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The Poverty Impact of Rural Roads: Evidence from Bangladesh[1]

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Abstract

The rationale for public investment in rural roads is that households can better exploit agricultural and non-agricultural opportunities to employ labor and capital more efficiently. But significant knowledge gaps remain as to how opportunities provided by roads actually filter back into household outcomes and their distributional consequences. This paper examines the impacts of rural road projects using household-level panel data from Bangladesh. Rural road investments are found to reduce poverty significantly through higher agricultural production, higher wages, lower input and transportation costs, and higher output prices. Rural roads also lead to higher girls' and boys' schooling. Road investments are pro-poor, meaning the gains are proportionately higher for the poor than for the non-poor.

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1. Introduction

Improved roads and infrastructure can create opportunities for economic growth and poverty reduction through a range of mechanisms. Roads reduce transportation costs and the costs of consumption and production of goods and services (BIDS 2004). With easier access to markets and technology, improved roads expand farm and nonfarm production through increased availability of relevant inputs and lower input costs (Binswanger, Khandker, and Rosenzweig 1993; BIDS 2004; Levy 1996) as well as growth in rural enterprises (Lokshin and Yemtsov 2005). At the household level, road development contributes to higher productivity and demand for labor (Leinbach 1983; World Bank 2000), and improved education and health, including for women and girls (Bryceson and Howe 1993; Levy 1996). Road-related studies have also suggested that household consumption is likely to get a boost from increased household income, consequently reducing poverty (BIDS 2004; Fan, Hazell, and Thorat 2000).

It has been difficult to precisely quantify the benefits of roads, due to methodological constraints and data limitations. While transport investments have consistently represented 15-20 percent of the World Bank's lending portfolio[2], traditional estimates of the returns to such investments using the internal rate of return approach are generally so low that the investments do not appear viable. Such approaches have also been criticized for not being able to capture the true distributional benefits to the targeted population, particularly for the poor (van de Walle, 2002). Additional mechanisms also depend on the type of road improvement project.[3] These problems are compounded by the fact that the effects of rural roads are also long-term and thus cannot be captured through the use of cross-sectional data, particularly since unobserved fixed area characteristics influence the placement of road investment in a village or community (Binswanger, Khandker and Rosenzweig, 1993).

Since the timeline for the full impact of road improvements to take effect is extremely long, panel data as well as careful selection of control areas are essential in examining the exact impact of road

[2] Indeed, transport expenditure shares have remained fairly constant in this range between 1999 and 2004. Within South Asia, this share jumps to 26% of the Bank's lending in that region, as compared to 27% for East Asia and the Pacific, 21% for African countries, 14% for Latin America and the Caribbean, 7% for Middle East and North Africa, and 5% for Europe and Central Asia.

[3] Such projects, for example, can range from paving dirt roads to facilitation of two-way traffic, straightening, or upgrade to dual carriageway or motorway status.

development.[4] A few recent studies have used improved scientific approaches for data collection to estimate the impact of roads. Lokshin and Yemtsov (2005) demonstrate the economic benefits of roads and other infrastructural projects, using a propensity score-matched double difference method. van de Walle and Cratty (2005) also use the same method to estimate the impact of road development.[5] Finally, BIDS (2004) employs a panel household survey data of a quasi-experimental nature to assess the impacts of road improvement projects. However, the BIDS (2004) study employs bivariate analysis (e.g., a difference-in-difference technique), which is not ideal for this dataset given that the data are not of random experimentation.

Examining the distributional consequences of road development across different income levels has been an additional challenge, particularly on top of the need for a methodology that estimates effects over time and is able to control for unobserved heterogeneity. Aside from Lokshin and Yemtsov (2005), who also conduct their analysis on "poor" and "non-poor" samples to find that each group benefits differently from road development,[6] distributional effects of rural road investments have not been addressed extensively in the rural road literature, hampering assessments of the true breakdown of poverty reduction from infrastructural improvements.

Our paper, using the BIDS panel data, estimates the income-consumption benefits of road investment by controlling for both household- and community-level heterogeneity. Because poverty reduction is an overarching goal of policymakers and donors, we also assess the poverty reduction effect of road investment projects. We offer an empirical assessment on the impact and role of roads on economic behavior across different income groups by using a fixed-effects quantile estimation approach. Finally, we estimate the distribution of road benefits by gender, examining whether road investment benefits men and women as well as boys and girls differently.

The paper is organized as follows. Section 2 presents an econometric framework to estimate the impact of road development. Section 3 discusses the panel data, spanning two project samples, and their respective control villages. Section 4 discusses the results and presents the estimates of economic rates of return to road investment. Section 5 discusses the distribution of road benefits accrued by households across different percentiles of per capita consumption. Section 6 shows how the effect of road

[4] In previous studies, control areas have often been selected retroactively, contaminating the data selection with the econometrician's knowledge of actual outcomes, as well as reducing much of the data to less-than-reliable, retrospective information.
[5] The main intent of this paper, however, is to assess the fungibility of development aid between ex ante targeted and non-targeted areas, presenting road improvement as one type of aid initiative.
[6] They find that the non-poor benefited more from roads through improved medical emergency assistance and opportunities for non-agricultural employment; in contrast, the poor benefited more from female off-farm employment opportunities.

development on consumption can be translated into poverty impacts, and presents the poverty effects of road investment across different types of households. The concluding section summarizes the results.

2. Assessing benefits of road investment: An econometric framework

Approaches to road evaluation can be distinguished by how wide a net they cast in the search for road impacts. Traditional cost-benefit evaluation of roads has focused on the measurable outputs of road improvements, namely road length, number of beneficiaries, reduced travel times, accident risk, transportation costs, and direct environmental consequences.[7] These methods are often based on the assumption that lower agricultural input costs brought about by a road project lead to an increased demand for transport, and hence increased farm production.

However, the effects of road improvements spring more generally from improved access to, and functioning of, markets (especially for key production inputs and outputs) as well as key facilities such as education and healthcare. Where existing traffic is small or negligible, estimates of transport demand are only credible if a detailed analysis of the production system is carried out. The broadest evaluation would also look at induced changes in the household production and consumption mix as well as social and political participation, including diversification of income sources, changes in capital accumulation patterns, and interaction with government policy. Binswanger, Khandker, and Rosenzweig (1993) show how roads and other infrastructural investments affect the relationships between input and output markets, household income and employment, and government policy interventions; these in turn are shown to be governed jointly by agroclimatic endowments and agricultural opportunities. Similarly, van de Walle (2002) proposes a diversified, operational approach to measuring the benefits of rural roads, where social welfare from a road is maximized with respect to the total cost of all proposed links, with reliance on community authorities and local residents in project appraisal.[8]

Our paper uses an econometric approach to estimate the impacts of road investment on household poverty and other rural household outcomes. We allow these outcomes to be directly influenced by agroclimatic and other community endowments as well as agricultural opportunities of a village/community. These observed and unobserved characteristics affect input and output markets, public investments in infrastructure such as roads, and government pricing, interest, and public spending

[7] The choice among different types of infrastructural programs has traditionally been based on cost-benefit analysis; however, this approach often ignores the externalities that infrastructure programs also generate. In a study of transport in Bangladesh, for example, the benefit-cost ratio of paving a road was calculated as 1.19 based upon existing traffic, but increased to 3.48 when projected increases in traffic were accounted for (Ahmed and Hossain, 1990).
[8] Social welfare in van de Walle's study is a weighted sum of the average user's social equity value in a community targeted by a particular road link, multiplied by the per-person efficiency gain and the number of people in that community.

decisions. Household outcomes are influenced by input and output markets, infrastructure, and government policy. Likewise, infrastructural investments also affect these input and output markets. Finally, government policymaking in credit and other markets (for crops such as paddy, for example) can also influence household outcomes directly and indirectly via the input and output markets as well as infrastructural investments. Such complex interactions make it difficult to identify the precise role of rural road investment on income, productivity, poverty, and human capital investment.

The following semi-logarithmic reduced-form income equation, conditional on road investment, can be written as

$$\ln Y_{ij} = \alpha H_{ij} + \beta V_j + \gamma R_j + \mu_j + \eta_i + \varepsilon_{ij}^{y} \tag{1}$$

where Y_{ij} is the per capita income or consumption of i-th household living in j-th village, H is set of observed household characteristics, R is an indicator of the road development project at the village level, V represents observed non-road village-level characteristics, μ is unobserved village-specific heterogeneity, η represents unobserved household characteristics, and ε is a vector of idiosyncratic errors distributed across households. Similar equations can be written for other outcomes such as prices (P) and institutional infrastructure (I) that are impacted by roads. Since income or consumption is also a function of input and output prices (P) as well as institutional infrastructure (I), road investment has a direct effect on household consumption as well as an indirect effect through prices and institutions. Thus, the total effect of road investment might be decomposed as:

$$d\ln Y_{ij} / dR_j = \partial \ln Y_{ij} / \partial R_j + \sum_{k=1}^{K} (\partial \ln Y_{ijk} / \partial P_{jk})(\partial P_{jk} / \partial R_j) + \sum_{l=1}^{L} (\partial \ln Y_{ij} / \partial I_{jl})(\partial I_{jl} / \partial R_j)$$

where dY / dR is the total derivative of the effect of road investment on outcomes, $\partial Y / \partial R$ is the partial effect of road investment, for example, given prices and other factors, $\partial Y / \partial P$ is the partial effect of prices and other intervening factors on outcomes of interest, and $\partial P / \partial R$ is the partial effect of local road conditions on price and similar intervening factors. Similarly, one can obtain partial effects through changes in the institutional factors (I). The changes are measured at i-th household in village j, for the k-th type of intervening price factors, and l-th type of institutional factors.

As the road intervention is a community-level variable, consider the community impact of road investment. In this case, one would assemble a sample of communities with varying levels of road improvements and regress the welfare outcome of interest on the road improvement variable. Several factors complicate this exercise, however. The most important concern is that community-level characteristics that are often unobserved to the researcher, such as agro-climatic endowments and agricultural opportunities, may affect both the placement of the road improvement and the welfare outcome of interest.

The standard solution for this unobserved heterogeneity bias is to assume that it is not time-varying and, therefore, can be controlled in a panel data regression with fixed community effects. Clearly, if this strategy is to work, there must be some variation in road status over time in the sample communities. The simplest way to proceed is if the data allow a clean division between periods when the road program is in effect (t=1) and when it is not (t=0), where the program villages are selected randomly. This allows a straightforward before-and-after comparison of welfare outcomes between the program and non-program villages and is the basis of the well-known difference-in-difference estimate, where the effect of the policy is estimated by the difference in the relevant outcome for program and non-program areas across the two periods.

Such estimates usually are not possible, however, because the decomposition into pre- and post-treatment years is often not available and/or the villages are not selected at random. In the absence of random selection, a difference-in-difference estimate can be constructed with a set of controls for other factors, including time. Also, community-level fixed-effects cannot resolve the bias if household unobserved heterogeneity influences how individual households accrue benefits from road investment. In this case, using household-level fixed-effects rather than community fixed-effects is the appropriate solution. Thus, a household-level panel would be required to resolve both the household and community heterogeneity that affect the estimates of the road investment. This can be done after introducing time-variation in the outcomes and explanatory variables including time in the estimation. Consider the following revised equation of (1):

$$\ln Y_{ijt} = \alpha H_{ijt} + \beta V_{jt} + \gamma R_{jt} + \mu_j + \eta_i + \varepsilon^y_{ijt} \tag{2}$$

Taking the difference over the two-year period of study, one would obtain the following difference equation, where the sources of endogeneity (i.e. the unobserved village and household characteristics, and assuming that these characteristics do not change over time) are dropped out. In this case, the simple OLS can be applied to the following differenced equation to estimate unbiased effect of road development (γ):

$$\Delta \ln Y_{ij} = \alpha \Delta H_{ij} + \beta \Delta V_j + \gamma \Delta R_j + \Delta \varepsilon_{ij} \tag{3}$$

3. Data characteristics

The panel data used in this paper, collected by the Bangladesh Institute of Development Studies (BIDS), are based on household and community surveys prior to, and following, implementation of two World Bank funded projects that allowed identification of control and treatment villages. The data are used here to calculate economic returns to roads and its impact on poverty, and overcome some of the pitfalls of past road evaluations that have relied mostly on cross-sectional household survey data. The datasets have a true before/after and with/without structure and are reasonably large, allowing a study of household-level impacts, especially with reference to households above and below the poverty line. They cover not just the standard road project outputs such as trip frequency and duration, but also key outcomes (consumption, employment) and a broad range of market interactions.

The data collection was financed under the World Bank-funded projects and conducted by BIDS as part of the government's efforts to analyze and quantify both the short-term and long-term impacts of rural road improvements. The first survey covered the Rural Roads and Markets Improvement and Maintenance Project – I (RRMIMP-I), which was a component of the Rural Development Project-7 (RDP-7). For the purposes of this paper, we will define this project as RDP. The RDP initiative entailed improvement of 47 FRBs to bitumen surfaced standard, upgrading of 65 secondary markets and construction of 3700 meters of culverts and small bridges. Its physical works were completed during 1995-96. The first phase of the survey collected benchmark information in the study area prior to the project work, and the second phase collected the same information during the first half of 2000. The next phase included 24 project and 18 control villages, and 1,260 households.

The second survey studied the Rural Roads and Markets Improvement and Maintenance Project – II (RRMIMP-II), which included improvement of 574 kilometers of FRBs to bitumen-surfaced standard, construction of 1,900 meters of culverts, 1,750 meters of bridges and 2,200 meters of small drainage structures on rural roads, and improvement of 136 Growth Center Markets and 41 Ghats (river jetties for boats and vessels). The first phase of the RRMIMP survey collected benchmark information on 872 households from 18 villages during May-September 1997, and the second phase covered the same households between August, 2000-February, 2001. Both projects were funded by the World Bank as part of its effort to promote rural infrastructural development, and, consequently, rural growth and poverty reduction.

In both project and control road areas, one roadside village was selected for each road project. The selected roadside villages indicate the immediate influence areas of road intervention. In addition, one remote village was selected for each of the sample roads to assess the decay effects of road development. The remote villages were similar to the roadside villages and were chosen such that they were at least 2 kilometers away from the study or any other paved road. About 50 households were selected from each study village using a stratified random sampling procedure. Both surveys collected a variety of information on general household characteristics, education, healthcare treatment, wage and self-employment, credit activities, assets, income, consumption, marriage, and fertility. Additionally, information on community characteristics and transportation was also collected.[9]

The outcomes of interest include variables such as household transport expenses, fertilizer price, male agricultural wage, agricultural output and price indices, and household outcomes such as per capita expenditure, male and female labor supply, and boys' and girls' schooling.

Road improvements affect the household through changes in three mechanisms: (1) transportation costs as well as input and output prices; (2) labor supply, as well as farm and non-farm production; and (3) household outcomes such as earnings, consumption, and schooling. In our results, we first examine the impact of road development on transport costs. Since there were very few households that reported transportation costs for production, we therefore focus on household transport costs that include costs incurred while going to such places as the market center, school, and nearest health facility.

Next, we consider input and output prices such as fertilizer (urea) price, daily agricultural wage for men, as well as agricultural output and price indices.[10] For the latter indices, we use the Laspeyres quantity and price indices for agricultural production. In constructing the Laspeyres indices, let *k* stand for commodity, *i* for household, and *t*={0,1} for year before and after the project. Defining the base year (*t*=0) price for each commodity as P_{k0}, and the base year quantity of each commodity produced by the household as Q_{k0}, then $Q_i = \frac{\sum_k Q_{k1} P_{k0}}{\sum_k Q_{k0} P_{k0}}$ is the Laspeyres quantity index for household *i*, and $P_i = \frac{\sum_k Q_{k0} P_{k1}}{\sum_k Q_{k0} P_{k0}}$ is the Laspeyres price index for household *i.*

In both the RDP and RRMIMP data, the agricultural commodities entering the indices were potato, wheat, as well as high-yielding variety (HYV) Boro paddy, HYV Aman, and local and HYV Aus. Since the study covers only a base and a follow-up year, the base year indices for both aggregate price and output indices are equal to one. Note that all the values are in real terms, adjusted by the consumer price index of the base year of each survey.

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[9] For the RRMIMP study, not all villages were visited again in the follow-up survey. A total of 7 out of 10 project villages and 2 out of 4 control villages were covered in the RRMIMP survey because (1) the roads were either not completed, or (2) control villages lost their control status as a paved road had been constructed within two kilometers of the village (thereby violating the basic assumption of being a control in the study).

[10] Note that similar to aggregate crop output and price indices, we could calculate an index for fertilizer prices consisting of a number of fertilizers. However, there are a few observations for types of fertilizer such as potash. So the fertilizer price here refers to the price of urea.

Finally, we consider household and individual outcomes such as annual total per capita expenditure, male and female labor supply, and boys' and girls' schooling. Labor supply is measured as the total number of hours in the last month worked by all men and women in household, and schooling is the percentage of school-aged boys and girls (5-17 years of age) who attended school in the year of the survey. The estimates are done separately for each project.

4. Estimates of the returns to road pavement

Our primary approach in this paper is to estimate equation (3) by household fixed-effects method for all outcomes of interest, namely the transport costs of consumption, average fertilizer price, men's agricultural wage, aggregate crop output and price indices, household per capita expenditure, male and female labor supply, and boys' and girls' school participation rates. For the purpose of comparison with the fixed-effects estimates, we first present double difference-in-difference treatment effects for these outcomes across the project and control villages (Table 1). The percentage change in each outcome between year 1 and year 0 was calculated separately for project and control villages; the difference across the two groups was then calculated and tested for significance using a standard t-test. Clearly, looking at Table 1, most of the estimates are not statistically significant, with the exception of significant positive impacts for household transport costs, fertilizer price, and household per capita expenditure in RDP villages. Does this suggest that rural road investment has no significant impact on household welfare? Note that these estimates are only valid if the data are based on a randomized study or experimental design. As our study is a quasi-experimental survey design, such a difference-in-difference technique yields biased estimates. The bias reflects the difference between an experiment in which both observable and unobservable attributes have the same expectation in both treatment and control villages, and a quasi-experiment in which they do not. This can be shown as follows.

From equation (3), which takes the form of a difference over time, we write the difference-in-difference equation for the treated villages (T) and control villages (C) for the two-period case as: [11]

$$[\Delta \ln Y_{ij}^{T} - \Delta \ln Y_{ij}^{C}] = \alpha[\Delta H_{ij}^{T} - \Delta H_{ij}^{C}] + \beta[\Delta V^{T}{}_{j} - \Delta V_{j}^{C}] + \gamma$$

In theory, if the data are from a pure randomized experiment, the expected values of the bracketed terms on the right-hand-side in the above expression collapse to zero, leaving only the road impact coefficient, γ, which is then an estimate of the road impact. However, if the data are not from an experiment, then taking the expectation does not similarly collapse the right-hand-side bracketed expressions, in which case the estimate of γ will be biased upward or downward depending on how the

[11] We implicitly assume the road status does not change in controlled villages, while the difference takes the value 1 for the treated villages.

expressions on the right-hand-side turn out after the differences are performed. So in the case of our quasi-experimental survey design, the differences between the time-varying observed variables such as *H* and *V* need to be controlled for in the regression; these results, shown below, are substantially different from those of the difference-in-difference technique.

The estimating equations in the household fixed-effects estimation are in semi-logarithmic form for all outcomes except for the schooling variables, where schooling is measured by the percentage of school-aged children who are in school for each household. The intervening policy variable of interest is a road investment indicator variable, equal to 1 for road project villages in year 1, and 0 otherwise (i.e. for year 0 and control villages). The road project villages include both roadside and off-road villages, while the control villages include both nearby and remote villages from the road.[12] Thus, the coefficient γ from equation (3) measures the proportionate change in the outcome of interest (such household per capita consumption) from paving a road. That is, it represents the returns to public investment in roads in terms of paving an earthen road; the control of a paved road is having an earthen road. Note therefore that we are *not* comparing in this paper the impact of having a road versus not having a road of any type.

The effect of having a paved versus earthen road can be shown by differentiating (3) with respect to *R*, where *R=1* for project villages and γ is estimated from equation (3):

$$(1/Y_{ijt})\partial\Delta Y_{ijt}/\partial\Delta R_{jt} = \gamma$$

The main estimation results for the road impact are presented in Table 2. Elasticities for the road impacts are presented in Table 3 (non-price outcomes), as well as net returns for the same outcomes (controlling for prices).

As the road coefficient measures the returns to road investment, we see a high return to investment in road pavement.[13] First consider the transport cost savings (Table 2). Households experience 36 percent lower transportation costs in RDP villages, and 38 percent lower costs in RRMIMP villages, because of a road development project.[14] The returns to road investment in terms of transport cost savings are quite substantial.

Households benefit not only in terms of transportation cost savings but also in terms of gains realized through higher prices of agricultural production, lower fertilizer prices, higher agricultural wages,

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[12] In estimations where we allow the road effect to vary by the distance of the household from the road, note that the distance of the remote village from either the paved or unpaved road is not far enough to make another village dummy called villages without any road. Nonetheless, we interacted the distance with road status in the regression to see if the returns do vary by distance.

[13] We estimated two models for each outcome equation. Table 2 represents the direct estimates with no interaction; in a separate estimation we also included an interaction term between the project indicator and household distance to a paved road. Results for this second round of estimations are available upon request, as are the results for the other covariates. We discuss the relevance of the project*distance interaction in Section 5.

[14] Transportation costs, however, may not necessarily go down as a result of better roads; they may also increase from increased transportation frequency due to better roads.

and higher value of agricultural production. Table 2 also displays the estimates of road returns for input and output prices as well as agricultural productivity. Fertilizer prices are 5 percent lower in RDP and RRMIMP project villages, and real agricultural wages for men in RDP project villages are 27 percent higher than in control villages. The aggregate price index of crops is 5 percent higher and the aggregate crop output index is 39 percent higher in RDP project villages because of rural road development; similar returns accrue in RRMIMP project villages where the aggregate crop price and crop output indices are 4 and 30 percent higher, respectively, due to road investment.[15]

Interestingly, when computing the elasticity of the agricultural output index with respect to the road project (Table 3), we find that the elasticity is 0.27 for RDP households and 0.23 for RRMIMP households.[16] These figures are very close to the road-aggregate output elasticity (0.21) obtained by Binswanger, Khandker and Rosenzweig (1993), where they use district-level data in India to examine the linkages between infrastructure, financial institutions, and aggregate output in India.[17] Road development thus not only helps farmers due to higher crop production and prices, and lower prices of inputs such as fertilizer, but also benefits households via higher demand for labor, thereby raising the real agricultural wage rate of male labor (at least in RDP villages) up to 27 percent.[18]

Higher wages and higher demand for labor can raise family labor supply. However, the net demand for family labor also depends on the negative effect of higher income on labor supply (thus, causing higher demand for leisure), which may reduce family labor supply. Nevertheless, as Table 2 shows, male labor supply increases by 49 percent and female labor by 51 percent in RDP villages because of a road development project. There are no similar statistically significant gains in RRMIMP villages for family labor supply.[19] The results do suggest that gains from both input and output markets due to road investment are substantial for rural households.

The overall economic returns to road development can be measured by summing over the gains through transportation cost savings, higher output and lower input market prices, and higher productivity. While there is no an easy way we can summarize these benefits in one return estimate, such gains

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[15] Jacoby (2000) predicts that land prices can also rise from better transport, using household distance from the market center as an indicator of transport quality in a household survey from Nepal. More specifically, he finds that land values rise by about 2% if household distance to the nearest market center falls by 10%.

[16] In RDP, about 68% of the villages were project villages, and about 75% of villages in the RRMIMP sample were targeted by the project.

[17] Normally, the effects are higher at the household level, and thus our findings are consistent with previous results for road development in comparable areas.

[18] This is consistent with results from Jacoby (2000) as well, who finds that wages are also lower in remote rural areas of Nepal. We also found rural electrification to have a significant negative impact on fertilizer price and increase agricultural real wage, aggregate crop price, and productivity. Interestingly, the returns to rural electrification are higher than those of road investment for some of the outcomes considered. The extended fixed effects results are available upon request.

[19] Lokshin and Yemtsov (2005) also find in their study of Georgia that road projects do not seem to significantly impact overall male and female labor supply in treatment as compared to control areas.

ultimately translate into higher household expenditure (both food and non-food), as well as human capital investment (in children, for example). The results show that the returns to road investment for household per capita expenditure are about 11 percent in the RDP and RRMIMP villages, a substantial gain in terms of higher consumption and income for rural households. This means that rural households in villages targeted by the road development project have on average an 11 percent higher consumption per capita per year.[20]

In addition to household consumption, average school participation among boys is about 20 percent higher in RDP villages, not controlling for proximity to the project road; road development also has a positive but barely significant impact on girls' schooling in the same sample. In the RRMIMP data, the project effect is fairly similar for boys and girls, leading to a 14 percent increase in schooling. Indeed, in our results only the project indicator seems to have had any significant impact on schooling in the RRMIMP sample. Higher school attendance of boys and girls are therefore some of social returns due to road investment; additional social returns to be assessed from road investment include returns to health and nutrition, which are not pursued in this paper.

Finally, as a robustness check, we estimate the non-price outcomes (HH per capita expenditure, Laspeyres quantity index, boys' and girls' schooling, as well as male and female labor supply) on the same set of explanatory variables as well as the price variables discussed above (men's agricultural wage, fertilizer price, and the agricultural price index facing the household). The net returns are presented in table 3, and reflect the returns if we held the structural model (taking prices as exogenous) to be correct. Overall, the estimated effects are slightly higher than our original returns, except for the aggregate output index where the return is lower. The results are fairly robust and in almost all cases retain significance with our earlier estimates.[21]

5. Distribution of benefits of road investment

While the above analysis allows for a broad range of controls in road project evaluation to generate average returns to road investment, it still imposes a single response coefficient γ on all households and communities conditional on other factors, such as the household distance to a paved road. The estimates of the earlier section are based on the assumption that distance does not matter in terms of gains from a road development project. This may not be the case, however. That is, households located in a roadside village may benefit more from road investment than households living away from a paved road. Testing this hypothesis requires differences in household distance from road, which is very minimal

[20] The returns to consumption seem to be higher for rural electrification than rural road investment (as high as 23 percent for electrification as compared to 11 percent for rural road development).
[21] The only exceptions are boys' schooling and female labor in the RDP sample.

by the fact that remote villages in both project and control road areas are selected on an almost equal distance basis, at least more so in RDP than RRMIMP areas. Yet when we have interacted road distance and its square with the road status variable, we find that not surprisingly, except for boys' schooling, the distance to a developed road does not matter at all in both RDP and RRMIMP villages for any outcome considered. In the case of boys' schooling, the effect of road development diminishes with the distance at an increasing rate.[22]

Gains from a road development project may also vary by household income status. In this paper, we examine the distributional issue of gains from road investment using quantile regression analysis. It is potentially important to investigate changes in outcomes observed at different points in the income or consumption distribution. Simply investigating changes in the mean may not be sufficient when the entire shape of the distribution changes significantly (Buchinsky, 1998). Studying the distributional impact also sheds light on political constraints on the allocation of infrastructural investment (Jacoby, 2000).

Following the model proposed by Koenker and Bassett (1978), assume y_i, $i = 1,...n$, is a sample of observations on the log consumption, and that x_i is a *K* x 1 vector (comprising the project (*R*), household (*H*), and village (*V*) level characteristics controlled on the right-hand side of equation (3)). The quantile regression model can be expressed as:

$$y_i = x_i^{'}\beta_\tau + \varepsilon_{\tau i},\ Q_\tau(y_i|x_i) = x_i^{'}\beta_\tau,\ \tau \in (0,1) \tag{4}$$

where $Q_\tau(y_i|x_i)$ denotes the quantile τ of log per capita expenditure conditional on the vector of covariates (*x*). In general, the τ-th sample quantile of *y* solves:

$$\min_\beta \frac{1}{n}\left[\sum_{i:y_i \geq x_i^{'}\beta} \tau\left|y_i - x_i^{'}\beta_\tau\right| + \sum_{i:y_i < x_i^{'}\beta}(1-\tau)\left|y_i - x_i^{'}\beta_\tau\right|\right] \tag{5}$$

Parameters using the quantile regression approach are estimated semi-parametrically by minimizing the sum of weighted absolute deviations, which fits medians to a linear function of covariates, and can be performed using linear programming methods (Buchinsky, 1998). Specifically, the quantile's coefficients can be interpreted as the partial derivative of the conditional quantile of *Y* with respect to one of the regressors such as a road development status variable.

One potential obstacle to applying quantile estimation in this paper is the difficulty in extending fixed-effects methods to quantile estimation. Unlike Gaussian models, quantiles are not linear operators

[22] Results interacting the road variable with household distance are not shown here and available upon request.

and thus differencing the dependent and independent variables will not in general be equal to the difference in the conditional quantiles:[23]

$$Q_\tau(y_{i2} - y_{i1}|x_i) \neq Q_\tau(y_{i2}|x_i) - Q_\tau(y_{i1}|x_i) \tag{6}$$

To overcome this, Koenker (2004) proposes a model for fixed-effects quantile regression where the unobserved fixed effect is a location shift on the distribution of the dependent variable; i.e. it is the same for each value of τ. Abrevaya and Dahl (2005) take this approach further and characterize the fixed effect using Chamberlain's (1982) unobserved effects model. In this paper, we implement Abrevaya and Dahl's procedure; following Chamberlain's model, we specify η_i (from equation (2)) as follows:

$$\eta_i = \phi + x_{i1}^{'}\lambda_1 + x_{i2}^{'}\lambda_2 + \omega_i \tag{7}$$

where ϕ is a scalar and ω_i is an error term uncorrelated with x_{it}, t=1,2. Given $y_{it} = x_{it}^{'}\beta + \eta_i + \varepsilon_{it}$, substituting equation (7) yields the following equations for periods 1 and 2:[24]

$$y_{i1} = \phi + x_{i1}^{'}(\beta + \lambda_1) + x_{i2}^{'}\lambda_2 + \omega_i + \varepsilon_{i1} \tag{8a}$$

$$y_{i2} = \phi + x_{i1}^{'}\lambda_1 + x_{i2}^{'}(\beta + \lambda_2) + \omega_i + \varepsilon_{i2} \tag{8b}$$

If we assume all of the error disturbances (ω_i, ε_{i1}, ε_{i2}) are independent of x_{it}, the conditional quantiles also take the analogous forms:

$$Q_\tau(y_{i1}|x_i) = \phi_\tau^1 + x_{i1}^{'}(\beta_\tau + \lambda_\tau^1) + x_{i2}^{'}\lambda_\tau^2 \tag{9a}$$

$$Q_\tau(y_{i2}|x_i) = \phi_\tau^2 + x_{i1}^{'}\lambda_\tau^1 + x_{i2}^{'}(\beta + \lambda_\tau^2) \tag{9b}$$

where ϕ_τ^1 and ϕ_τ^2 are location shifts in the conditional quantiles for each year, λ_τ^1 is the unobserved effect λ_1 for the τ^{th} quantile, and λ_τ^2 is the unobserved effect λ_2 for the τ^{th} quantile. Without the independence assumption, the conditional quantile functions would in most cases not assume a linear form; this is also true for most cross-sectional quantile estimations, even if the data-generating process is linear in the covariates. Based on equations (8a) and (8b), we run a pooled linear quantile regression where the observations corresponding to the same household are stacked as a pair. Specifically, a quantile regression (using the estimator for the τ^{th} quantile) would be run using:

[23] For simplicity, we have suppressed the village subscript j in this section.
[24] As mentioned before, the household fixed effect η subsumes the village fixed effect included in equation (2).

$$\begin{bmatrix} y_{11} \\ y_{12} \\ \cdots \\ y_{21} \\ y_{22} \\ \cdots \\ \vdots \\ \cdots \\ y_{N1} \\ y_{N2} \end{bmatrix} = \begin{bmatrix} 1 & 0 & x'_{11} & x'_{11} & x'_{12} \\ 1 & 1 & x'_{12} & x'_{11} & x'_{12} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & 0 & x'_{21} & x'_{21} & x'_{22} \\ 1 & 1 & x'_{22} & x'_{21} & x'_{22} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ & & \vdots & & \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & 0 & x'_{N1} & x'_{N1} & x'_{N2} \\ 1 & 1 & x'_{N2} & x'_{N1} & x'_{N2} \end{bmatrix} \begin{bmatrix} \phi \\ \pi \\ \beta \\ \lambda_1 \\ \lambda_2 \end{bmatrix} + \begin{bmatrix} \upsilon_{11} \\ \upsilon_{12} \\ \cdots \\ \upsilon_{21} \\ \upsilon_{22} \\ \cdots \\ \vdots \\ \cdots \\ \upsilon_{N1} \\ \upsilon_{N2} \end{bmatrix} \quad (10)$$

Along with the parameters $(\phi, \beta, \lambda_1, \lambda_2)$, the parameter π is also estimated (representing the "year effect"). Next, since observations are clustered and hence not independent, standard errors for the estimators are obtained via a bootstrap method that repeatedly draws (with replacement) a household from the sample of households, including both observations on that household (Abrevaya and Dahl (2005)).

Table 2 also presents the panel quantile estimates *(β)* for the distributional effects of the road project on log per capita annual expenditure.[25] There are five percentiles, 0.15, 0.25, 0.50, 0.75, and 0.85. For the observed effect *β,* the road impact is significant and positive for all quantiles in the RDP sample, with effects varying between 13 and 16 percent.[26] For RRMIMP, though, the road impact continues to dominate for the poor, with only a 21 percent return for the 15th percentile of the sample. The results indicate that gains from road investment do not necessarily accrue only to relatively wealthier households.[27] Furthermore, particularly for the RRMIMP sample, the benefits of road investments are focused primarily among the very poor.

6. Poverty effects of rural road investment

Given that the consumption gains from road investment are substantial and that such improvements are proportionately higher for lower rather than higher income strata, we now attempt to determine how much poverty reduction is possible with rural road investment. Before we discuss the poverty impacts of road investment, let us examine the general trend in the poverty status of rural households in project and

[25] Like the fixed-effects method, the quantile regression also includes other explanatory variables as reported in Table 2.
[26] Results for the unobserved effects λ_1 and λ_2 are available upon request.
[27] Electrification also helps the lower income groups more than higher income groups. The findings do suggest that both road development and electrification are pro-poor policies towards increasing income and productivity in rural areas of Bangladesh. Detailed quantile regression results are available upon request.

control villages surveyed over the years before and after the road projects were implemented. Poverty in this paper is measured by the daily consumption expenditure needed for an individual to be above the poverty line, where such per capita consumption expenditure is a function of food calorie and other nutritional requirements set by Food and Agriculture Organization (FAO) standards. We define moderate poverty as per capita consumption expenditure required to meet the FAO guidelines of a daily dietary requirement of 2,112 calories, as well as non-food expenditure that is approximately 30 percent of this food expenditure.[28] Similarly, we establish an extreme poverty line using consumption expenditure required to meet a lower calorie requirement of 1,739 calories, with non-food expenditure again about 30 percent of food expenditure. The extreme poverty line is usually 80 percent below the moderate poverty line; the estimated moderate poverty line was Tk.4698 in RRMIMP villages in 2001 and Tk.3984 in RDP villages in 2000.

Table 4 presents the distribution of households across project and control villages over the two survey periods based on the poverty line. In RDP areas, both moderate and extreme poverty declined in project villages, surprisingly without any change in either measure of poverty in control villages. In RDP project villages, about 57 percent of households were moderately poor before the road was paved, while some 48 percent of households were poor after the road was paved, representing a 9 percent reduction of moderate poverty. About a 6 percent reduction of extreme poverty (from 35 percent to 29 percent) was registered in RDP project villages after road was paved. Interestingly, for control villages there was no significant change in poverty over time. In the RRMIMP survey, poverty fell in both project and control villages. Moderate poverty dropped by about 11 percent in project villages, compared to a 12 percent reduction in control villages. On the other hand, an approximate 17 percent reduction of extreme poverty registered in project road villages, against 13 percent reduction in control villages.

Since poverty reduction in project villages is caused by multiple factors, we sought to determine how much of the poverty reduction in project villages was actually due to road improvement. Based on the fixed effects estimates of the returns to consumption due to road improvement (Table 2), we calculated the predicted gains in per capita consumption due to road improvement and added it to the actual per capita consumption level before the project was implemented.[29] The results are presented in Table 5. With the predicted consumption level, we then re-calculated the incidence of poverty in project villages. For RDP project villages, we find that the predicted incidence of moderate poverty is 52

[28] This percentage varied slightly, depending on the mean share of nonfood to food expenditure for project and control villages in the two samples.

[29] The returns to road improvement in household per capita consumption were 11 percent each in both RDP and RRMIMP villages. These returns were, however, realized after the project was implemented. The average time to project completion in both RDP and RRMIMP villages was as high as 2 years, although the survey period covers a span of 4 years in both areas. Therefore, the consumption returns to road investment need to be adjusted for this factor. The multiplication factor for road-related consumption gains we use, therefore, is one-half of 11 percent.

percent, compared to an actual poverty headcount of 57 percent before the road project was implemented and 48 percent after the road was completed. Thus, the change in poverty incidence from 57 percent to 52 percent was due to road improvement and from 52 percent to 48 percent due to other factors. Similarly, predicted extreme poverty is 30 percent, compared to an actual extreme poverty rate of 35 percent in the base year and 29 percent in the year after the project completion. In other words, a road improvement project in RDP project villages has led to an approximate 5 percent reduction of moderate and extreme poverty; p-values for these reductions are also presented in Table 5, and the differences are statistically significant.

In RRMIMP project villages, improved roads have also modestly reduced the incidence of poverty. Predicted moderate poverty is 46 percent, against an actual poverty headcount of 52 percent in year 0, suggesting a 6 percent reduction in moderate poverty. Similarly, the predicted extreme poverty rate is 31 percent against an actual poverty rate of 38 percent in the base year, indicating an approximate 7 percent gain in extreme poverty reduction in RRMIMP villages that could be attributed to road improvement.[30] Again, the predicted reductions are statistically significant. Thus, overall we see a fairly substantial reduction in moderate and extreme poverty due to rural road development across both samples, with a slightly steeper decline in RRMIMP project villages.

7. Conclusions

Road investment constitutes a major portfolio of public investment in rural areas, reinforcing the notion that rural income and productivity growth depend critically on roads and other public investments. Yet the traditional way of evaluating a rural road project has underestimated the impact of road projects through the use of transport surveys that simply determine the extent of transport cost savings for a road by the likely road users. While this way of estimating the project's rate of return (the so-called internal rate of return) is a standard practice, roads are important public investments that have both short- and long-term effects that go beyond transport cost savings. Transport cost savings reflect the short-run and immediate impact of road investment; roads, however, also have short- and long-term effects on employment, income, and productivity as well as investment in the human capital of children. Furthermore, these household effects can be both direct and indirect results of road investment, and often cannot be captured through the traditional transport surveys. Household surveys are necessary to capture the full treatment effects of road development, and in particular, panel data for project and comparable

[30] These estimates are likely to be an upper estimate, because of the assumption that each household on average gained the same way. To the extent that gains accrued to households vary by household income distribution, the predicted impact of poverty could be lower than the reported estimates.

control villages over time are necessary to capture changes in road conditions before and after the road investment.

This paper uses household-level panel data collected by BIDS with reference to two projects — the Rural Development Project (RDP) and the Rural Roads and Markets Improvement and Maintenance Project (RRMIMP) — supported by the World Bank. The data provide information on both project and control villages at the household level. We use a household fixed-effects technique to estimate the returns to road investment in terms of its impact on household per capita consumption (a measure of household welfare), labor supply, school participation rate of boys and girls among school age children, aggregate crop output and price indices, agricultural wages, fertilizer prices, and household transport expenses. We find that households do benefit in a variety of ways from road investment by paving an earthen road.

The results suggest that the savings of household transport expenses are quite substantial, averaging about 36 percent in RDP villages and 38 percent in RRMIMP villages. Road improvement also has a significant impact on men's agricultural wage (increases by 27 percent in RDP villages), fertilizer price (falls by about 5 percent in RDP and RRMIMP areas) and aggregate crop indices (price indices increase by about 4 percent in both project samples, while output indices rise significantly by about 38 percent in RDP and 30 percent in RRMIMP project villages). The road effects are substantial for adult labor supply in RDP project villages, and schooling of both boys and girls. The overall effect of road improvement on household per capita annual consumption is also 11 percent in both project areas.

The distribution of benefits is not, however, independent of household resource endowments and location specific factors. We employ panel quantile regression techniques that show that while in RDP, project returns for per capita consumption average about 12-16 percent across different per capita expenditure quantiles (with the highest return for households in the 50th percentile), in RRMIMP the consumption benefits from rural road investments accrue largely to households in the 15th percentile of the overall distribution. Thus, rural road projects do benefit the poor, and disproportionately so in the RRMIMP sample.

The overall poverty effect of road improvement projects has been significant. In RDP villages, we find a poverty reduction (moderate and extreme) due to road improvements of about 5 percent; with an approximate 6-7 percent poverty reduction in RRMIMP project villages. Thus, had the duration of road pavement taken about 5 years, we could argue that each year poverty fell by about 1 percent, solely due to rural road improvements.

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Table 1. Double difference-in-difference estimates for outcomes

	RDP				RRMIMP			
	(A)	(B)			(A)	(B)		
	$\left(\frac{Y_{i2}-Y_{i1}}{Y_{i1}}\right)$: Project	$\left(\frac{Y_{i2}-Y_{i1}}{Y_{i1}}\right)$: Control	(A) -(B)	p-value	$\left(\frac{Y_{i2}-Y_{i1}}{Y_{i1}}\right)$: Project	$\left(\frac{Y_{i2}-Y_{i1}}{Y_{i1}}\right)$: Control	(A) -(B)	p-value
Outcomes								
Household daily transport costs	-0.86 (0.01)	-0.68 (0.05)	-0.18 (0.05)	0.00	-0.53 (0.11)	-0.55 (0.10)	0.02 (0.15)	0.89
Input price: fertilizer (taka/kg)	-0.19 (0.006)	-0.15 (0.005)	-0.05 (0.008)	0.00	-0.15 (0.003)	-0.16 (0.003)	0.001 (0.005)	0.69
Daily agricultural wage (men)	0.04 (0.01)	0.07 (0.01)	0.03 (0.01)	0.01	-0.07 (0.01)	-0.09 (0.01)	0.02 (0.01)	0.17
Laspeyres Price Index	-0.19 (0.002)	-0.19 (0.004)	0.003 (0.005)	0.53	0.055 (0.006)	0.056 (0.006)	0.001 (0.01)	0.84
Laspeyres Quantity Index	1.74 (0.26)	1.35 (0.17)	0.39 (0.30)	0.19	0.48 (0.11)	0.41 (0.10)	0.07 (0.16)	0.68
HH per capita expenditure	0.13 (0.03)	0.05 (0.02)	0.08 (0.03)	0.01	0.07 (0.02)	0.09 (0.02)	-0.02 (0.03)	0.55
Boys' schooling, 5-17 years: HH average	-0.10 (0.03)	-0.16 (0.02)	0.06 (0.04)	0.12	-0.12 (0.04)	-0.19 (0.03)	0.08 (0.05)	0.14
Girls' schooling, 5-17 years: HH average	0.03 (0.03)	-0.03 (0.02)	0.06 (0.04)	0.12	0.02 (0.03)	0.01 (0.03)	0.01 (0.04)	0.83
Monthly employment hours: adult men	0.13 (0.04)	0.14 (0.03)	-0.01 (0.05)	0.92	0.37 (0.06)	0.19 (0.04)	0.17 (0.07)	0.01
Monthly employment hours: adult women	5.44 (0.83)	4.58 (0.56)	0.86 (0.98)	0.38	3.28 (0.59)	2.36 (0.60)	0.91 (0.88)	0.30

Table 2. Effect of road development: summary of fixed-effects and panel quantile results (β)

	RDP	RRMIMP
Fixed-effects results		
Household daily transport costs	-0.363 *** (0.116)	-0.380 ** (0.150)
Input price: fertilizer (taka/kg)	-0.045 * (0.024)	-0.047 *** (0.011)
Daily agricultural wage (men)	0.270 *** (0.027)	0.019 (0.032)
Laspeyres Price Index	0.050 *** (0.008)	0.035 *** (0.009)
Laspeyres Quantity Index	0.386 *** (0.111)	0.304 *** (0.102)
Monthly employment hours: adult men	0.4915 * (0.2790)	0.3617 (0.3685)
Monthly employment hours: adult women	0.5069 * (0.2865)	0.0158 (0.2897)
HH per capita expenditure	0.1124 * (0.0581)	0.1066 * (0.0630)
Boys' schooling, 5-17 years: HH average	0.198 * (0.120)	0.201 * (0.104)
Girls' schooling, 5-17 years: HH average	0.147 (0.118)	0.21 ** (0.093)
Panel quantile results: Quantile		
0.15	0.126 *** (0.045)	0.208 * (0.126)
0.25	0.144 *** (0.047)	0.184 (0.141)
0.50	0.155 *** (0.044)	0.033 (0.107)
0.75	0.127 *** (0.047)	-0.041 (0.161)
0.85	0.144 *** (0.059)	-0.169 (0.241)

Notes:

(a) Estimates for [project*(distance from selected road)] and [project*(distance from selected road)^2] were not presented since overall they seemed to have very little significant impact.
(b) Transportation expenses do not include transportation costs for production.
(c) Agricultural crops that entered the index include potato and wheat, as well as hyv boro, hyv aman, hyv aus, and local aus paddy.
(d) All estimations include district*year interactions; panel quantile estimates include village dummies as well.
(e) All estimations in semi-log form.
(f) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(g) In the panel quantile estimation, parameters estimated with bootstrapped standard errors, drawing pairs of observations to construct the bootstrap sample.

Table 3. Elasticities and net effects of road development: fixed-effects model

	Estimates not controlling for prices		Estimates controlling for prices	
	Return	Elasticity	Return	Elasticity
RDP				
HH per capita expenditure	0.112 ***	0.076 ***	0.121 *	0.082 *
Laspeyres quantity index	0.386 ***	0.262 ***	0.312 **	0.212 **
Boys' schooling	0.198 *	0.135 *	0.195	0.133
Girls' schooling	0.147	0.100	0.139	0.094
Monthly labor hours: men	0.4915 *	0.334 *	0.603 *	0.410 *
Monthly labor hours: women	0.5069 *	0.345 *	0.398	0.271
RRMIMP				
HH per capita expenditure	0.107 **	0.080 **	0.113 *	0.083 *
Laspeyres quantity index	0.304 ***	0.228 ***	0.344 ***	0.258 ***
Boys' schooling	0.201 *	0.151 *	0.237 **	0.178 **
Girls' schooling	0.21 **	0.158 **	0.290 **	0.217 **
Monthly labor hours: men	0.362	0.271	0.371	0.278
Monthly labor hours: women	0.016	0.012	-0.041	-0.031

Notes:

(1) Prices we controlled for included men's agricultural wage, fertilizer price, and the agricultural price index facing the household.

(2) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.

Table 4. Poverty status before and after road investment

		Percent of households below moderate poverty line		Percent of households below extreme poverty line	
		year=0	year=1	year=0	Year=1
RDP	Project	0.57 *** (0.50)	0.48 *** (0.50)	0.35 *** (0.48)	0.29 *** (0.45)
	Control	0.74 (0.44)	0.74 (0.44)	0.55 (0.50)	0.55 (0.50)
RRMIMP	Project	0.52 *** (0.50)	0.41 *** (0.49)	0.38 *** (0.48)	0.21 *** (0.41)
	Control	0.59 *** (0.49)	0.47 *** (0.50)	0.38 *** (0.49)	0.25 *** (0.43)

Notes:
(a) Poverty lines were determined by village, using average expenditure on a food bundle of 2,122 kcal suggested by the Food and Agriculture Organization (FAO).
(b) Differences in means are statistically significant as indicated by *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.

Table 5. Predicted impact of road investment on poverty, household fixed effects estimates

		Predicted poverty		
	Actual poverty before road development	Predicted poverty after road development	Predicted road impact on poverty	P-value
RDP villages				
Moderate poverty headcount	0.57	0.52	0.05	0.04
Extreme poverty headcount	0.35	0.30	0.05	0.03
RRMIMP villages				
Moderate poverty headcount	0.52	0.46	0.06	0.08
Extreme poverty headcount	0.38	0.31	0.07	0.03

Notes:
(a) Predicted poverty is based on the household fixed-effects estimates from Table 4A.

The Poverty Impact of Rural Roads: Evidence from Bangladesh

(Appendix of Tables)

Table A1. Summary statistics for outcomes and explanatory variables: RDP

	(A) Year=0			(B) Year=1			Combined			Equality of Means (A)-(B): p-value
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Outcomes										
Producer transport cost - rice (rainy season, taka/maund)	609	8.18	5.02	494	3.18	1.84	1103	5.94	4.64	0.000
Producer transport cost -rice (dry season, taka/maund)	608	6.32	3.11	495	3.28	2.15	1103	4.95	3.11	0.000
Household daily transport costs	1065	2.32	5.87	1058	0.98	3.16	2123	1.66	4.76	0.000
Input price: fertilizer (taka/kg)	681	6.21	1.08	727	5.08	0.21	1407	5.63	0.95	0.000
Daily agricultural wage (men)	834	41.40	8.78	758	42.42	10.18	1592	41.88	9.48	0.032
Laspeyres Price Index	653	1.00	-	654	0.79	0.09	1307	-	-	0.000
Laspeyres Quantity Index	653	1.00	-	654	1.78	1.57	1307	-	-	0.000
HH per capita expenditure	1075	4524.68	1636.09	1076	4738.13	4220.84	2151	4631.46	3202.54	0.122
Boys' schooling, 5-17 years: HH average	489	0.68	0.44	623	0.73	0.40	1112	0.71	0.42	0.048
Girls' schooling, 5-17 years: HH average	479	0.71	0.42	636	0.78	0.38	1115	0.75	0.40	0.004
Monthly employment hours: adult men	1075	269.49	226.44	1076	236.54	191.96	2151	253.01	210.50	0.000
Monthly employment hours: adult women	1075	25.76	83.20	1076	36.94	90.13	2151	31.35	86.90	0.003
Explanatory variables										
Road project (1=Y, 0=N)	1075	0	-	1076	0.70	0.46	2151	-	-	-
HH head's sex (1=M,0=F)	1075	0.97	0.18	1076	0.92	0.26	2151	0.95	0.23	0.000
HH head's age (years)	1075	43.89	14.71	1076	46.41	13.60	2151	45.15	14.22	0.000
HH head's education (years)	1075	2.97	3.92	1076	2.85	3.86	2151	2.91	3.89	0.475
Maximum schooling of adult men in HH: years	1075	4.54	4.73	1076	5.84	4.21	2151	5.19	4.52	0.000
Maximum schooling of adult women in HH: years	1075	2.56	3.66	1076	3.44	3.87	2151	3.00	3.79	0.000
Village has electricity: 1=Y, 0=N	1075	0.32	0.46	1076	0.63	0.48	2151	0.47	0.50	0.000
Number of grocery and fertilizer shops in district	1075	16.53	11.58	1076	29.33	21.63	2151	22.94	18.49	0.000
Percentage of village land that is irrigated	1075	0.41	0.25	1076	0.84	0.34	2151	0.62	0.37	0.000
Household land owning (in acres)	1075	3.02	5.75	1076	1.53	2.82	2151	2.27	4.59	0.000

Table A2. Summary statistics for outcomes and explanatory variables: RRMIMP

	(A) Year=0			(B) Year=1			Combined			Equality of Means (A)-(B): p-value
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Outcomes										
Producer transport cost - rice (rainy season, taka/maund)	183	6.19	2.83	286	2.87	1.48	469	4.16	2.66	0.000
Producer transport cost -rice (dry season, taka/maund)	183	4.82	2.29	286	2.50	0.97	469	3.40	1.97	0.000
Household daily transport costs	509	1.11	2.42	499	0.62	1.12	1008	0.87	1.90	0.000
Input price: fertilizer (taka/kg)	377	5.31	0.46	396	4.43	0.23	773	4.86	0.57	0.000
Daily agricultural wage (men)	427	49.32	10.90	387	45.22	10.86	814	47.37	11.06	0.000
Laspeyres Price Index	327	1.00	-	327	1.05	0.10	654	-	-	0.000
Laspeyres Quantity Index	327	1.00	-	327	1.54	2.42	654	-	-	0.000
HH per capita expenditure	528	5301.13	1971.26	528	5380.24	2012.89	1056	5340.69	1991.64	0.519
Boys' schooling, 5-17 years: HH average	294	0.69	0.42	307	0.67	0.43	601	0.68	0.43	0.691
Girls' schooling, 5-17 years: HH average	301	0.70	0.42	292	0.79	0.37	593	0.74	0.40	0.005
Monthly employment hours: adult men	535	172.49	107.41	535	165.59	112.82	1070	169/04	110.15	0.305
Monthly employment hours: adult women	535	7.88	33.34	535	7.82	37.77	1070	7.85	35.61	0.976
Explanatory variables										
Road project (1=Y, 0=N)	535	0	-	535	0.83	0.38	1070	-	-	-
HH head's sex (1=M,0=F)	535	0.95	0.22	535	0.94	0.24	1070	0.94	0.23	0.510
HH head's age (years)	535	39.28	12.10	535	43.12	12.60	1070	41.20	12.50	0.000
HH head's education (years)	535	2.78	3.94	535	2.76	3.98	1070	2.77	3.96	0.926
Maximum schooling of adult men in HH: years	535	3.52	4.39	535	3.90	4.51	1070	3.71	4.45	0.161
Maximum schooling of adult women in HH: years	535	2.47	3.45	535	3.25	3.79	1070	2.86	3.64	0.001
Village has electricity: 1=Y, 0=N	535	0.73	0.44	535	1.00	0.00	1070	0.86	0.34	0.000
Number of grocery and fertilizer shops in district	535	21.44	7.40	535	36.39	10.37	1070	28.92	11.71	0.000
Percentage of village land that is irrigated	535	0.81	0.15	535	0.84	0.14	1070	0.82	0.15	0.004
Household land owning (in acres)	535	1.15	2.01	535	1.21	2.32	1070	1.18	2.17	0.612

Table A3. Fixed-effects estimates of household transportation expenses

	RDP		RRMIMP	
	Transportation expenses		Transportation expenses	
Project area (Y=1, N=0)	-0.363 ***	-0.415 ***	-0.380 **	-0.348 *
	(0.116)	(0.119)	(0.150)	(0.191)
Project*Distance from project road		0.018		-0.236
		(0.160)		(0.289)
Project*Distance from project road squared		0.056		0.184
		(0.078)		(0.175)
Year	-0.339 ***	-0.352 ***	0.686	0.652
	(0.085)	(0.085)	(0.477)	(0.606)
Sex of HH head (M=1, F=0)	-0.052	-0.055	0.139	0.134
	(0.113)	(0.112)	(0.355)	(0.356)
Age of HH head	-0.002	-0.002	0.002	0.003
	(0.003)	(0.003)	(0.005)	(0.005)
Years of education: HH head	-0.017	-0.014	0.042 **	0.041 **
	(0.011)	(0.011)	(0.018)	(0.018)
Maximum male years of schooling	0.016 **	0.016 **	-0.019	-0.017
	(0.007)	(0.007)	(0.013)	(0.013)
Maximum female years of schooling	-0.013 *	-0.011 *	-0.011	-0.010
	(0.007)	(0.007)	(0.012)	(0.012)
Village has electricity (Y=1, N=0)	0.070	0.061	0.114	0.128
	(0.056)	(0.056)	(0.237)	(0.308)
Number of grocery and fertilizer shops in thana	0.003	0.004 *	-0.017	-0.017
	(0.002)	(0.002)	(0.011)	(0.015)
Percentage of village land that is irrigated	0.054	0.059	-1.412	-1.383
	(0.087)	(0.088)	(0.899)	(1.029)
HH landownings (log)	-0.003	-0.007	-0.033	-0.034
	(0.023)	(0.023)	(0.042)	(0.042)
Sample size	2123	2123	1008	1008
R-squared	0.34	0.35	0.18	0.18
F-statistic	25.52	24.15	7.15	6.33

Notes:
(a) Transportation expenses does not include transportation cost for production that was considered in table 3 above.
(b) All estimations in semi-log form.
(c) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(d) All estimations include district*year interactions.

Table A4. Fixed-effects estimates of fertilizer price and men's daily agricultural wage

	RDP				RRMIMP			
	Input price: fertilizer		Daily agricultural wage (men)		Input price: fertilizer		Daily agricultural wage (men)	
Project area (Y=1, N=0)	-0.045 *	-0.037	0.270 ***	0.266 ***	-0.047 ***	-0.055 ***	0.019	0.043
	(0.024)	(0.025)	(0.027)	(0.028)	(0.011)	(0.013)	(0.032)	(0.038)
Project*Distance from project road		-0.006		0.013		0.014		-0.042
		(0.032)		(0.034)		(0.018)		(0.054)
Project*Distance from project road squared		-0.006		-0.003		-0.004		0.016
		(0.016)		(0.017)		(0.011)		(0.033)
Year	-0.045 **	-0.042 **	0.167 ***	0.166 ***	0.145 ***	0.173 ***	-0.737 ***	-0.811 ***
	(0.020)	(0.020)	(0.022)	(0.022)	(0.032)	(0.041)	(0.095)	(0.117)
Sex of HH head (M=1, F=0)	0.040	0.042	0.052	0.050	-0.021	-0.023	0.293 ***	0.290 ***
	(0.028)	(0.028)	(0.032)	(0.032)	(0.028)	(0.028)	(0.083)	(0.083)
Age of HH head	-1.4E-04	-1.6E-04	3.5E-04	3.5E-04	6.1E-05	5.1E-05	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(3.1E-4)	(3.1E-4)	(0.001)	(0.001)
Years of education: HH head	0.001	8.0E-05	-0.003	-0.003	-0.003 **	-0.003 **	-3.2E-	-2.7E-04
	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)	(0.004)	(0.004)
Maximum male years of schooling	-0.003 **	-0.003 **	0.001	0.001	0.001	0.001	0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
Maximum female years of schooling	0.001	5.0E-04	3.5E-04	3.8E-04	0.002 ***	0.003 ***	-2.4E-	-2.7E-04
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Village has electricity (Y=1, N=0)	-0.003	-0.003	-0.015	-0.016	-0.226 ***	-0.243 ***	0.268 ***	0.309 ***
	(0.011)	(0.011)	(0.013)	(0.013)	(0.016)	(0.021)	(0.047)	(0.061)
Number of grocery and fertilizer shops in thana	-0.003 ***	-0.003 ***	-0.007 ***	-0.007 ***	-0.007 ***	-0.008 ***	0.023 ***	0.025 ***
	(0.000)	(0.000)	(4.2E-4)	(4.2E-4)	(0.001)	(0.001)	(0.002)	(0.003)
Percentage of village land that is irrigated	-0.005	-0.007	0.058 ***	0.057 ***	-0.628 ***	-0.670 ***	1.058 ***	1.168 ***
	(0.018)	(0.018)	(0.021)	(0.021)	(0.065)	(0.075)	(0.191)	(0.216)
HH landownings (log)	0.001	0.001	0.017 ***	0.017 ***	-0.009 ***	-0.009 ***	-0.005	-0.005
	(0.006)	(0.006)	(0.005)	(0.005)	(0.003)	(0.003)	(0.008)	(0.008)
Sample size	1416	1416	1592	1592	773	773	814	814
R-squared	0.76	0.76	0.68	0.68	0.94	0.94	0.67	0.67
F-statistic	87.77	81.11	67.20	61.30	372.59	325.47	48.34	42.27

Notes:
(a) All estimations in semilog form. (b) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(c) All estimations include district*year interactions.

Table A5. Fixed-effects estimates of Laspeyres aggregate crop price and output indices

	RDP				RRMIMP			
	Laspeyres Price Index		Laspeyres Quantity Index		Laspeyres Price Index		Laspeyres Quantity Index	
Project area (Y=1, N=0)	0.050 ***	0.050 ***	0.386 ***	0.373 ***	0.035 ***	0.031 ***	0.304 ***	0.218 *
	(0.008)	(0.008)	(0.111)	(0.112)	(0.009)	(0.011)	(0.102)	(0.120)
Project*Distance from project road		-0.001		-0.077		0.005		-0.128
		(0.010)		(0.140)		(0.016)		(0.169)
Project*Distance from project road squared		0.001		0.073		-0.001		0.193 *
		(0.005)		(0.069)		(0.010)		(0.104)
Year	-0.068 ***	-0.068 ***	0.196 **	0.191 **	-0.275 ***	-0.262 ***	-1.242 ***	-0.897 **
	(0.006)	(0.006)	(0.090)	(0.090)	(0.027)	(0.034)	(0.291)	(0.355)
Sex of HH head (M=1, F=0)	0.013	0.013 *	0.076	0.086	-0.009	-0.009	0.055	0.035
	(0.008)	(0.008)	(0.112)	(0.111)	(0.014)	(0.014)	(0.147)	(0.145)
Age of HH head	-2.3E-04	-2.3E-04	0.003	0.002	2.3E-04	2.3E-04	-0.002	-0.002
	(1.6E-4)	(1.6E-4)	(0.002)	(0.002)	(2.7E-4)	(2.7E-4)	(0.003)	(0.003)
Years of education: HH head	-0.001	-0.001	0.001	0.003	-0.002 *	-0.002 *	-0.022 **	-0.025 **
	(0.001)	(0.001)	(0.009)	(0.009)	(0.001)	(0.001)	(0.010)	(0.010)
Maximum male years of schooling	3.1E-04	3.2E-04	1.6E-04	2.3E-04	0.003 ***	0.003 ***	0.004	0.006
	(4.1E-4)	(4.1E-4)	(0.006)	(0.006)	(0.001)	(0.001)	(0.008)	(0.008)
Maximum female years of schooling	-3.1E-05	3.8E-06	-0.007	-0.006	2.4E-04	2.6E-04	-0.008	-0.007
	(4.2E-4)	(4.2E-4)	(0.006)	(0.006)	(0.001)	(0.001)	(0.007)	(0.007)
Village has electricity (Y=1, N=0)	-0.005	-0.005	0.059	0.059	0.159 ***	0.152 ***	0.722 ***	0.519 ***
	(0.003)	(0.003)	(0.049)	(0.049)	(0.013)	(0.017)	(0.140)	(0.182)
Number of grocery and fertilizer shops in thana	-0.002 ***	-0.002 ***	-0.006 ***	-0.005 ***	0.009 ***	0.009 ***	0.031 ***	0.022 ***
	(1.1E-4)	(1.1E-4)	(0.002)	(0.002)	(0.001)	(0.001)	(0.006)	(0.008)
Percentage of village land that is irrigated	0.004	0.004	0.115	0.129 *	0.320 ***	0.301 ***	1.913 ***	1.373 **
	(0.005)	(0.005)	(0.077)	(0.078)	(0.056)	(0.064)	(0.605)	(0.672)
HH landownings (log)	0.001	0.001	0.078 ***	0.081 ***	0.001	0.001	0.310 ***	0.297 ***
	(0.002)	(0.002)	(0.024)	(0.024)	(0.003)	(0.003)	(0.031)	(0.030)
Sample size	1307	1307	1307	1307	654	654	654	654
R-squared	0.92	0.92	0.31	0.31	0.67	0.67	0.32	0.36
F-statistic	358.02	326.54	13.40	12.54	44.91	39.14	10.90	10.76

Notes:
(a) All estimations in semilog form.
(b) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(c) All estimations include district*year interactions.
(d) Agricultural crops that entered the index include potato and wheat, as well as hyv boro, hyv aman, hyv aus, and local aus paddy.

Table A6. Fixed-effects estimates of male and female employment

	RDP				RRMIMP			
	Male monthly employment hours		Female monthly employment hours		Male monthly employment hours		Female monthly employment hours	
Project area (Y=1, N=0)	0.4915 *	0.5129 *	0.5069 *	0.4692 *	0.3617	-0.2802	0.0158	-0.1914
	(0.2790)	(0.2865)	(0.2865)	(0.2997)	(0.3685)	(0.4701)	(0.2897)	(0.3709)
Project*Distance from project road		-0.2120		0.2878		1.4768 **		0.2492
		(0.3894)		(0.4579)		(0.6925)		(0.5463)
Project*Distance from project road squared		0.1121		-0.1504		-0.7553 *		-0.0369
		(0.1907)		(0.2242)		(0.4247)		(0.3350)
Year	-0.0207	-0.0211	0.0758	0.0827	-1.7272	0.1501	0.6108	1.2998
	(0.2066)	(0.2069)	(0.2212)	(0.2216)	(1.1776)	(1.4783)	(0.9255)	(1.1662)
Sex of HH head (M=1, F=0)	1.5520 ***	1.5545 ***	-0.1009	-0.1038	2.7235 ***	2.7987 ***	-1.6993 ***	-1.6718 ***
	(0.2527)	(0.2530)	(0.2971)	(0.2973)	(0.5739)	(0.5734)	(0.4511)	(0.4524)
Age of HH head	-0.0155 **	-0.0155 **	-0.0071	-0.0070	-0.0030	-0.0042	-0.0038	-0.0038
	(0.0062)	(0.0062)	(0.0073)	(0.0073)	(0.0121)	(0.0121)	(0.0095)	(0.0096)
Years of education: HH head	-0.0127	-0.0117	0.0251	0.0239	-0.0410	-0.0375	-0.0068	-0.0078
	(0.0260)	(0.0261)	(0.0306)	(0.0307)	(0.0444)	(0.0444)	(0.0349)	(0.0350)
Maximum male years of schooling	0.0049	0.0045	-0.0132	-0.0127	0.0243	0.0196	-0.0027	-0.0025
	(0.0165)	(0.0166)	(0.0194)	(0.0194)	(0.0329)	(0.0330)	(0.0259)	(0.0260)
Maximum female years of schooling	0.0338 **	0.0342 **	0.0087	0.0082	0.0047	0.0043	0.0690 ***	0.0696 ***
	(0.0168)	(0.0168)	(0.0197)	(0.0198)	(0.0294)	(0.0293)	(0.0231)	(0.0232)
Village has electricity (Y=1, N=0)	-0.0550	-0.0479	-0.0352	-0.0447	0.1291	-0.8868	-0.7545 *	-1.1360 *
	(0.1352)	(0.1363)	(0.1588)	(0.1600)	(0.5810)	(0.7596)	(0.4566)	(0.5993)
Number of grocery and fertilizer shops in thana	-0.0101 **	-0.0101 **	-0.0051	-0.0049	0.0481 *	0.0007	-0.0227	-0.0410
	(0.0046)	(0.0047)	(0.0054)	(0.0055)	(0.0273)	(0.0358)	(0.0215)	(0.0282)
Percentage of village land that is irrigated	0.2006	0.2143	-0.0759	-0.0906	3.0499	0.4227	1.2631	0.2727
	(0.2100)	(0.2116)	(0.2245)	(0.2257)	(2.2003)	(2.5366)	(1.7294)	(2.0012)
HH landowning (log)	0.0645	0.0637	0.0036	0.0045	-0.0894	-0.0875	0.0192	0.0181
	(0.0562)	(0.0563)	(0.0661)	(0.0662)	(0.1015)	(0.1012)	(0.0797)	(0.0798)
Sample size	2151	2151	2151	2151	1070	1070	1070	1070
R-squared	0.08	0.08	0.08	0.08	0.09	0.10	0.11	0.11
F-statistic	4.49	4.11	4.50	4.11	3.81	3.66	4.37	3.89

Notes:
(a) All estimations in semilog form. (b) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(c) All estimations include district*year interactions.

Table A7. Fixed-effects estimates of household per capita annual expenditure

	RDP		RRMIMP	
	Log per capita expenditure		Log per capita expenditure	
Project area (Y=1, N=0)	0.1124 * (0.0581)	0.1080 * (0.0597)	0.1066 * (0.0630)	0.0927 (0.0806)
Project*Distance from project road		-0.0077 (0.0811)		-0.0985 (0.1184)
Project*Distance from project road squared		0.0106 (0.0397)		0.1025 (0.0724)
Year	-0.0129 (0.0430)	-0.0142 (0.0431)	-0.6222 *** (0.2019)	-0.5344 ** (0.2536)
Sex of HH head (M=1, F=0)	-0.0723 (0.0527)	-0.0725 (0.0527)	0.0031 (0.0971)	0.0057 (0.0971)
Age of HH head	0.0005 (0.0013)	0.0005 (0.0013)	-0.0044 ** (0.0021)	-0.0042 * (0.0021)
Years of education: HH head	-0.0044 (0.0054)	-0.0040 (0.0054)	0.0156 ** (0.0077)	0.0144 * (0.0077)
Maximum male years of schooling	-0.0011 (0.0034)	-0.0011 (0.0034)	-0.0055 (0.0058)	-0.0045 (0.0058)
Maximum female years of schooling	-0.0109 *** (0.0035)	-0.0108 *** (0.0035)	-0.0092 * (0.0050)	-0.0087 * (0.0050)
Village has electricity (Y=1, N=0)	0.0285 (0.0282)	0.0280 (0.0284)	0.2327 ** (0.0996)	0.1797 (0.1306)
Number of grocery and fertilizer shops in thana	-0.0007 (0.0010)	-0.0006 (0.0010)	0.0215 *** (0.0047)	0.0188 *** (0.0061)
Percentage of village land that is irrigated	0.0445 (0.0438)	0.0455 (0.0441)	0.2814 (0.3757)	0.1420 (0.4343)
HH landownings (log)	0.0187 (0.0117)	0.0183 (0.0117)	0.0578 *** (0.0172)	0.0568 *** (0.0171)
Sample size	2151	2151	1056	1056
R-squared	0.13	0.13	0.16	0.17
F-statistic	7.38	6.76	7.02	6.45

Notes:
(a) All estimations in semilog form. (b) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(c) All estimations include district*year interactions.

Table A8. Fixed-effects estimates of children's schooling

	RDP				RRMIMP			
	Boys' schooling, 5-17 years (HH average)		Girls' schooling, 5-17 years (HH average)		Boys' schooling, 5-17 years (HH average)		Girls' schooling, 5-17 years (HH average)	
Project area (Y=1, N=0)	0.198 *	0.284 **	0.147	0.150	0.136 *	0.142	0.141 **	0.047
	(0.120)	(0.126)	(0.118)	(0.122)	(0.081)	(0.213)	(0.069)	(0.176)
Project*Distance from project road		-0.573 ***		-0.064		-0.027		
		(0.183)		(0.181)		(0.053)		
Project*Distance from project road squared		0.284 ***		0.040		0.003		
		(0.089)		(0.088)		(0.005)		
Year	-0.141 *	-0.134	-0.027	-0.028	-0.010	0.026	-0.037	-0.034
	(0.080)	(0.087)	(0.084)	(0.084)	(0.184)	(0.244)	(0.156)	(0.198)
Sex of HH head (M=1, F=0)	0.030	0.042	-0.039	-0.040	-0.092	-0.087	0.245	0.242
	(0.122)	(0.121)	(0.112)	(0.112)	(0.164)	(0.165)	(0.171)	(0.171)
Age of HH head	-0.004	-0.004	-0.007 ***	-0.007 ***	-0.003	-0.003	0.000	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)
Years of education: HH head	0.020	0.022 *	-0.003	-0.002	0.017	0.016	0.003	0.004
	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.014)	(0.012)	(0.012)
Maximum male years of schooling	-0.010	-0.011	-0.013 *	-0.013 *	-0.016	-0.016	-0.011	-0.012
	(0.007)	(0.007)	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)	(0.009)
Maximum female years of schooling	0.016 *	0.015 *	-0.013 *	-0.012	-0.003	-0.003	-0.007	-0.008
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.007)	(0.007)
Village has electricity (Y=1, N=0)	0.024	0.043	0.017	0.017	-0.081	-0.092	-0.019	-0.030
	(0.065)	(0.064)	(0.062)	(0.062)	(0.084)	(0.113)	(0.073)	(0.093)
Number of grocery and fertilizer shops in thana	0.003	0.002	0.001	0.001	-0.006	-0.005	-0.003	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.004)	(0.005)
Percentage of village land that is irrigated	0.077	0.123	0.053	0.054	0.251	0.234	0.157	0.154
	(0.101)	(0.101)	(0.099)	(0.099)	(0.291)	(0.305)	(0.239)	(0.248)
HH landownings (log)	0.014	0.012	-0.018	-0.018	0.028	0.029	0.010	0.005
	(0.028)	(0.028)	(0.024)	(0.025)	(0.033)	(0.033)	(0.027)	(0.028)
Sample size	1112	1112	1115	1115	972	972	957	957
R-squared	0.08	0.11	0.11	0.11	0.04	0.04	0.06	0.06
F-statistic	1.86	2.17	2.46	2.25	1.1	0.98	1.59	1.51

Notes:
(a) All estimations in semilog form. (b) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(c) All estimations include district*year interactions.

Table A9: Panel quantile regression estimates, β; Dependent variable: log annual per capita expenditure

	RDP					RRMIMP				
	0.15	**0.25**	**0.50**	**0.75**	**0.85**	**0.15**	**0.25**	**0.50**	**0.75**	**0.85**
Project area (Y=1, N=0)	0.126 ***	0.144 ***	0.155 ***	0.127 ***	0.144 ***	0.208 *	0.184	0.033	-0.041	-0.169
	(0.045)	(0.047)	(0.044)	(0.047)	(0.059)	(0.126)	(0.141)	(0.107)	(0.161)	(0.241)
Year	-0.128 ***	-0.146 ***	-0.103 ***	-0.068	-0.054	-0.939 **	-0.938 **	-0.367	-0.246	-0.165
	(0.047)	(0.043)	(0.040)	(0.050)	(0.059)	(0.441)	(0.434)	(0.412)	(0.514)	(0.838)
Village has electricity (Y=1, N=0)	-0.018	-0.011	0.001	-0.014	0.027	0.545 ***	0.448 *	0.086	-0.115	-0.104
	(0.042)	(0.040)	(0.038)	(0.039)	(0.051)	(0.219)	(0.231)	(0.221)	(0.269)	(0.395)
Percentage of village land that is irrigated	0.037	0.012	-0.009	0.017	-0.005	0.572	0.349	-0.170	-0.117	-0.126
	(0.051)	(0.039)	(0.043)	(0.058)	(0.066)	(1.034)	(0.864)	(0.708)	(0.994)	(1.524)
Number of grocery and fertilizer shops in thana	0.001	4.6E-04	-0.001	-0.001	-0.001	0.024 **	0.026 ***	0.013	0.013	0.015
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.011)	(0.010)	(0.010)	(0.011)	(0.019)
HH landownings (log)	0.017	0.017	0.033 *	0.034	0.025	0.046	0.042	0.050 *	0.030	0.017
	(0.022)	(0.024)	(0.020)	(0.026)	(0.029)	(0.042)	(0.041)	(0.030)	(0.038)	(0.041)
Sex of HH head (M=1, F=0)	-0.017	0.018	0.025	-0.078	-0.157	-0.022	-0.061	0.010	0.126	0.015
	(0.093)	(0.110)	(0.094)	(0.123)	(0.166)	(0.392)	(0.335)	(0.262)	(0.224)	(0.261)
Age of HH head	0.002	4.3E-04	-0.001	-9.5E-05	0.001	-0.003	-0.003	-0.002	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)
Years of education: HH head	-0.004	-0.008	-0.007	0.001	0.004	-0.003	-0.006	0.012	0.017	0.027
	(0.010)	(0.010)	(0.009)	(0.011)	(0.014)	(0.018)	(0.018)	(0.013)	(0.017)	(0.024)
Maximum male years of schooling	-0.001	0.004	0.001	-0.003	-0.009	0.011	-5.0E-04	-0.004	-0.014	-0.011
	(0.006)	(0.004)	(0.006)	(0.008)	(0.010)	(0.011)	(0.012)	(0.011)	(0.012)	(0.017)
Maximum female years of schooling	-0.007	-0.007	-0.011 ***	-0.016	-0.021 ***	-0.012	-0.018 *	-0.011	-0.001	0.004
	(0.008)	(0.006)	(0.005)	(0.010)	(0.008)	(0.010)	(0.009)	(0.011)	(0.013)	(0.013)
Sample size	2151	2151	2151	2151	2151	1070	1070	1070	1070	1070
R-squared	0.18	0.16	0.18	0.20	0.20	0.18	0.18	0.20	0.22	0.24

Notes:
(a) All estimations in semilog form. (b) *** = significant at 0.01 level, ** = significant at 0.05 level, * = significant at 0.10 level.
(c) All estimations include district*year interactions, as well as village dummies.
(d) Parameters estimated with bootstrapped standard errors, drawing pairs of observations to construct the bootstrap sample.

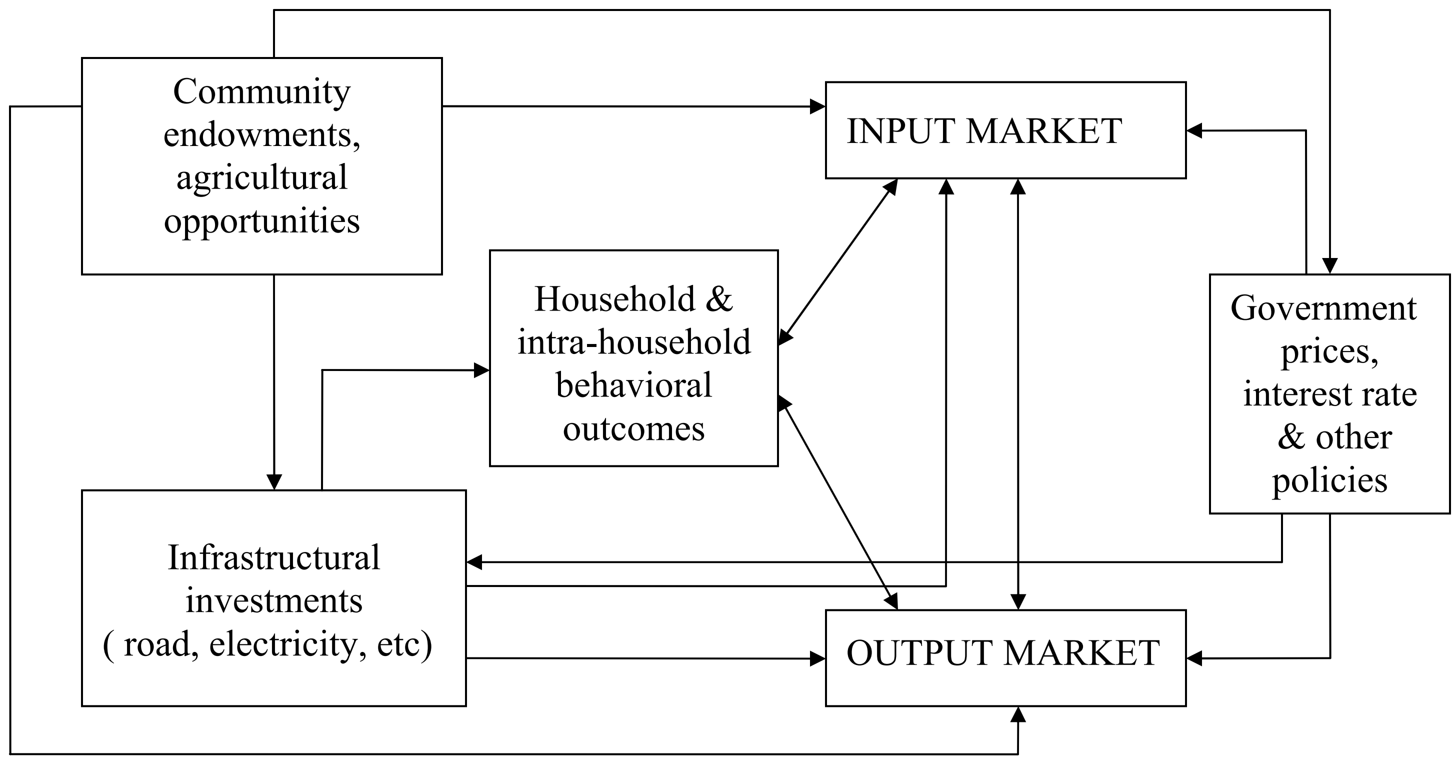

Figure 1: Flow chart of the relationships among road investment, input and output markets, and household and intra-household outcomes.