village size: Small is for villages with less than 300 inhabitants; Medium, with more than 300 to 850 inhabitants; Large, with more than 850 inhabitants. Altitude: Low is for villages which are 2500 meters above sea level, Medium, between 2500 and 3400 meters above sea level, High, from more than 3400 to 5500 meters above sea level. Power Infrastructure: "with" if the village has a functioning electric power network and/or street ligthing. Marketplace: "with" if the village has a functioning marketplace. Public telephone: "with" if the village has a functioning public telephone. Technical assistance: "with" if there are farmers in the village that receive agricultural technical assistance. Credit: "with" if there are farmers in the village that receive credit .

Table 8: Baseline - Follow-up statistics and impact of rural roads on employment (%)

Dependent variable [a/]	Nº of individuals	Baseline			Follow-up			DD		DD (FE)	
		Treated	Control	Diff	Treated	Control	Diff				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	
Motorized roads											
Working days per year	4141	170.929	170.206	0.723	168.105	172.134	-4.029	-4.752		-4.553	
				(4.412)			(4.417)	(5.367)		(5.420)	
Wage - Agriculture	4141	7.501	6.313	1.188	10.506	5.712	4.793 **	3.606	**	3.808	**
				(1.574)			(1.579)	(1.678)		(1.702)	
Wage - No agriculture	4141	10.044	10.883	-0.839	16.108	11.397	4.710 **	5.549	**	5.683	**
				(2.011)			(2.017)	(2.213)		(2.244)	
Non wage - Agriculture	4141	74.869	77.989	-3.120	75.625	78.078	-2.453	0.667		-0.539	
				(3.777)			(3.781)	(5.342)		(5.436)	
Non wage - No Agriculture	4141	23.776	20.495	3.281	22.810	21.542	1.268	-2.014		-2.036	
				(3.062)			(3.072)	(3.275)		(3.320)	
Unpaid family worker - Agriculture	4141	50.991	50.942	0.049	37.773	47.895	-10.122 ***	-10.171	**	-8.986	**
				(2.944)			(2.950)	(4.024)		(4.026)	
Unpaid family worker - No Agriculture	4141	2.754	2.368	0.385	4.630	6.524	-1.894	-2.280		-2.527	
				(1.189)			(1.193)	(1.523)		(1.539)	
Non-Motorized tracks											
Working days per year	1322	177.461	176.311	1.149	179.608	167.201	12.408 *	11.258		10.141	
				(7.556)			(7.536)	(9.680)		(9.781)	
Wage - Agriculture	1322	1.996	4.377	-2.380	4.118	5.425	-1.307	1.074		1.383	
				(1.802)			(1.795)	(2.431)		(2.457)	
Wage - No agriculture	1322	8.976	7.978	0.998	9.858	13.874	-4.016	-5.014		-4.994	
				(3.191)			(3.190)	(3.567)		(3.633)	
Non wage - Agriculture	1322	92.564	92.491	0.072	89.580	89.679	-0.099	-0.171		1.584	
				(7.275)			(7.234)	(10.260)		(10.544)	
Non wage - No Agriculture	1322	16.713	9.898	6.815 *	17.582	10.571	7.011 *	0.197		-1.373	
				(3.854)			(3.848)	(4.705)		(4.747)	
Unpaid family worker - Agriculture	1322	53.783	58.624	-4.841	53.795	41.515	12.279 **	17.120	**	16.393	**
				(5.472)			(5.448)	(7.500)		(7.511)	
Unpaid family worker - No Agriculture	1322	2.470	1.526	0.944	3.752	4.742	-0.990	-1.935		-2.701	
				(1.772)			(1.762)	(2.499)		(2.530)	

Notes: Each row in the table is from a separate regression. Standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviations in column (8) control for household-level fixed effects. Double difference estimates are reported as measures of impact. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9: Employment effects by gender

Dependent variable [a/]	Base model			Gender					
				Female			Male		
	Nº of individuals	Treated at baseline (1)	DD(FE) (2)	Nº of individuals	Treated at baseline (3)	DD(FE) (4)	Nº of individuals	Treated at baseline (5)	DD(FE) (6)
Motorized roads									
Working days per year	4141	170.929	-4.55	2064	148.991	-9.61	2077	189.195	3.33
			(5.42)			(7.43)			(7.33)
Wage - Agriculture	4141	7.501	3.81 **	2064	2.215	4.06 *	2077	12.430	3.53
			(1.70)			(2.41)			(2.38)
Wage - No agriculture	4141	10.044	5.68 **	2064	4.360	3.56	2077	15.535	7.98 **
			(2.24)			(3.16)			(3.12)
Non wage - Agriculture	4141	74.869	-0.54	2064	25.741	2.90	2077	125.913	-3.44
			(5.44)			(6.92)			(6.84)
Non wage - No Agriculture	4141	23.776	-2.04	2064	29.147	-2.91	2077	16.216	-0.73
			(3.32)			(4.72)			(4.66)
Unpaid family worker - Agriculture	4141	50.991	-8.99 **	2064	82.479	-14.45 ***	2077	18.890	-1.86
			(4.03)			(5.45)			(5.38)
Unpaid family worker - No Agriculture	4141	2.754	-2.53	2064	5.049	-3.14	2077	0.212	-2.00
			(1.54)			(2.18)			(2.16)
Non-Motorized tracks									
Working days per year	1322	177.461	10.14	662	142.193	29.92 **	660	211.522	-8.73
			(9.78)			(13.29)			(13.22)
Wage - Agriculture	1322	1.996	1.38	662	0.621	1.09	660	3.632	1.87
			(2.46)			(3.47)			(3.46)
Wage - No agriculture	1322	8.976	-4.99	662	3.902	-4.23	660	13.089	-5.66
			(3.63)			(5.10)			(5.07)
Non wage - Agriculture	1322	92.564	1.58	662	37.408	16.37	660	149.519	-12.77
			(10.54)			(13.48)			(13.41)
Non wage - No Agriculture	1322	16.713	-1.37	662	20.547	1.03	660	12.674	-3.79
			(4.75)			(6.72)			(6.69)
Unpaid family worker - Agriculture	1322	53.783	16.39 **	662	75.335	20.46 **	660	32.110	12.59
			(7.51)			(10.24)			(10.19)
Unpaid family worker - No Agriculture	1322	2.470	-2.70	662	4.379	-4.65	660	0.499	-0.95
			(2.53)			(3.58)			(3.56)

Notes: Each group of rows of the same category is from a separate regression. Coefficient and standard deviations control for household-level fixed effects. Double difference estimates are reported as measures of impact.
* significant at 10%; ** significant at 5%; *** significant at 1%. Heterogeneous categories are defined as follows. Gender: if the individual is female or male.

Table 10: Baseline - Follow-up statistics and impact of rural roads on school attendance (%)

Dependent variable [a/]	Nº of individuals	Baseline Treated (1)	Baseline Control (2)	Baseline Diff (3)		Follow-up Treated (4)	Follow-up Control (5)	Follow-up Diff (6)		DD (7)		DD (FE) (8)	
Motorized roads													
Males 6-11 years	711	95.435	92.597	2.837		91.938	90.872	1.066		-1.772		-3.752	
				(2.009)				(2.027)		(2.614)		(3.082)	
Males 12-18 years	612	84.153	89.268	-5.115	*	84.104	79.561	4.543		9.659	**	7.291	*
				(3.044)				(2.921)		(3.808)		(4.276)	
Females 6-11 years	734	93.196	95.524	-2.328		95.180	88.719	6.462	***	8.789	***	6.898	**
				(1.913)				(1.953)		(2.459)		(2.862)	
Females 12-18 years	521	80.628	84.530	-3.902		84.022	85.976	-1.954		1.948		-0.222	
				(3.319)				(3.139)		(3.696)		(4.156)	
Non-Motorized tracks													
Males 6-11 years	232	92.936	95.637	-2.702		83.689	92.352	-8.662	**	-5.960		-2.751	
				(3.704)				(3.866)		(5.275)		(6.276)	
Males 12-18 years	212	83.541	91.777	-8.236		72.452	85.730	-13.277	**	-5.041		-6.706	
				(5.328)				(4.965)		(6.509)		(7.372)	
Females 6-11 years	222	89.290	91.215	-1.925		85.740	89.567	-3.827		-1.903		-1.789	
				(4.331)				(4.301)		(5.678)		(6.592)	
Females 12-18 years	172	79.579	78.880	0.699		76.656	83.504	-6.847		-7.546		-8.741	
				(6.410)				(5.965)		(7.247)		(8.286)	

Notes: Each row in the table is from a separate regression. Double difference (DD) estimates are reported as measures of impact. Standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviation in column (8) control for household fixed effects. * significant at 10%; ** significant at 5%; ***significant at 1%.

Table 11: Baseline - Follow-up statistics and impact of rural roads on morbidity and use of health services (%)

Dependent variable [a/]	N[a] of individuals	Baseline Treated (1)	Baseline Control (2)	Baseline Diff (3)		Follow-up Treated (4)	Follow-up Control (5)	Follow-up Diff (6)		DD (7)		DD (FE) (8)	
Motorized roads													
Sickness and accidents in last 4 weeks													
All household members	7574	38.569	35.573	2.996	**	30.661	31.471	-0.811		-3.807	**	-3.724	**
				(1.401)				(1.413)		(1.426)		(1.434)	
Children 0-5 years	1396	47.757	42.929	4.828	*	35.830	38.233	-2.403		-7.231	**	-8.789	**
				(2.780)				(3.100)		(3.685)		(3.998)	
Attention from a heath professional													
All household members	7574	21.441	19.804	1.637		20.718	21.661	-0.943		-2.581	**	-2.591	**
				(1.154)				(1.165)		(1.246)		(1.255)	
Children 0-5 years	1396	38.368	38.442	-0.074		30.063	35.271	-5.208	*	-5.134		-8.078	**
				(2.673)				(2.990)		(3.659)		(3.972)	
Non-Motorized tracks													
Sickness and accidents in last 4 weeks													
All household members	2348	32.806	34.790	-1.984		33.783	33.219	0.565		2.549		2.141	
				(2.483)				(2.478)		(2.552)		(2.567)	
Children 0-5 years	369	46.487	36.114	10.374	**	33.724	35.066	-1.342		-11.715	*	-7.385	
				(5.284)				(5.508)		(6.824)		(7.526)	
Attention from a heath professional													
All household members	2348	17.254	18.677	-1.422		19.933	18.406	1.526		2.949		2.598	
				(1.989)				(1.985)		(2.109)		(2.120)	
Children 0-5 years	369	35.768	31.436	4.332		22.120	30.876	-8.756	*	-13.087	**	-12.498	*
				(4.999)				(5.207)		(6.375)		(7.008)	

Notes: Each row in the table is from a separate regression. Double difference (DD) estimates are reported as measures of impact. Standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviations in column (8) control for household-level fixed effects. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 12: Baseline - Follow-up statistics and impact of rural roads on access to social programs (%)

Dependent variable [a/]	Nº of households	Baseline			Follow-up				DD		DD (FE)	
		Treated (1)	Control (2)	Diff (3)	Treated (4)	Control (5)	Diff (6)		(7)		(8)	
Motorized roads												
Social Programs												
Food	1525	73.208	72.055	1.153	62.390	56.849	5.541	**	4.388		4.388	
				(2.402)			(2.402)		(2.695)		(2.695)	
Education	1525	63.396	64.658	-1.261	65.409	62.603	2.806		4.067		4.067	
				(2.461)			(2.461)		(2.595)		(2.595)	
Health	1525	54.843	53.288	1.555	75.849	73.425	2.424		0.869		0.869	
				(2.398)			(2.398)		(2.852)		(2.852)	
ECD1												
All households	1525	57.484	54.658	2.827	76.226	73.699	2.528		-0.299		-0.299	
				(2.388)			(2.388)		(2.834)		(2.834)	
Households with children under 6 years	958	79.923	81.136	-1.214	88.996	82.273	6.723	***	7.937	**	7.937	**
				(2.415)			(2.415)		(3.353)		(3.353)	
ECD2												
All households	1525	76.730	76.027	0.702	81.761	80.548	1.213		0.511		0.511	
				(2.093)			(2.093)		(2.442)		(2.442)	
Households with children under 6 years	958	95.560	97.727	-2.167	93.243	89.318	3.925	***	6.092	***	6.092	***
				(1.529)			(1.529)		(2.093)		(2.093)	
Non-Motorized tracks												
Social Programs												
Food	478	68.619	67.364	1.255	60.251	61.088	-0.837		-2.092		-2.092	
				(4.378)			(4.378)		(4.788)		(4.788)	
Education	478	69.874	64.854	5.021	67.782	70.293	-2.510		-7.531		-7.531	
				(4.264)			(4.264)		(4.875)		(4.875)	
Health	478	44.351	51.046	-6.695	73.222	75.314	-2.092		4.603		4.603	
				(4.297)			(4.297)		(5.118)		(5.118)	
ECD1												
All households	478	46.025	51.046	-5.021	74.059	76.151	-2.092		2.929		2.929	
				(4.280)			(4.280)		(5.086)		(5.086)	
Households with children under 6 years	261	73.134	79.528	-6.393	82.836	92.126	-9.290	**	-2.897		-2.897	
				(4.721)			(4.721)		(6.143)		(6.143)	
ECD2												
All households	478	71.967	74.477	-2.510	80.753	80.753	0.000		2.510		2.510	
				(3.842)			(3.842)		(4.422)		(4.422)	
Households with children under 6 years	261	94.776	94.488	0.288	91.045	96.850	-5.806	**	-6.094		-6.094	
				(2.882)			(2.882)		(3.904)		(3.904)	

Notes: Each row in the table is from a separate regression. Standard deviations in columns (3), (6) and (7) are adjusted by clustering at household level. Coefficient and standard deviations in column 8 control for household-level fixed effects. Double difference estimates are reported as measures of impact. * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variables are defined as follows. Food programs include the following: a) Glass of Milk Program, Nurturing Basket Program (PANFAR), b) Food for Children Program (PACFO), c) Food for the sick and the elder and d) Cheap eateries. Education Programs include the following: a) Breakfast or food for school students, b) School uniforms and school footwear, c) School books and schooling material, d) Student insurance at school level, e) Juvenile job training and d) Job training for women. Health Programs include de following: a) Control of children´s growth and development (CRED) , b) Family planning, c) Control of Tuberculosis and d) Vaccination Program. ECD1 denotes Early Childhood Development Programs, includes the following: PANFAR, PACFO, CRED, Vaccination Program. ECD2 adds to ECD1 the Glass of Milk Program.

Table 13: Number of observations per group of analysis

		Education		Village Size			Altitude			Gender		Age		
	Total	Lower	Higher	Small	Medium	Large	Low	Medium	High	Female	Male	Younger	Middle	Older
Motorized roads														
Households	1521	965	556	510	480	344	407	402	443	n.a.	n.a.	n.a.	n.a.	n.a.
All individuals	7574	4849	2725	2431	2471	1769	2082	1970	2193	n.a.	n.a.	n.a.	n.a.	n.a.
All members > 15 years old	3642	n.a.	n.a.	1360	1321	961	1127	1090	1193	2064	2077	1270	2091	780
Children 0-5 years	1396	881	515	424	465	334	389	351	399	n.a.	n.a.	n.a.	n.a.	n.a.
Boys														
Males 6-11 years	711	459	252	215	263	157	210	188	198	n.a.	n.a.	n.a.	n.a.	n.a.
Males 12-18 years	612	403	209	194	198	144	168	149	183	n.a.	n.a.	n.a.	n.a.	n.a.
Girls														
Females 6-11 years	734	466	268	239	233	180	195	197	218	n.a.	n.a.	n.a.	n.a.	n.a.
Females 12-18 years	521	331	190	165	168	124	144	130	153	n.a.	n.a.	n.a.	n.a.	n.a.
Non-Motorized tracks														
Households	474	303	171	185	126	111	89	124	168	n.a.	n.a.	n.a.	n.a.	n.a.
All individuals	2348	1501	847	890	633	555	431	603	856	n.a.	n.a.	n.a.	n.a.	n.a.
All members > 15 years old	1181	n.a.	n.a.	488	350	343	230	362	478	662	660	421	661	240
Children 0-5 years	369	228	141	153	103	78	78	80	146	n.a.	n.a.	n.a.	n.a.	n.a.
Boys														
Males 6-11 years	232	156	76	83	62	48	37	58	79	n.a.	n.a.	n.a.	n.a.	n.a.
Males 12-18 years	212	143	69	83	51	53	42	52	80	n.a.	n.a.	n.a.	n.a.	n.a.
Girls														
Females 6-11 years	222	143	79	95	67	31	42	49	85	n.a.	n.a.	n.a.	n.a.	n.a.
Females 12-18 years	172	98	74	55	50	52	32	57	58	n.a.	n.a.	n.a.	n.a.	n.a.

Notes: Heterogeneous categories are defined as follows. Education: Lower is for household head with primary or no education; Higher, with secondary or higher education. Village size: Small is for villages with less than 300 inhabitants; Medium, with more than 300 to 850 inhabitants; Large, with more than 850 inhabitants. Altitude: Low is for villages which are 2500 meters above sea level, Medium, between 2500 and 3400 meters above sea level, High, from more than 3400 to 5500 meters above sea level. Gender: if the individual is female or male. Age: Cohort 1 is for indivuduals younger than 25 years old; Cohort 2, from 26 to 50 years old; Cohort 3, older than 50.

Figure 1: Treated Roads – Geographical context

Figure 2: Treated Roads – Examples of Non-motorized tracks

Figure 3: Treated Roads – Examples of maintenance work

Figure 4: Treated Roads – Example of before and after