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Impact Evaluation of Pradhan Mantri Gram Sadak Yojana (PMGSY)

2019

Transport

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Executive Summary

At the end of the 20th century, about 300 million people in rural India had limited connectivity with the rest of India and the world because their villages and habitations lacked all-weather road access. In response to this poor connectivity and limited opportunities, in 2000 the prime minister announced the Pradhan Mantri Gram Sadak Yojana (PMGSY) rural roads program. The program seeks to establish farm-to-market connectivity by providing access to all-weather roads to about 178,000 habitations across India. By December 2017 it had built more than 550,000 kilometers of rural roads, connecting more than 159,000 habitations, at a cost of $27 billion.

This report presents the results of an impact evaluation of PMGSY that uses a difference-in-difference approach and panel data from the states of Himachal Pradesh, Madhya Pradesh, and Rajasthan collected in 2009 and 2017.

PMGSY improved accessibility, particularly in hilly areas

On average, people travelled to their destinations, particularly work, in shorter time, thanks to improved connectivity, but they did not change the distance travelled. Reductions in travel time were greater in hilly areas. Households' transport costs did not seem to have changed after PMGSY roads were built, possibly because people switched from walking and public transport to bicycles and private motorized vehicles. Thanks to improved connectivity, people in hilly areas made more trips to work per week; in flat areas they made fewer weekly trips to work. Patterns on trips to local markets were similar.

PMGSY increased access to economic opportunities, triggering a change in the structure of employment in rural India

The improved accessibility provided by PMGSY roads triggered a shift from farm to nonfarm employment, particularly nonfarm employment outside the habitation. As a consequence of PMGSY roads, the rate of primary employment in the nonfarm sector increased by about 12 percentage points in the habitations studied. This increase represents a 33 percent increase over the average share of nonfarm primary employment in 2009 in habitations that were connected after 2009. The share of people with primary employment outside their habitation increased by 8 percentage points. This increase represents a 35 percent increase relative to the average share of primary employment outside the habitation in 2009 in habitations that were connected after 2009. Most workers who switched to nonfarm employment were men. Women stepped in to take care of the farm after road connectivity was improved. The entrance of women into the workforce was the main force behind the 5.5 percent increase in employment in connected habitations.

The impact on employment was correlated with distance from urban areas. In habitations 10 kilometers farther away from the nearest urban agglomeration than the average habitation, employment increased by 6 percentage points more than in the average habitation. More isolated habitations also experienced larger increases in the shares of students and housewives getting part-time jobs. The shift to employment outside the habitation, particularly nonfarm employment, was more pronounced in hilly areas than in flat land, a finding that is consistent with people making more weekly trips to work in those areas.

PMGSY improved farm-to-market connectivity, but it had limited impact on farming practices

PMGSY roads yielded an 8 percentage point increase in the share of crops transported to markets for sale, a tripling over levels observed before PMGSY roads were built. The increase in the share of crops sold at market was larger in hillier areas than in flatter ones. Farmers selling food grains traveled 8.9 kilometers farther after the PMGSY roads were built, which suggests that farmers were travelling to locations where prices for their crops were higher. The cost to carry the crops did not seem to have changed as a result of improved connectivity. Hence the results suggest improvement in rural road connectivity allowed farmers to take advantage of more favorable market conditions.

Increased access to markets had some effects on farming practices, but they were smaller than expected, potentially hinting at the need for complementary interventions to support the development of agriculture value chains. The average land area under cultivation did not change after road construction, except in hilly areas, where it decreased. Rural roads had a positive impact on food grain yields in habitations farther away from urban agglomerations and in hilly areas, which could be driven by less productive land being taken out of cultivation.

PMGSY roads had a positive impact on human capital formation in rural India, with boys and girls benefiting equally

Improved rural connectivity provides a long-term and sustained boost in the living standards of rural populations if it allows households to accumulate wealth and human capital. In the habitations studied, rural roads had a positive but small effect on the average wealth of households, equivalent to adding small appliances (like a pressure cooker and radio) to the household's assets. The estimated impact on wealth is statistically significant only under certain specifications.

On average, children who were in middle or high school at the time their habitation was connected had 0.7 more years of schooling in 2017 as a result of PMGSY roads that were built in the previous three years. The analysis found no overall impact on primary schooling, although years of primary schooling rose in hilly areas.

The share of babies delivered at home decreased by 30 percent in connected habitations, and the reduction was even larger in habitations farther away from urban agglomerations. Young children in connected habitations were also less likely to fall sick, possibly because vaccination take-up among children under the age of four increased by 15 percentage points, with boys and girls benefiting equally.

Abbreviations

CNCPL	Comprehensive New Connectivity Priority List
DPIU	District Program Implementation Unit
DRRP	District Rural Roads Plan
MoRD	Ministry of Rural Development
NRIDA	National Rural Infrastructure Development Agency
OMMAS	Online Management, Monitoring, and Accounting System
PMGSY	Pradhan Mantri Gram Sadak Yojana
SRRDA	State and Rural Roads Development Agency

Introduction

At the end of the 20th century, about 330,000 of India's 825,000 villages and rural habitations (hamlets or subvillages) lacked all-weather road access.[1] As a result, about 300 million people—28 percent of the population—had limited connectivity with the rest of India and the world.

Limited connectivity means that people have to travel long distances to reach certain places and to pay more to do so. It thus limits access to economic opportunities (employment, product markets) and to basic services (education and health). Limited connectivity also hinders interactions between productive activities holding down economic efficiency and growth.

Limited access to economic opportunities and human capital accumulation hinders improvements in the living standards of the rural poor. High transport costs are an impediment to higher income (Escobal and Ponce 2002, Jacoby and Minten 2009, Cuong 2011); per capita consumption and better livelihoods (Emran and Hou 2013); and poverty reduction (Dercon and others 2008; Khandker, Bakht, and Koolwal 2009). Households with limited connectivity are also more likely to be poor in multiple dimensions (Ali and others 2015).

Limited connectivity affects men and women differently, because they have different mobility patterns (Hanson 2010) and face different restrictions and challenges. In many contexts gender-related restrictions and challenges to mobility translate into limited access to and utilization of economic and social opportunities. Poor transportation can lead women to limit their job search radius (Gutiérrez-i-Puigarnau and van Ommere 2010) or to open a business at or closer to home (Rosenthal and Strange 2012). It also lowers female educational attainment and access to health care services.

It was against this background of poor connectivity and limited opportunities that India's prime minister announced the Pradhan Mantri Gram Sadak Yojana (PMGSY) rural road program, in 2000. PMGSY set a target of connecting every habitation with a population of more than 500 with all-weather roads.[2] It was estimated that about 178,000 habitations would be provided with connectivity under the program. By 2018 PMGSY had delivered more than 550,000 kilometers of all-weather rural roads, connecting more than 159,000 habitations, at a cost of $27 billion.

Evaluating the Impact of PMGSY

A wealth of anecdotal evidence suggests that PMGSY has had positive impacts on rural communities. According to one beneficiary, "It would take nearly two to three days to reach the nearest hospital as we had only camel carts to transport our sick and pregnant women and children. Many of them would die on the way to hospital. Now, the nearest hospital … is just two hours away" (World Bank 2014). Another beneficiary noted, "My husband can now cycle to the local market to sell the farm produce. My children can now go to the English-language school in town" (World Bank 2014).

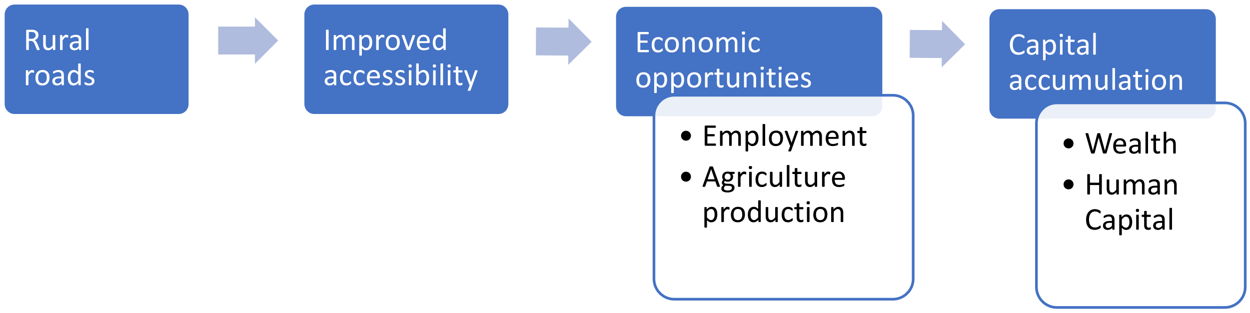
Several studies document the impacts of PMGSY (Mukherjee 2012; Bell and van Dillen 2014, 2015; Banerjee and Sachdeva 2015; Asher, Garg, and Novosad 2017; Aggarwal 2018; Asher and Novosad 2018; Adukia, Asher, and Novosad 2019). Overall, they find that PMGSY had positive albeit limited impact on the economic structure of rural areas and on education and health outcomes. This report adds to this body of research by using a novel panel dataset based on household and habitation-level surveys conducted in 2009 and 2017 with the purpose of evaluating the program.

All previous research on PMGSY except Bell and van Dillen (2014, 2015) used census and surveys designed for purposes other than evaluating the impact of roads, limiting the research questions that could be tackled. Only one previous study examined the impacts of PMGSY roads on mobility (Bell and van Dillen 2015), who examine accessibility to medical facilities. The use of census and surveys designed for purposes other than evaluating the impact of roads also constrains the analysis to the village or a higher level of aggregation, which attenuates the estimated effect of rural roads, as the intervention is at the habitation level.

This report presents the results of an impact evaluation of PMGSY and compares the results with the findings in the literature on the impacts of PMGSY. It answers eight questions, based on the result chain presented in figure I.1:

1. What are the impacts of PMGSY roads on mobility?
2. What are the impacts of PMGSY roads on transportation of farm products to markets?
3. Did PMGSY roads improve access to economic opportunities through changes in employment?
4. How did agriculture production respond to improved farm-to-market access?
5. Did households in connected habitations increase their wealth?
6. Are PMGSY roads providing the foundations for sustained poverty reduction, by increasing access to education and health services?
7. Did some types of habitations benefit more from PMGSY roads than others?
8. Did men and women benefit differently from improved connectivity?

Figure I.1 Results chain of rural road interventions



Organization of the Report

This report is organized as follows. Chapter 1 provides an overview of the PMGSY program. It discusses its design, its salient features, and progress so far. Chapter 2 presents the methodological framework and describes the data used in the analysis. Chapter 3 assesses the transport-related impacts. Chapter 4 describes the impacts on economic opportunities and examines differential impacts. Chapter 5 looks at the impacts on wealth and human capital.

Notes

[1] An all-weather road is one that is negotiable every season of the year, implying that the road bed is drained effectively (by adequate cross-drainage structures, such as culverts, minor bridges and causeways). It need not be paved, surfaced, or black-topped.

[2] The cut-off is 250 people in the hill states (the North-Eastern states, Sikkim, Himachal Pradesh, Jammu and Kashmir, and Uttarakhand); desert areas; and tribal areas.

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Chapter 1 Overview of PMGSY

History of Rural Road Building in India

In 1929 the government of India appointed the Jayakar Committee, the first organized effort at road building at the national level. As a follow-up to a recommendation of the committee, the central government set up the Indian Roads Congress in 1934. It facilitated the formulation of a sequence of plans: the Nagpur Plan (1943–62), the Bombay Plan (1961–81), and the Lucknow Plan (1981–2001).

Each plan was more ambitious than the previous one, setting standards, norms, and targets for road development of various categories. The Bombay Plan envisaged that no village should be more than a mile and a half from a road in developed agricultural areas, three miles from a road in semi-developed areas, and five miles from a road in underdeveloped and uncultivable areas.

The Lucknow Plan set accessibility targets and provided direction on how states could prepare their own perspective plans for road development, bearing in mind differences in the land-use patterns, population, terrain, stage of and potential for economic development, and social infrastructure needed to achieve a balanced road network. Several states followed through by formulating their own plans for rural roads.

Before 2000, rural roads were built largely under rural development programs. The Minimum Need Programme included rural roads for the first time in the Fifth Five-Year Plan (1974–79). In later years, rural roads were also constructed under several schemes funded by the central government, including the National Rural Employment Programme, the Rural Landless Employment Guarantee Programme, and the Employment Assurance Scheme. In some states, market committees and sugar cane societies also built rural roads.

Although road length increased under these schemes, these efforts were not enough to achieve full connectivity of villages. The specifications for these roads were probably good enough for animal-drawn carts and pedestrians, but the advent of fast and heavy vehicles, coupled with the lack of adequate maintenance, caused rapid deterioration of these roads, sometimes rendering them impassable. At the end of the 20th century, about 330,000 of India's 825,000 villages and habitations (hamlets or subvillages) lacked any all-weather road access (Government of India 2006).[1] As a result, about 300 million people—28 percent of India's population—had limited access to education, health services, and economic and social opportunities.

In response to the huge gap in rural connectivity, in October 1999, the president of India announced a new program to build all-weather roads to connect all villages and habitations. The government constituted the National Rural Road Development Committee on January 2000 to make specific recommendations on the way forward. Subsequently, the prime minister announced the Prime Minister's Rural Roads Program (Pradhan Mantri Gram Sadak Yojana [PMGSY]), which was launched on December 2000. For the first time, the government focused on rural connectivity.

What Is PMGSY?

PMGSY's objective is to establish farm-to-market connectivity by providing access to all-weather roads to eligible unconnected habitations.[2] The focus of the program is a habitation, not a revenue village or *Panchayat*. A habitation is a cluster of people living in the area whose location does not change over time, according to the program rules (Government of India 2015). The PMGSY administrative database shows that most villages have more than one habitation.

PMGSY set a target of providing all-weather road access to every habitation with a population of more than 1,000 by 2003 and to every habitation with a population of more than 500 by the end of 2007.[3] The population thresholds were set based on the 2001 census. It was estimated that about 178,000 habitations would be provided with connectivity under the program.

A PMGSY intervention includes both construction and maintenance. Eligible unconnected habitations are connected to nearby habitations already connected by an all-weather road or to another existing all-weather road, in order to make services (educational, health, and marketing facilities) available to residents.[4] Connectivity is provided through construction of a new all-weather road or upgrading of an intermediate link that cannot provide all-weather connectivity. During the five years after construction of the road, the contractor is responsible for routine maintenance of the road and all its components. This practice seeks to encourage contractors to place more importance on the quality of the initial construction works, thereby reducing failures and defects resulting from poor workmanship. At the end of the five-year period, the road is transferred to local government (*Panchayati Raj*) institutions or other owner institutions for maintenance.

Selection and Sequencing of Roads

PMGSY established high management standards and operating procedure that are applied nationwide. It has a well-structured framework for delivery of rural roads based on detailed guidelines.

The District Rural Roads Plan (DRRP) is the starting point of the exercise, the basic instrument for project selection and prioritization of construction and upgradation and the basis for allocation of funds for maintenance in the core network. Selection of road works follows a bottom-up approach. Through a consultative process involving *Panchayati Raj* institutions, district *Panchayats* and elected representatives prepare the DRRP. This plan lists the complete road network in the district (village roads, major district roads, state roads, and national highways) and "the proposed roads for providing connectivity to eligible unconnected habitations in an economic and efficient manner in terms of cost and utility" (Government of India 2015). The district core network, consisting of the set of roads required to provide connectivity to all eligible habitations, is the key element of the DRRP. Once the district *Panchayat* approves the core network, the plan is sent to the state-level agency and the National Rural Infrastructure Development Agency (NRIDA), the central implementing agency under the Ministry of Rural Development (MoRD).

The list of roads works to be taken up under PMGSY each year is prepared by the district and intermediate *Panchayats*, in accordance with the funds made available for the district. Once the core network is ready, the states are required to prepare a Comprehensive New Connectivity Priority List (CNCPL), at the block and district level, of all proposed road links under PMGSY. Unconnected habitations are prioritized based on their population in the 2001 census. Habitations with population of 1,000 or more have the highest priority, followed by habitations with populations of 500–999 and habitations with populations of 250–499 (where eligible).

Once the CNCPL has been firmed up, road works of lower-order priority are not taken up in the district where road works of higher-order priority remain to be taken up. Lower-order roads can be considered only when it is not feasible to execute the higher order of work (because, for example, land is not available). In districts where no new connectivity is required, a Comprehensive Upgradation Priority List is prepared based on a road condition survey, with higher priority given to roads in worse condition.

Role of Central and State Governments

As provision of all-weather road connectivity was conceived as part of the larger poverty reduction strategy, MoRD was entrusted with the task of administering and managing the program. However, as rural roads are a state responsibility under the Constitution of India, PMGSY is executed by state/union territory governments. Road construction was fully funded by the central government until 2014–15. Since 2015–16, the central and state governments have shared construction costs, with the central government funding 60 percent of the costs in plain areas and 90 percent in special category states. Maintenance is the responsibility of the states.

The inherent strength of PMGSY is its strong national focus on rural road development through the central implementing agency, the National Rural Infrastructure Development Agency (NRIDA) under MoRD. NRIDA is responsible for overseeing and coordinating all technical aspects and facilitating systematic monitoring of program implementation in the states/union territories. State rural roads development agencies execute the program.

Progress So Far

PMGSY has been identified as one of India's 60 success stories since independence, according to a survey conducted by *India Today* (an Indian news magazine and television channel). Implementation has brought a sea change in the rural roads sector, thanks to rigorous planning, technical specifications and standards, procurement and contracting requirements, and attention to quality.

PMGSY has already met about 90 percent of its original target. Of the 178,184 habitations intended to benefit from the program, 159,759 habitations (90 percent) have been connected, through 562,047 kilometers of new and improved rural road network, at a cost of about ₹1.88 trillion ($27 billion).

The real story is not how many kilometers were built, however, but where these roads were built. The states that recorded the most road construction by December 2017—Madhya Pradesh (68,796 kilometers), Rajasthan (63,465), Uttar Pradesh (51,999), Bihar (44,705), and Odisha (43,117)—are the ones that were least connected at the turn of this century. Bihar alone had 34,586 habitations originally eligible under PMGSY; 27,590 (80 percent) now have road connectivity, and work on another 6,040 habitations was ongoing by December 2017. Connectivity has been impressive in Madhya Pradesh (17,826 out of 18,404 eligible habitations), Rajasthan (16,165 out of 16,694), Chhattisgarh (9,368 out of 10,191) and West Bengal (12,557 out of 18,641). Implementation capacity also greatly enhanced over time, with the number of kilometers completed rising from 15,500 in the program's first year (2001) to 52,400 kilometers in its last full year (2017).

PMGSY achieved 90 percent of its initial targets 17 years after its launch, mainly as a result of lack of resources and limited implementation capacity. The uniform structure of the program led to constraints, with many states lacking the capacity to implement the program in a timely manner. The largest number of unconnected habitations come from five states: Bihar (6,996 habitations), Assam (5,276), Odisha (2,497), Jharkhand (2,015), and West Bengal (1,632).

The Online Management, Monitoring, and Accounting System (OMMAS)

To monitor the program and increase efficiency, accountability, and transparency in implementation, the government developed a web-enabled system with a centralized database. The Online Management, Monitoring, and Accounting System (OMMAS) facilitates the operational requirements of planning, scheduling, monitoring, tracking, and execution in implementing PMGSY. Most data are entered at the program implementation unit level. Exceptions include technical clearance by state technical agencies, the sanction of proposals by NRIDA, and monitoring by state rural roads development agencies and NRIDA. Execution of the program is decentralized, but monitoring is centralized.

Modules in OMMAS exist for every process in PMGSY; data are captured at the relevant agency level. The process flow starts with preparation of the DRRP, followed by identification of the core network and preparation of proposals from the core network, which are cleared by the state technical agencies and sanctioned by MoRD. For the sanctioned proposals, tenders are published, works are awarded to the selected contractor, and agreement is executed. While works are being executed, the quality of work is monitored, and expenditures are recorded. Upon completion of work, maintenance is planned. Table 1.1 describes the system's main modules.

Table 1.1 Modules of the Online Management, Monitoring, and Accounting System (OMMAS)

Module	*Description*
Master data	Includes master data on districts, constituents, blocks, villages, habitations, *Panchayats*, roads, contractors, and so forth.

Core network (rural road plan)	Includes District Rural Road Plans (DRRPs), which identify national highways, state highways, major district roads, rural roads, link routes, and through-routes in each district.
Proposals	Includes proposals for selection of road links from the core network.
Tendering	Includes tendering data and contractor award details.
Execution	Documents progress of works (physical/financial).
Online fund processing	Processes requests for funds from the State Rural Roads Development Agency (SRRDA) to MoRD. States initiate proposals and forward the request to MoRD, submitting all required and relevant information. After approvals from the project and finance departments of MoRD, a letter specifying the amount sanctioned and released is issued to the state.
Quality monitoring	Includes data on quality control inspection carried out by national quality monitors.
Receipts and payments	Includes accounting data on classified expenditures against each road work.
Maintenance	Includes physical and financial data for five years.
Security and administration	Used to create users, define roles, and map menus to the roles and assignment of roles to users.
Analysis of rate for rural roads	Maintains schedule of rates, based on analysis of different items of work derived from the “Specification for Rural Roads” published by the Indian Roads Congress, for different items
Receipts and payments bank	Used by personnel of bank at which the SRRDA has account for payment of PMGSY-related bills. When bank clears checks or e-payments related to a voucher, the bank authority logs ins and reconciles the payment, which is reflected in the District Program Implementation Unit and SRRDA reports.
Data gap	Allows viewing of data gaps in entry of proposals.
Updating of user manual	Annex provides latest enhancements to OMMAS.

Source: http://omms.nic.in/.

Notes

[1] A majority of the poorly connected rural communities are in 10 states: Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, and West Bengal.

[2] An all-weather road is one that is negotiable every season of the year, implying that the road bed is drained effectively (by adequate cross-drainage structures, such as culverts, minor bridges and causeways). The road need not be paved, surfaced, or black-topped.

[3] The cut-off is 250 people in the hill states (the North-Eastern states, Sikkim, Himachal Pradesh, Jammu and Kashmir, and Uttarakhand); desert areas; and tribal areas

[4] An eligible habitation is considered as connected if it is no more than 500 meters (1.5 kilometers of path distance in case of hills) from an all-weather road or a connected habitation.

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Chapter 2 Methodology and Data

This chapter outlines the analytical framework for evaluating the impacts of PMGSY and describes the data used in the analysis. Although it is aimed for both technical and nontechnical audience, some readers may wish to skip it.

Empirical Approach

The aim of an impact evaluation is to go beyond simple correlations between outcomes and program participation, to detect causal relationships between the relevant variables. The causal effect of a program or treatment is defined as the difference between the observed outcome of a treated unit and the result that this same unit would have obtained in the absence of the treatment (the counterfactual outcome). In the case of PMGSY, the treatment is the construction of an all-weather road, and the treated unit is a habitation connected through that road. As the counterfactual outcome is unobservable by definition, to assess the average impact of a program it is necessary to compare the treated units to a pool of nonparticipants (a comparison or control group).

The main challenge of an impact evaluation is to construct a control group. It should be as similar to the test group as possible, to ensure that differences in outcomes can be attributed exclusively to the program. The key to the construction of a valid control group are the identification assumptions, which state the conditions under which the untreated group can be considered comparable to the treated group.

An ideal impact evaluation would randomly choose the habitations that would be connected through new roads from a list of eligible habitations. This randomization would ensure that the treated and untreated sites were, on average, identical in terms of both observable and unobservable characteristics. In this context, the comparison of outcomes between groups yields an estimate of the causal effect of the program.

Randomizing the construction of roads is not feasible, because of the huge investment cost of these roads. Instead, roads that were built first can be compared with roads that were built later to estimate causal impact.

To statistically compare treated habitations with untreated habitations, the analysis uses a difference-in-differences approach (Gujarati 2003). This methodology consists of measuring the average change in an outcome before and after the intervention and then comparing the changes between the control and treatment groups. The before-after difference corrects for any time-invariant difference between treatment and control; the difference between groups deals with external factors that affect the target population during the interval of analysis. Assuming that those factors affect the treatment and control groups equally (parallel trends assumption), the double difference successfully isolates the true causal effect of the intervention. Even in an experimental context, where there should be no baseline differences between groups, difference-in-differences may help account for some “contamination” of the data, especially when sample sizes are small. This approach requires the existence of baseline and postintervention (endline) information for treatment and control groups.

Empirically, the difference-in-differences model can be specified as

$$Y_{st} = \beta_0 + \beta_1\, Treat_s + \beta_2\, Post_t + \beta_3\, (Treat_s \times Post_t) + \beta_4\, X_{st} + \varepsilon_{st}$$

where

- Y_{st} is the observed outcome in group s and period t.
- $Treat_s$ is a dummy variable that takes a value of 1 if the observation is from the treatment group and a value of 0 if the observation is from the control group.
- $Post_t$ is a dummy variable that takes a value of 1 if the observation is from the posttreatment period and a value of 0 if the observation is from the pretreatment period.
- X_{st} are the control variables in group s and period t.
- β_3 is the difference-in-differences estimate of the treatment effect.

β_3 captures whether there is a significant difference in the outcome of interest between treatment and control groups as a result of the building of PMGSY roads. The difference-in-differences estimate is given by

$$\beta_3 = (\bar{Y}_{treatment\ endline} - \bar{Y}_{treatment\ baseline}) - (\bar{Y}_{control\ endline} - \bar{Y}_{control\ baseline}).$$

Baseline data were collected in 2009; endline data were collected in 2017. The identification strategy exploits the phasing of the PMGSY investment (the fact that some habitations were connected before others). Habitations connected before 2009 by a PMGSY road serve as the control group; most of these habitations were connected in 2007. Habitations that were connected between 2009 and 2017 (meaning they were unconnected in 2009) serve as the treatment group; most of these habitations were connected in 2014. Rural roads are expected to have annual marginal effects on habitations over a period of time. β_3 captures the difference between the sum of the marginal effects in the first few years minus the marginal effects in the later years. The estimator thus underestimates the effect of PMGSY, which is the sum of all of the annual marginal effects.

This difference-in-differences framework is the main analytical tool used in this report; some variations are applied in some sections. The study is based on household survey data for a sample of habitations in three states: Himachal Pradesh, Madhya Pradesh, and Rajasthan.

The difference-in-differences analysis includes three models with state fixed-effects. Thus, across all three specifications, the analysis accounts for differences across states:

- The first model examines outcomes without including control variables (beyond state fixed effects).
- The second model controls for several village-level variables, including variables from the 2011 census: population; whether the habitation had a public primary school, a public middle school, or a bank; and whether power supply for domestic use was available.[1] It also includes distance to the nearest statutory or census town and a measure of the ruggedness of the terrain.
- The third model controls for several household-level variables, including the social group; the number of household members; and the gender, age, marital status, and number of schooling years of the head of household.

Heterogeneous impacts are calculated by extending the difference-in-differences model by including interactions with some key characteristics, including distance from an urban agglomeration, the ruggedness of the terrain, and gender (one at a time). This part of the analysis was conducted to determine whether distance from an urban agglomeration or the ruggedness of the terrain affected the impact of PMGSY roads and whether there were gender differences in the program's impact.

Data

The impact evaluation combines two main sources of data to construct a panel of habitations with two data points: baseline (2009) and endline (2017). MoRD collected data between 2009 and 2011 to understand the magnitude and distribution of impacts of PMGSY. The 2009 round is used as the baseline. In 2017 the study team revisited the habitations in Himachal Pradesh, Madhya Pradesh, and Rajasthan that were surveyed in 2009.

The baseline data lacked habitation names but included the end nodes of the road connecting each habitation and the names of the state, district, block, and village. The team merged these data with the OMMAS data to find the name of each habitation. A team was sent to the identified habitations with information on all households surveyed in 2009. It confirmed 80 percent of the habitations.

Only the habitations confirmed were surveyed in 2017 to create the panel of habitations. It consisted of 127 habitations in the control group and 26 in the treatment group (table 2.1). Treatment and control habitations are from different villages but from the same nine districts and three states.[2] On average the sample contains 18 households per habitation at baseline and 15 at endline.[3] Because of the eight-year span between the surveys, about a third of the households surveyed in 2009 could not be found in 2017. Random replacements were selected in the corresponding habitations. As the dataset is a panel of habitations and a repeated cross-section of households, attrition at the household level is not a concern.

Table 2.1 Number of habitations and households included in the panel

	2009		*2017*	
Item	*Control group*	*Treatment group*	*Control group*	*Treatment group*
Habitations				
Total	127	26	127	26
Himachal Pradesh	21	3	21	3
Madhya Pradesh	43	14	43	14
Rajasthan	63	9	63	9
Households				
Total	2,301	425	1,914	391
Himachal Pradesh	430	51	315	45
Madhya Pradesh	697	221	644	211
Rajasthan	1,174	153	955	135

A household survey and a habitation survey were conducted at baseline and endline. For the endline survey, in 2017, the questionnaires were streamlined to remove questions for which the response rates were too low in the baseline; a few questions were also added, in order to collect more information for quality-check purposes and for a potential third round of data collection in a few years. A section on gender was also added, including questions about agency, economic empowerment, and physical mobility for the main woman in the household. The rest of the household questionnaire collected information about household characteristics, profiles of household members, employment, travel, medical treatment, immunization and health, cropping patterns, household amenities, and household assets. The habitation survey collected data by interviewing key informants considered to be the habitation leader, representative, or well-informed elder. It covers amenities and general characteristics of the habitations.

Spatial data were also used as control variables in the analysis. Information about the presence of a public primary school, public middle school, and a commercial bank; domestic power supply; and the population were obtained from the 2011 census (Government of India 2011). The ruggedness of the terrain of the habitation was extracted from the dataset of terrain ruggedness created by Nunn and Puga (2012).[4] Distance to the nearest statutory or census town is the linear distance between a habitation and the nearest statuary or census town in the 2011 census (the centroid of the polygon marked as a statuary town).

Tables 2.2 and 2.3 present the mean and sample size for all control variables used and the *t*-test for the difference in the sample means. The population in the average village was 941 in the control group and 916 in the treatment group. The average village has power supply for domestic use. Only about 5 percent of villages have a bank. More than 85 percent of villages have a public primary school, but less than 40 percent have a public middle school. The distance to the nearest statutory or census town is 16 kilometers in the control group and 13 kilometers in the treatment group. The average terrain ruggedness is higher in treatment habitations than in control habitations. The treatment and control groups are not statistically different in terms of the village/habitation-level controls.

Table 2.2 Summary statistics for village-level control variables from the 2011 Census of India

	Control group		*Treatment group*		
Control variable	*Mean*	*N* [a]	*Mean*	*N* [a]	T-*test*
Village population	941	126	919	25	0.179
Distance to nearest statutory or census town (kilometers)[b]	16	126	13	25	1.054
Terrain ruggedness [b]	0.64	126	1.08	25	–1.218
Availability of power supply for domestic use	0.92	126	1.00	25	–1.458
Village has public primary school	0.87	126	0.80	25	–0.839
Village has public middle school	0.39	126	0.28	25	–1.026
Village has bank (commercial or cooperative)	0.06	126	0.04	25	0.315

Note: a. Data on some of village/habitation-level controls are missing for one habitation in each group. b. Variable is at the habitation level.

The average households in the control and treatment groups were similar. At baseline the average household in the control group had 5.4 members, and the average household in the treatment group had 5.1 members. Up to 7 percent of households were headed by a woman at baseline, which slightly increased by endline. In both groups, the average household head was 47 years old at baseline, with almost four years of schooling; about 90 percent of household heads were married. At baseline, about 75 percent of households in the control group and 86 percent of households in the treatment group were from a scheduled caste, scheduled tribe, or other backward class. The small difference in household size and social group were the only statistically significant differences. Even in randomly selected samples, there can be some differences across treatment and control groups, pointing to the importance of adding control variables to the regression model.

Table 2.3 Summary statistics for household-level control variables

	2009					*2017*				
	Control group		*Treatment group*			*Control group*		*Treatment group*		
Control variable	*Mean*	*N*	*Mean*	*N*	T-*test*	*Mean*	*N*	*Mean*	*N*	T-*test*
Social group[a]	0.25	2,301	0.14	425	4.923***	0.20	1,914	0.14	391	3.103**
Household size	5.4	2,300	5.1	424	2.403**	5.0	1,914	4.8	391	1.582
Female-headed household	0.06	2,286	0.07	419	–1.137	0.09	1,914	0.11	391	–0.850
Age of head of household	47	2,283	47	417	–0.008	51	1,914	50	391	1.209
Head of household is married	0.91	2,286	0.90	419	0.205	0.88	1,914	0.87	391	0.565

Years of schooling of head of household	3.7	2,277	3.6	419	0.737	4.1	1,914	4.3	391	–0.745

Note: a. Social group is the share of households that are not scheduled castes, scheduled tribes, or other backward classes, as defined by the government of India. *** p < 0.01.

The main challenge of an impact evaluation is to define a control group that differs from the treatment group in only one respect: not receiving the program. Table 2.4 presents the means for the village-level control variables for the control and treatment groups using data from the 2001 Census of India and the test for differences in means. The test for differences in means indicates that the treatment and control groups were not statistically different in 2001, before any of the habitations was connected.

Table 1.4 Summary statistics for village-level control variables from the 2001 Census of India

	Control group		*Treatment group*		
Control variable	*Mean*	*N*	*Mean*	*N*	T-*test*
Village population	817.83	127	792.64	25	0.170
Power supply for domestic use is available	0.79	127	0.92	25	–1.530
Village has a primary school	0.94	127	0.96	25	–0.435
Village has a middle school	0.25	127	0.20	25	0.531
Village has a bank (commercial or cooperative)	0.03	127	0.04	25	–0.224

The assumption of parallel trends in outcomes in the absence of treatment was tested using two data sources: nightlights and data from the 1991 and 2001 Censuses of India. Annual nightlights data were used to compare economic activity (for which these data are proxies) by control and treatment habitations between 1992 and 1998, one year before the launch of PMGSY (the one-year cutoff was used to avoid picking up any impact of the expectation of road connectivity). The treatment and control habitations followed similar trends (figure 2.1). To statistically test for differences in nightlights trends, a difference-in-differences model at the habitation level was estimated. It confirmed that there is no significant difference between treatment and control groups over time. A difference-in-differences regression model on 27 variables from the 1991 and 2001 Censuses of India was used to assess whether the treatment and control habituations followed significantly different trends between 1991 and 2001. For all 27 variables, the null hypothesis of equal trends could not be rejected (table 2.5). These results indicate that there were no discernable differences across treatment and control groups over time.[5]

Figure 2.1 Trends in nightlights

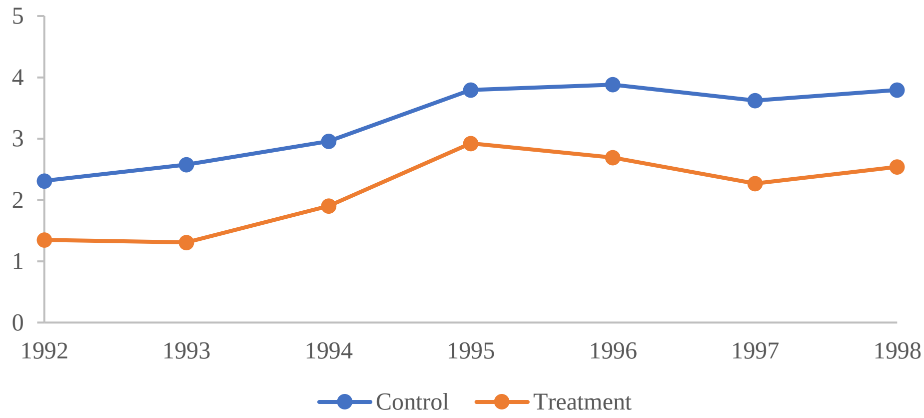


Table 2.5 Test of parallel trends in treatment and control groups, 1991–2001

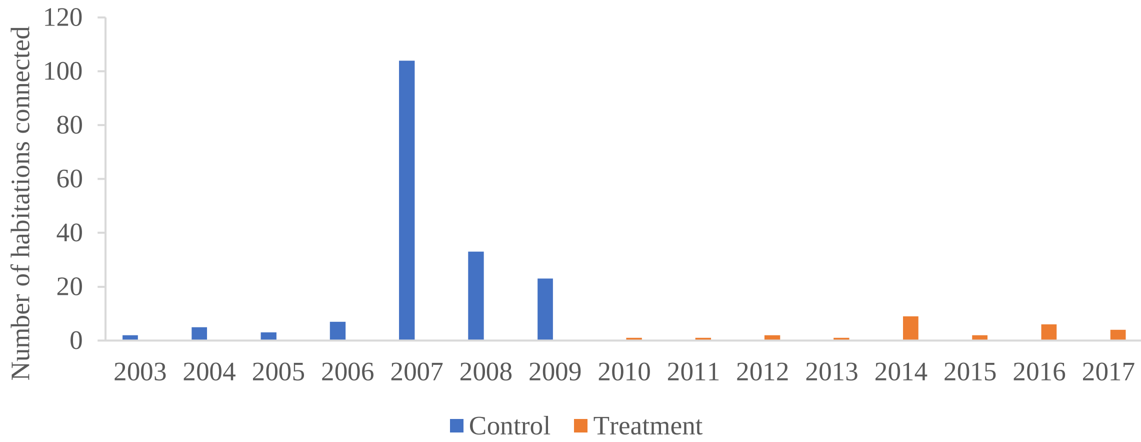
Variable	P-*value*	*Variable*	P-*value*
Total population	0.80	Number of post offices	0.56
Total scheduled caste population	0.94	Number of telephone connections	0.45
Total literate population	0.86	Bus services (yes/no)	0.38
Total literate population (male)	0.95	Paved approach road	0.71
Total main workers	0.96	Mud approach road	0.63
Main worker (male)	0.89	Power supply (yes/no)	0.54
Educational facilities (yes/no)	0.37	Total irrigated area	0.84
Number of primary schools	0.46	Unirrigated area	0.77
Number of middle schools	0.59	Scheduled caste population as share of total population	0.75
Number of secondary schools	0.64	Literate population as a share of total population	0.20
Medical facilities (yes/no)	0.93	Literate male population as share of total literate population	0.17
Number of hospitals	0.95	Main workers as share of total population	0.43
Number of health centers	0.68	Main male worker as share of total main workers	0.57
Tap water (yes/no)	0.71		

Robustness Checks

A set of robustness checks was performed, including testing the models with no fixed effects and district fixed effects. For binary outcomes, logistic regressions were estimated. The results are discussed in the following chapters.

A few habitations were connected with a PMGSY road in 2009 (figure 2.2), the year the baseline survey was implemented. As the time between completion of the roads and implementation of the survey was only a few months for these habitations, inclusion of these habitations in the control group could attenuate the impacts of PMGSY. Therefore, as a robustness check, all regressions were estimated after dropping all habitations connected in 2009 from the sample. The results were similar to those presented in chapters 3–5.

Figure 2.2 Number of control and treatment habitations connected, 2003–17



Notes

[1] The 2011 Census of India is used because most of its variables relevant to the analysis were recorded in 2009, the same year as the baseline.

[2] The nine districts are Kangra and Shimla in Himachal Pradesh; Dhar, Sagar, Seoni and Sidhi in Madhya Pradesh; and Barmer, Bhilwara, and Nagaur in Rajasthan.

[3] The difference in the number of households between baseline and endline is a survey design feature because of budget constraints.

[4] Ruggedness is measured in hundreds of meters of elevation difference for grid points 30 arc-seconds (926 meters on a meridian) apart.

[5] Because of the small sample size (26 treatment habitations), the tests are underpowered. Both sets of results still give confidence about the comparability of treatment and control groups.

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Chapter 3 Impacts of PMGSY on Travel Patterns

Spatial isolation is an important contributing factor to sustained poverty in rural areas (Chambers 1984). Better transportation infrastructure provides the means to link spatially isolated rural population to market areas and to vital social and economic services. The role of transport in stimulating rural development is therefore critical.

This chapter examines the effect of PMGSY on travel patterns. It begins by reviewing the literature on the effect of rural roads on travel patterns.

Review of the Literature

Investment in rural roads in developing countries improved accessibility of rural populations, by cutting travel times, reducing transport costs, and increasing trip frequency. Tian, Li, and Chen (2009) investigate the impact of rural road investments in a group of villages in Fujian Province, China, using a propensity score–matched difference-in-differences method. They find evidence of travel time savings and an increase in trip frequency in villages in which roads had been rehabilitated. A comparative (ex ante versus ex post) analysis by Asomani-Boateng, Fricano, and Adarkwa (2015) finds that provision of rural roads in rural Ghana was associated with reductions in trip duration to schools and health facilities.

Limited empirical evidence exists, however, on the causal impact of rural road provision on travel patterns in India. Using a with-and-without study design, Bell and van Dillen (2014) find evidence of better accessibility to primary and secondary schools and health services and reduction in the cost of transporting crops in villages connected by PMGSY in Orissa. Using multiple-criteria decision-making tools, Kanuganti and others (2015) find evidence of better accessibility to medical facilities in a group of villages in Rajasthan, India connected by an all-weather road. Aparna and others (2017) examine three geographical areas in the West Midnapore district of West Bengal. They use simple *t*-tests to examine the number of trips before and after these areas were served by PMGSY roads. They find that an increase in the number of trips for work, education, and other purposes is correlated with the construction of PMGSY roads in West Bengal.

Results of This Study

Impact on Mobility Patterns and Costs

This section examines the travel patterns of rural populations in habitations connected by all-weather roads through the PMGSY program. It uses a trip as the basic unit of measurement. Trips are characterized by various social and economic purposes (destinations) inside and outside the habitation, as well as, by various modes of transport.

Improvement in road connectivity can affect various aspects of a trip. It can result in people traveling farther, faster, and/or cheaper.

Did people in PMGSY-connected habitations experience reductions in average trip duration and cost, increases in travel speed and distance, and increases in trip frequency? In the sample at baseline, an average trip took about 37 minutes, covered 8.2 kilometers, and cost about 19.3 rupees (see table 3A.1 in the annex for summary statistics). Trips to school and work tended to be shorter, took less time, and cost less. Trips to hospitals/medical centers and local markets took longer and cost more. On average at baseline a household made about 8.4 trips a week. Households that travelled for work or school made 6.1 and 6.3 trips a week on average, respectively. In contrast households who travel to local market or hospital/medical center make fewer trips on average per week, 1.6 and 0.7, respectively. Regarding the modes of transport at baseline, on average households make half of their trips walking, followed by public transport (37 percent of trips), bicycle (8 percent), and motorized vehicles (4 percent).

The results of the difference-in-differences analysis suggest that on average, rural roads improved accessibility by reducing travel time without reducing travel distance: People did not travel farther, but they got to their destinations faster. The estimated coefficients in table 3.1 show that the average travel time for people connected after 2009 (treated habitations) significantly decreased. This decrease appears to have been driven by trips to work and the local market. The estimated coefficient (–13.63) of model 3 in table 3.1 suggests an overall travel time saving of nearly 14 minutes for trips to the local market. For trips to work, the time saving was about nine minutes. For distance travelled by destination, it cannot be ruled out that the average effect is statistically zero.

Table 3.1 Impact of PMGSY roads on travel time and distance, by destination

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Travel time by destination (minutes)			
All destinations	–10.999***	–10.259***	–10.819***
	(3.94)	(3.81)	(3.87)
Work	–8.290**	–8.626**	–8.530**
	(3.98)	(4.11)	(3.96)
School	2.108	3.198	3.031
	(5.41)	(4.37)	(5.05)
Local market	–13.981**	–14.388**	–13.627**
	(5.70)	(5.98)	(5.61)
Hospital/medical center	–14.358**	–10.416*	–14.155**
	(7.01)	(5.67)	(7.00)
Travel distance by destination (kilometers)			
All destinations	0.837	0.865	0.930
	(1.20)	(1.25)	(1.20)
Work	–0.664	–0.597	–0.701
	(2.02)	(2.08)	(2.02)
School	0.974	1.380	1.481

	(1.96)	(1.85)	(1.86)
Local market	2.611	2.438	2.608
	(1.99)	(2.08)	(1.98)
Hospital/medical center	1.527	1.918	1.554
	(2.48)	(2.52)	(2.48)
Travel time per kilometer by destination (minutes)			
All destinations	–2.462	–2.413	–2.557*
	(1.50)	(1.55)	(1.51)
Work	–5.753**	–6.218**	–5.809**
	(2.51)	(2.55)	(2.54)
School	1.011	0.861	–0.049
	(3.36)	(3.43)	(3.31)
Local market	–2.041*	–1.700	–2.000*
	(1.09)	(1.04)	(1.08)
Hospital/medical center	–1.750	–1.787	–1.815
	(1.98)	(2.09)	(2.01)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

People in connected habitations enjoyed savings in travel time as a result of faster travel speed (travel time per kilometer). Travel time per kilometer variables have mostly negative values, suggesting an increase in travel speed, with the impact on travel time per kilometer to the workplace, local market and all destinations being statistically significant.[1] On average, the increase in travel speed to the workplace yielded a six-minute reduction in travel time for every kilometer traveled (the estimated coefficients range between –5.753 and –6.218 across the three models).

The impact of the all-weather roads built under PMGSY, depends on the terrain around the habitation. For distance to hospitals and medical centers, it cannot be ruled out that the average effect is statistically zero (table 3.1). When interacted with the ruggedness of the terrain in and around the habitation, the effect becomes significant (table 3.2). For habitations in hillier areas, the distance declines; for habitations in flatter areas, it increases. The coefficient for the terrain interaction effect on travel distance to hospitals and medical centers of –2.387 (model 3 in table 3.2) implies that in habitations with terrain that is two standard deviations more rugged than the mean, travel distance decreased by 8 kilometers more than in habitations with average terrain ruggedness.[2] The impact on travel time to all destinations, the local market, and the hospital is similar with respect to terrain.

Table 3.2 Differential impacts of PMGSY roads on travel time and distance based on terrain

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Travel time by destination (minutes)			
All destinations	–4.478**	–4.568**	–4.498**
	(1.89)	(1.89)	(1.89)
Work	–1.246	–1.175	–1.309
	(1.09)	(1.10)	(1.09)
School	–2.023	–1.781	–2.176
	(1.57)	(1.45)	(1.57)
Local market	–7.493***	–7.751***	–7.512***
	(2.44)	(2.43)	(2.45)
Hospital/medical center	–8.994***	–8.991***	–9.058***
	(2.66)	(2.61)	(2.63)
Travel distance by destination (kilometers)			
All destinations	–0.626	–0.620	–0.647
	(0.56)	(0.56)	(0.58)
Work	–0.543	–0.543	–0.575
	(0.54)	(0.54)	(0.55)
School	–0.779	–0.647	–0.780
	(0.92)	(0.93)	(0.88)
Local market	–0.643	–0.705	–0.693
	(0.89)	(0.88)	(0.89)
Hospital/medical center	–2.339**	–2.231**	–2.387**
	(1.01)	(1.01)	(1.02)
Travel time per kilometers by destination (minutes)			
All destinations	–0.349	–0.348	–0.345
	(0.34)	(0.34)	(0.35)
Work	–0.114	–0.048	–0.137
	(0.65)	(0.66)	(0.64)
School	–1.224	–1.428*	–1.071
	(0.74)	(0.80)	(0.73)
Local market	–0.166	–0.181	–0.156
	(0.32)	(0.31)	(0.32)
Hospital/medical center	–0.060	–0.051	–0.034
	(0.32)	(0.35)	(0.31)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Rural roads have no statistically significant impact on transport costs. The estimated coefficients for travel cost to a local market range between 5.5 and 7.7 across the three models (table 3.3), suggesting a five- to eight-rupee increase in travel cost. However, it cannot be ruled out that these estimates are zero. The same results arise when looking at travel cost per kilometer. Total travel costs could increase if people switch to more expensive transport modes. The share of motorized vehicles rose, but so did the share of bicycles as mode of transport, which may explain the lack of impact on transport costs (table 3.4).[3]

Table 3.3 Impact of PMGSY roads on travel cost, by destination

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Travel cost by destination (rupees)			
All destinations	4.702	3.321	4.984
	(3.40)	(3.52)	(3.33)
Work	2.674	2.296	2.978
	(3.27)	(3.75)	(3.28)
School	4.556	2.960	5.181
	(3.55)	(3.62)	(3.37)
Local market	7.710	5.479	7.724
	(4.97)	(4.71)	(4.94)
Hospital/medical center	4.624	2.888	4.406
	(5.86)	(6.07)	(5.79)
Travel cost per kilometers by destination (rupees)			
All destinations	–0.121	–0.022	–0.099
	–0.57	(0.59)	(0.58)
Work	0.630	1.056	0.737
	(0.65)	(0.93)	(0.72)
School	0.207	0.288	0.304
	(0.63)	(0.72)	(0.66)
Local market	–0.219	–0.105	–0.229
	(0.47)	(0.46)	(0.47)
Hospital/medical center	–0.481	–-0.370	–0.518
	(1.05)	(1.01)	(1.07)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.

Table 3.4 Impact of PMGSY roads on trip frequency, by destination and mode

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Number of trips per week			
To all destinations	–0.116	0.057	-0.136
	(1.02)	(1.03)	(1.02)
To work	–0.557**	–0.493*	–0.557**

	(0.26)	(0.26)	(0.26)
To school	–0.065	–0.235	–0.106
	(0.34)	(0.32)	(0.32)
To local market	–0.120	–0.121	–0.133
	(0.28)	(0.29)	(0.28)
To hospital/medical center	–0.036	0.061	–0.044
	(0.15)	(0.12)	(0.16)
Share of trips by mode			
Walking	–0.023	–0.015	–0.028
	(0.07)	(0.07)	(0.07)
Bicycle	0.033*	0.030*	0.031*
	(0.02)	(0.02)	(0.02)
Motorized vehicles	0.073**	0.068**	0.074**
	(0.03)	(0.03)	(0.03)
Public transport	–0.083	–0.086	–0.079
	(0.08)	(0.08)	(0.08)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Public transport includes buses, minibuses, auto-rickshaws, and jeeps/vans.
** $p < 0.05$, * $p < 0.1$.

Rural roads have a stronger impact on the frequency of trips to work and local markets in the hardest to reach habitations. The average effect of rural roads on the number of weekly trips for all destinations except work is not statistically significant (see table 3.4). For trips to work, the average household in habitations connected after 2009 traveled about half a trip a week less than households in the control group. This decrease was less pronounced in habitations in hillier areas. The coefficient for the terrain interaction effect on trips to work of 0.231 (model 3 in table 3.5) implies that in habitations with terrain ruggedness two standard deviations above the mean, households made 0.77 more trips to work a week than in the habitation with average terrain ruggedness; in the flattest habitation in the sample, the number of weekly trips to work decreased by 0.66. Patterns on trips to local markets were similar, suggesting that in hilly areas, construction of all-weather roads increased access to economic opportunities. However, relative to flatter areas, PMGSY roads in hillier areas did not have a statistically significant impact on the number of trips to school or hospital.

Table 3.5 Differential impact of PMGSY roads on trip frequency based on terrain ruggedness

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Number of trips per week			
To all destinations	0.128	0.120	0.125
	(0.09)	(0.09)	(0.09)
To work	0.234***	0.220***	0.231***
	(0.07)	(0.07)	(0.07)
To school	–0.126	–0.115	–0.128

	(0.09)	(0.09)	(0.09)
To local market	0.318***	0.327***	0.321***
	(0.10)	(0.10)	(0.10)
To hospital/medical center	0.064	0.040	0.065
	(0.07)	(0.07)	(0.07)
Share of trips by mode			
Walking	–0.016	–0.017	–0.016
	(0.02)	(0.02)	(0.02)
Bicycle	–0.010***	–0.009***	–0.009***
	(0.00)	(0.00)	(0.00)
Motorized vehicle	–0.007	–0.006	–0.007
	(0.01)	(0.01)	(0.01)
Public transport	0.033*	0.034*	0.033*
	(0.02)	(0.02)	(0.02)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Public transport includes buses, minibuses, auto-rickshaws, and jeeps/vans.
*** $p < 0.01$, * $p < 0.1$.

Impacts on Crop Transport Patterns and Costs

Improvements in road connectivity could affect several aspects of crops and trips. It could, for example, result in farmers traveling to markets to sell their crops instead of selling the crops to middlemen that come to the farm (or not selling their crops at all). It could also result in farmers travelling to markets farther away and/or incurring lower transport costs. The objective of this section is to determine whether farmers in PMGSY-connected habitations enjoyed these benefits.

PMGSY improved farm-to-market connectivity in the sample of habitations surveyed. In 2009 farmers in habitations that were not connected with a PMGSY road travelled to markets to sell only 4 percent of their food grain crops, the most common crop in the surveyed habitations. PMGSY roads triggered an 8 percentage point increase in the share of crops transported to markets for sale (table 3.6), tripling the average share of crops sold in market. The impact of all-weather roads on the share of crops transported to markets was more pronounced in hillier areas than in flatter ones, as indicated by the positive and statistically significant coefficient in table 3.7.

Table 3.6 Impact of PMGSY roads on crop transport patterns and costs

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Food grains transported to market (share)	0.078*** (0.03)	0.076** (0.03)	0.080*** (0.03)
Distance to market for food grains (kilometers)	9.769** (4.20)	7.239* (3.94)	8.909** (3.99)
Transport cost to carry food grains to market (rupees)	–132.742 (349.54)	–151.520 (347.74)	–171.048 (334.52)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
*** $p < 0.01$, ** $p < 0.05$.

Table 3.7 Differential impact of PMGSY roads on crop transport patterns and costs based on terrain ruggedness

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Food grains transported to market (share)	0.049***	0.049***	0.049***
	(0.01)	(0.01)	(0.01)
Distance to carry food grains to market (kilometers)	–0.346	–0.422	–0.400
	(0.95)	(0.93)	(0.93)
Transport cost to carry food grains (rupees)	19.959	22.399	13.396
	(59.41)	(59.33)	(60.03)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
*** $p < 0.01$.

The improvement in rural road connectivity seem to have led farmers to take advantage of more favorable market conditions. Farmers selling food grains travelled 8.9 kilometers farther to sell their crops in response to the improved connectivity provided by PMGSY roads, which represents an 88 percent increase in the distance travelled. The cost to carry crops to markets does not seem to have increased as a result of improved connectivity. The results suggest that farmers are travelling to locations where they can get better prices for their crops.

Robustness Check

The results on mobility, crop transport patterns, and costs are robust to different specifications. When using district fixed effects and no fixed effects for each outcome variable, the results from the three models remained largely the same as the results presented in this chapter. The only exception is that the average effect on distance to transport food grains becomes statistically insignificant with district fixed effects.

Concluding Remarks

The analysis presented in this chapter is the first comprehensive assessment of the impacts of PMGSY on households' travel patterns and costs and farmers' transportation patterns and costs using a difference-in-differences approach. Bell and van Dillen (2014) look at travel patterns to school and health facilities and costs for transporting crops in habitations connected by PMGSY. Because of data limitations, they used a with-and-without design or single-difference approach, which raises concerns about the attribution of the impacts to PMGSY. Asher and Novosad (2018) used a regression discontinuity approach and census data. They found an increase in the availability of transport services as a result of PMGSY roads. Because of data limitations, they did not look at impacts on the demand side.

The analysis presented in this chapter is one of the main contributions of this report to understanding how people respond to improvements in connectivity. Thanks to PMGSY roads, on average people reached their destinations, particularly work, faster. The number of weekly trips to work increased in hilly areas and decreased in flat areas, possibly indicating that people travelled to towns farther away and stayed overnight instead of commuting daily. Shedding light on every link of the result chain would allow policy makers to design interventions that maximize net benefits.

Households' transport costs did not seem to change after PMGSY roads were built. This finding might reflect the fact that people switched from walking and public transport to bicycles and private motorized vehicles. Lack of competition in the provision of transport services could also explain the lack of change in transport costs. If the availability of transport services increased in the studied habitations, as Asher and Novosad (2018) found for the habitations in their sample, the poor quality of transport services could explain people switching away from public transport. The collection and analysis of data on market structure, competition, quality of service, and people's choices of public transport could help policy makers make decisions.

Notes

[1] The coefficients for all destinations in models 1 and 2 and local market in model 2 are significant at just below the 90 percent.

[2] The mean terrain ruggedness for the sample is 0.71, the standard deviation is 1.67, and the minimum is 0.02.

[3] The share of trips by bicycle loses significance when habitations connected in 2009 are dropped.

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Annex 3A Summary Statistics

Table 3A.1 Summary statistics on outcome variables

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Travel time by destination (minutes)								
All destinations	35.2	5,583	47.4	983	36.5	3,946	37.2	749
Work	23.9	1,643	29.0	301	25.3	1,215	21.9	249
School	23.2	786	24.5	118	27.9	759	31.3	131
Local market	43.8	1,795	60.7	326	48.4	1,113	50.5	204
Hospital/medical center	44.7	1,359	64.0	238	44.5	859	48.4	165
Travel time per kilometers by destination (minutes)								
All destinations	11.1	5,583	13.9	983	4.7	3,946	4.8	749
Work	16.0	1,643	22.6	301	6.1	1,215	6.4	249
School	19.6	786	19.5	118	6.8	759	7.0	131
Local market	6.9	1,795	8.4	326	3.2	1,113	2.7	204
Hospital/medical center	6.1	1,359	7.6	238	2.8	859	2.9	165
Travel distance by destination (kilometers)								
All destinations	8.3	5,583	7.9	983	14.8	3,946	15.2	749
Work	2.9	1,643	2.2	301	8.2	1,215	6.9	249
School	3.8	786	3.7	118	8.9	759	9.8	131
Local market	11.5	1,795	10.6	326	20.7	1,113	22.2	204
Hospital/medical center	13.1	1,359	13.7	238	21.8	859	23.3	165
Travel cost by destination (rupees)								
All destinations	20.1	3,502	15.4	727	25.1	3,941	25.7	748
Work	8.8	666	1.8	166	12.3	1,215	8.2	249
School	8.1	421	5.2	88	11.3	758	12.5	131
Local market	23.4	1,351	19.8	261	33.8	1,112	38.9	204
Hospital/medical center	27.8	1,064	24.7	212	44.3	856	46.6	164
Travel cost per kilometers by destination (rupees)								
All destinations	1.9	3,502	1.9	727	1.6	3,941	1.5	748
Work	1.5	666	0.4	166	1.1	1,215	0.7	249
School	1.4	421	1.0	88	1.0	758	0.8	131
Local market	2.0	1,351	2.2	261	2.0	1,112	2.1	204
Hospital/medical center	2.3	1,064	2.9	212	2.4	856	2.8	164
Number of trips per week								
To all destinations	8.3	2,255	8.4	412	8.4	1,689	8.4	324
To work	6.1	1,638	6.6	299	6.4	1,215	6.4	249
To school	6.3	785	6.5	117	6.7	759	6.8	131
To local market	1.7	1,790	1.7	325	1.1	1,113	1.0	204
To hospital/medical center	0.7	1,356	0.7	237	0.2	859	0.1	165
Share of trips by mode								
Walking	0.50	5,583	0.52	983	0.41	3,946	0.41	749
Bicycle	0.08	5,583	0.05	983	0.03	3,946	0.03	749
Motorized vehicle	0.05	5,583	0.03	983	0.15	3,946	0.21	749
Public transport	0.37	5,583	0.39	983	0.41	3,946	0.36	749

Note: An observation is a trip made by household members for specific purposes. *N* represents the total number of trips made by all households in the data set. Public transport includes bus, minibus, auto-rickshaw, and jeep/van.

Table 3A.2 Summary statistics of agriculture-related outcome variables

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Crops transported to market (share)								
Food grains	0.08	2,974	0.04	626	0.95	1,519	0.99	413
Distance to market (kilometers)								
Food grains	12.1	242	10.1	24	16.8	1,448	22.4	408
Cash crops	11.9	18	—	0	18.8	266	14.8	32
Horticulture	12.0	41	15.0	2	39.7	69	3.0	1
Transport cost to market (rupees)								
Food grains	594	223	726	22	344	1,261	322	348
Cash crops	173	14	—	0	425	224	435	25
Horticulture	1,630	40	1,457	2	4,739	65	175	2

Note: — Not available.

Chapter 4 Impact of PMGSY on Economic Opportunities and Well-Being

This chapter presents the results of the difference-in-differences analysis on employment and agriculture outcomes. It begins by reviewing the literature on the effect of connectivity on economic opportunities and well-being of the rural poor.

Review of the Literature

The rural poor often have extremely limited mobility beyond their immediate settlement, because of geographical isolation and the high cost of motorized transport. As a result, they are not able to take advantage of employment opportunities, such as seasonal work, beyond their settlements. Reducing transport costs allows workers to shift from the farm sector to the nonfarm sector (Khandker and Koolwal 2011; Gertler and others 2014; Gachassin, Najman, and Raballand 2015) and to work more (Rand 2012). Construction of new roads also supports the emergence of new nonfarm activities (Mu and van de Walle 2011). Better access to the outside world improves access to economic opportunities and increases welfare (Jacoby 2000, Fafchamps and Shilpi 2009).

Agriculture is the backbone of the rural economy. Rural connectivity plays a pivotal role in promoting agricultural production and commercialization. Improved rural transport can accelerate the introduction of improved farming practices and the transition from subsistence farming to cash crops and a market economy (Omamo 1998; Minten, Koru, and Stifel 2013; Damania and others 2017). Improved rural connectivity also leads farmers to specialize in fewer types of crops (Qin and Zhang 2016). Transport improvements reduce production costs by lowering the delivered price of inputs, including capital and information (the latter by facilitating increased speed of know-how and technological diffusion). Transport improvements reduce the cost of shipping agricultural products to market and extend the distance to break-even locations, thereby expanding the area of land where cultivation is profitable. Consequently, rural connectivity increases net farm gate prices, raises farmer incomes (Kyeyamwa and others 2008), yields more stable incomes, and enables the poor to improve their management of risks.

Studies of PMGSY find positive effects on employment, agriculture, and the wellbeing of rural population. Asher and Novosad (2018) find that a new road causes a 9 percentage points decline in the share of agricultural workers and an equivalent rise in wage labor. They conclude that the changes are driven by work outside the village. Aggarwal (2018) finds an increase in the labor force participation rate of prime-age women in districts in which more people have access to a PMGSY road. She finds evidence of greater market integration through lower prices and increased availability of nonlocal goods in the consumption basket, as well as higher adoption rates of fertilizer and hybrid seeds among farmers in districts with PMGSY roads. The World Bank (2014) finds some evidence of a shift in cropping patterns from food grains to cash crops in Jharkhand and Himachal Pradesh following connection to PMGSY roads.

Results of This Study

Impact on Employment

Employed people include people 21- to 60-years-old who report wage work or business as their primary occupation and people 21- to 60-years-old who report being a student or housewife as their primary occupation but report wage work or business as secondary occupation.[1] Based on these definitions, at baseline the employment rate was 62 percent (see annex table 4A.1). Fifty-five percent of people reported primary employment, with 22 percent of them reporting secondary employment as well; 13 percent of students and housewives reporting having part-time employment.

The analysis shows a robust increase in employment as a result of PMGSY roads. The employment rate increased by 5.5 percentage points between 2009 and 2017 in habitations connected after 2009 thanks to PMGSY roads. The increase represents a 9.5 percent change relative to the mean in 2009 in habitations that were unconnected at that time. The increase in employment reflects an increase in part-time employment, particularly among housewives who started to work, as indicated by a 12 percentage point increase in part-time employment. There was no increase in primary employment and secondary employment (table 4.1).

Table 4.1 Impact of PMGSY roads on employment

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Employment	0.055* (0.03)	0.054* (0.03)	0.056** (0.03)
Primary employment	0.013 (0.02)	0.012 (0.02)	0.013 (0.02)
Secondary employment	0.038 (0.05)	0.048 (0.06)	0.040 (0.05)
Part-time employment	0.116*** (0.04)	0.116*** (0.04)	0.120*** (0.04)
Part-time employment (housewives only)	0.129*** (0.04)	0.130*** (0.05)	0.132*** (0.04)
Nonfarm employment	0.095 (0.06)	0.093 (0.06)	0.089 (0.06)
Nonfarm primary employment	0.127** (0.06)	0.126** (0.06)	0.122** (0.06)
Nonfarm secondary employment	0.136 (0.12)	0.125 (0.12)	0.126 (0.12)
Nonfarm part-time employment	–0.082 (0.16)	–0.051 (0.16)	–0.089 (0.16)

Primary employment outside habitation	0.087* (0.05)	0.082* (0.05)	0.079* (0.05)
Primary nonfarm employment outside habitation	0.076* (0.04)	0.074* (0.04)	0.069* (0.04)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

PMGSY roads triggered a change in the structure of employment in rural India. The rate of primary employment in the nonfarm sector increased by about 12 percentage points as a consequence of PMGSY roads. In 2009 on average 36 percent of people working in unconnected habitations reported a primary occupation in the nonfarm sector. PMGSY roads thus increased the nonfarm primary employment rate by a third. The analysis seems to indicate that many students and housewives stepped in to take care of the farm after road connectivity improved (as indicated by an increase in part-time employment and no observed change in the share of nonfarm part-time employment). The analysis does not show statistically significant changes in secondary employment in the nonfarm sector as a result of PMGSY roads.

PMGSY roads allow people to travel and access markets, including labor markets, outside their habitations. The share of people with primary employment outside their habitation increased by 8 percentage points as a result of PMGSY roads. This increase represents a 35 percent increase relative to the average share of primary employment outside the habitation in 2009 in habitations that were connected after 2009. The observed increase in nonfarm primary employment as a result of PMGSY roads was driven largely by people working outside their habitations, as it became easier to commute to other villages and urban agglomerations. The share of people with nonfarm primary employment outside their habitation increased by 7 percentage points as a result of PMGSY roads.

The effect on employment was stronger in habitations farther from urban agglomerations. Distance to urban agglomerations is defined as the distance from a habitation to the nearest census or statutory town. The increase in employment, particularly part-time employment was higher (and statistically significant) in more remote habitations. PMGSY roads caused a 5.5 percentage point increase in the employment rate in the average habitation (see table 4.1). The coefficient for the distance interaction effect on employment of 0.006 (table 4.2) implies that in habitations 10 kilometers farther away from the nearest urban agglomeration than the average habitation, the effect of PMGSY roads on employment rate was 6 percentage points higher than in the average habitation. The effect of PMGSY roads on part-time employment rate was 11 percentage points higher in habitations 10 kilometers farther away from the nearest urban agglomeration than in the average habitation.

Table 4.2 Differential impact of PMGSY roads on employment based on distance

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Employment	0.006*	0.006*	0.006*
	(0.00)	(0.00)	(0.00)
Primary employment	0.002	0.002	0.002
	(0.00)	(0.00)	(0.00)
Secondary employment	0.006	0.005	0.006
	(0.01)	(0.01)	(0.01)
Part-time employment	0.011**	0.011**	0.011**
	(0.00)	(0.01)	(0.00)
Part-time employment (housewives only)	0.011**	0.011**	0.011**
	(0.01)	(0.01)	(0.01)
Nonfarm employment	–0.004	–0.004	–0.004
	(0.01)	(0.01)	(0.01)
Nonfarm primary employment	–0.003	–0.003	–0.003
	(0.01)	(0.01)	(0.01)
Nonfarm secondary employment	0.002	0.001	0.002
	(0.01)	(0.01)	(0.01)
Nonfarm part-time employment	–0.020	–0.023	–0.018
	(0.01)	(0.01)	(0.01)
Primary employment outside habitation	–0.001	–0.000	–0.001
	(0.00)	(0.00)	(0.00)
Primary nonfarm employment outside habitation	–0.002	–0.001	–0.002
	(0.01)	(0.01)	(0.01)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
** $p < 0.05$, * $p < 0.1$.

In hilly areas, the increase in nonfarm primary employment outside habitations was stronger than in the average habitation, as indicated by the positive coefficient in table 4.3. In habitations with terrain ruggedness two standard deviations above the mean, the rate of nonfarm primary employment outside habitations increased by 9 percentage points more than in the habitation with average terrain ruggedness. As there was no change in the rate of nonfarm primary employment related to terrain, the stronger increase in nonfarm primary employment outside the habitations indicates that people switched the location of their employment without changing the sector thanks to PMGSY roads. In hilly areas, PMGSY roads led to an increase in part-time nonfarm employment (table 4.3).

Table 4.3 Differential impact of PMGSY roads on employment based on terrain

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Employment	0.002	0.003	0.003
	(0.01)	(0.01)	(0.01)
Primary employment	–0.006	–0.006	–0.006
	(0.01)	(0.01)	(0.01)
Secondary employment	–0.002	–0.004	–0.003
	(0.01)	(0.01)	(0.01)
Part-time employment	0.011	0.011	0.011
	(0.02)	(0.02)	(0.02)
Part-time employment (housewives only)	0.016	0.015	0.016
	(0.02)	(0.02)	(0.02)
Nonfarm employment	0.017	0.018*	0.017
	(0.01)	(0.01)	(0.01)
Nonfarm primary employment	0.019	0.019	0.018
	(0.01)	(0.01)	(0.01)
Nonfarm secondary employment	–0.018	–0.019	–0.027
	(0.05)	(0.05)	(0.04)
Nonfarm part-time employment	0.098*	0.081	0.103*
	(0.06)	(0.06)	(0.06)
Primary employment outside habitation	0.015	0.015	0.013
	(0.02)	(0.02)	(0.02)
Primary nonfarm employment outside habitation	0.030***	0.030***	0.028***
	(0.01)	(0.01)	(0.01)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
*** $p < 0.01$, * $p < 0.1$.

Impact on Agriculture

By improving farm-to-market connectivity, PMGSY roads are expected to expand the area of land under cultivation, ease the introduction of improved farming practices, and/or facilitate the transition from subsistence farming to cash crops. At baseline the average farmer cultivated about 10 acres of land. Between 2009 and 2017, the average area of cultivated land decreased in both groups of habitations, with habitations connected after 2009 seeing a smaller decrease (see annex table 4A.2 for summary statistics). The average area of land farmers cultivated for cash crops also decreased. The average yield for each type of crop increased in both groups of habitations between 2009 and 2017.

The impact of PMGSY roads on agriculture outcomes was weaker than expected, possibly suggesting the need for complementary interventions to support the development of agriculture value chains. The analysis found no effect of rural roads on the average land under cultivation when considering all crops (table 4.4). Farmers in habitations connected after 2009 reduced the average land area cultivated for cash crops by 0.3 acres less than farmers in habitations that were already connected by 2009.

Table 4.4 Impact of PMGSY roads on agriculture

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Area of cultivated land (acres)			
All crops	0.832 (1.17)	0.771 (1.10)	0.621 (1.19)
Food grains	0.379 (1.18)	0.375 (1.11)	–0.001 (1.21)
Cash crops	0.301** (0.15)	0.300** (0.15)	0.349** (0.16)
Crop yield (quintals per acre)			
All crops	0.216 (1.28)	0.874 (1.28)	–0.209 (1.28)
Food grains	–0.759 (1.25)	–0.159 (1.21)	–1.022 (1.28)
Cash crops	0.699 (2.37)	1.088 (2.44)	0.815 (2.28)
Crop diversification (Herfindahl Index)	–0.010 (0.05)	0.002 (0.05)	–0.012 (0.04)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Horticulture is not included because of the small number of observations in the treatment group.
** $p < 0.05$.

The impact of PMGSY roads on agriculture outcomes varied with the level of accessibility of the habitation. The area of land under cultivation for food grains decreased in habitations in hilly areas. In habitations with terrain ruggedness two standard deviations above the mean, the area of cultivated land for food grains decreased by 1.4 acres per crop more than in the habitation with average terrain ruggedness after PMGSY roads were built. The average changes in yield between 2009 and 2017 and the differences between both groups of habitations cannot be attributed to PMGSY roads. However, when considering food grains, yields increased in habitations that were farther away from urban agglomerations and in hilly areas as a result of improved connectivity (table 4.5).[2] In habitations with terrain ruggedness two standard deviations above the mean, the yield of food grains increased by 5 quintals per acre more than in the habitation with average terrain ruggedness as a result of PMGSY roads.

Table 4.5 Differential impact of PMGSY roads on agriculture based on distance and terrain

Outcome variable	*Model 1* No controls	*Model 2* Village-level controls	*Model 3* Household-level controls
Area of land cultivated with food grains (acres)			
Distance interaction effect	0.054	0.047	0.043
	(0.05)	(0.05)	(0.05)
Terrain ruggedness interaction effect	–0.457**	–0.453**	–0.434***
	(0.19)	(0.19)	(0.16)
Yield on food grains (quintals per acre)			
Distance interaction effect	0.080*	0.065	0.080*
	(0.04)	(0.04)	(0.04)
Terrain ruggedness interaction effect	1.568**	1.599**	1.541**
	(0.68)	(0.67)	(0.69)
Crop diversification (Herfindahl Index)			
Distance interaction effect	–0.001	–0.001	–0.001
	(0.00)	(0.00)	(0.00)
Terrain ruggedness interaction effect	0.004	0.004	0.004
	(0.01)	(0.01)	(0.01)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Horticulture is not included because of the small number of observations in the treatment group.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Crop diversification offers opportunities to mitigate risks related to the production and price of crops (Mukherjee 2010; Chhatre, Devalkar, and Seshadri 2016). Using the Herfindahl Index to examine crop diversification in 14 Indian states, Mukherjee (2010) finds that Indian farmers increasingly adopt crop diversification to mitigate the risks associated with the production of a single crop.

To assess the impact of PMGSY roads, a crop diversification index is calculated (box 4.1). PMGSY roads do not seem to have any significant average impact on the diversification of crops across habitations (the coefficients for crop diversification in table 4.4 are not statistically significant).

Box 4.1 Crop diversification index

Crop diversification is calculated for each farmer (household) using the Herfindahl Index, which is the sum of the square shares of cultivated land for each crop on the farm:

$$H = \sum_{i=1}^{n} p_i^2$$

where values range between 0 and 1, and p is the share of each crop per farm, defined as

$$p_i = \frac{A_i}{\sum_{i=1}^{n} A_i}$$

where A_i is the acreage of cultivated land for each crop within a farm, and $\sum_{i=1}^{n} A_i$ is the total acreage of cultivated land for all crops. An H equal to 1 indicates complete specialization on a single crop; an H close to 0 indicates high crop diversification.

Robustness Check

The results on employment and agriculture are robust to different specifications. When using district fixed effects and no fixed effects for each outcome variable, the results from the three models (without controls, with village-level controls, and with household-level controls) remained the same in terms of the magnitude of coefficients, their sign, and their statistical significance. For binary outcomes, results were also checked using a binary logistic regression; they were consistent with the results presented in this chapter. The only exception is the heterogeneous effect of terrain ruggedness on nonfarm part-time employment, which becomes insignificant with district fixed effects.

Concluding Remarks

The improved mobility provided by PMGSY roads increased access to economic opportunities, triggering a change in the structure of employment in rural India. Asher and Novosad (2018) find a 9 percentage points decline in the share of agricultural workers and an equivalent rise in wage labor. They conclude that work outside the village is driving the changes, as they do not find commensurate changes in nonfarm employment in the villages.

The analysis presented in this chapter finds a similar shift from farm to nonfarm employment, with the rate of primary employment in the nonfarm sector increasing by about 12 percentage points. The household surveys used for the analysis confirm that the shift to nonfarm employment was largely to nonfarm employment outside the habitation: The share of people with primary employment outside their habitation increased by 8 percentage points as a result of PMGSY roads.

The analysis finds that men are switching primarily to nonfarm employment and that their wives step in to take care of the farm after road connectivity improves. The entrance of married women into the workforce is the main force behind the increase in employment in connected habitations. This result is in line with Aggarwal (2018), who finds an increase in the labor force participation rate of prime-age women in districts with access to a PMGSY road.

PMGSY improved farm-to-market connectivity, as indicated by the large and significant increase in the share of crops transported by farmers to markets. But the increase did not translate into significant changes in farming practices. The average land area under cultivation did not change as a result of road construction, except in habitations in hilly areas, where it decreased. For food grains, the main crop in the habitations studied, rural roads had a positive impact only in habitations farther away from urban agglomerations and in hilly areas. Aggarwal (2018), whose unit of observation is the district, not the habitation, finds higher adoption of fertilizer and hybrid seeds among farmers in districts with more PMGSY roads. The results presented in this chapter are consistent with those of Asher and Novosad (2018), who find no evidence of farmers moving away from subsistence crops, land intensification, or increases in ownership of mechanized farm and irrigation equipment.

The results on employment and agriculture indicate that improved connectivity in rural areas mainly leads people to look for employment opportunities outside their habitations instead of improving and expanding their farming to take full advantage of improved access to input and output markets. This outcome is not bad per se, as villagers may be earning higher incomes by moving to more productive and higher paying activities. However, if India wants to make more efficient use of agriculture land, it needs complementary programs to support the development of agriculture value chains. Such programs should look at the entire value chain, in order to remove constraints on agriculture logistics, such as lack of aggregation and marketing services, take-up of more efficient farming practices, and factors limiting economies of scale.

Notes

[1] A person is considered employed if he or she reported any of the following occupations: farmer, agricultural labor, construction/other labor, artisan, service (private/government), trade/business, or household worker.

[2] The heterogeneous effects on cash crops was not analyzed, because of the small sample size.

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Annex 4A Summary Statistics

Table 4A.1 Summary statistics on employment outcomes

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Employment	0.62	5,794	0.58	1,024	0.59	4,851	0.60	976
Primary employment	0.56	5,794	0.55	1,024	0.53	4,851	0.54	976
Secondary employment	0.22	3,061	0.19	546	0.22	2,561	0.23	522
Part-time employment (students and housewives)	0.14	2,506	0.07	456	0.14	1,931	0.18	360
Part-time employment (housewives only)	0.15	2,396	0.07	441	0.14	1,813	0.19	332
Nonfarm employment	0.42	3,570	0.36	591	0.44	2,854	0.48	588
Nonfarm primary employment	0.45	3,219	0.36	561	0.44	2,587	0.48	525
Nonfarm secondary employment	0.28	684	0.44	106	0.40	565	0.63	118
Nonfarm part-time employment	0.15	351	0.40	30	0.44	267	0.51	63
Primary employment outside habitation	0.26	3,210	0.23	557	0.30	2,587	0.37	525
Primary nonfarm employment outside habitation	0.22	3,210	0.15	557	0.26	2,587	0.28	525

Table 4A.2 Summary statistics on agriculture-related outcome variables

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Area of cultivated land (acres)								
All crops	10.2	1,744	9.0	313	4.7	469	4.8	117
Food grains	8.8	1,744	8.4	313	4.1	469	4.6	117
Cash crops	1.0	1,744	0.5	313	0.4	469	0.3	117
Horticulture	0.3	1,744	0.1	313	0.2	469	0.00	117
Crop yield (quintals per acre)								
All crops	7.3	3,451	6.9	672	9.8	2311	9.4	549
Food grains	6.4	2,946	7.1	617	9.7	1944	9.4	508
Cash crops	3.9	342	4.4	49	8.1	311	8.7	39
Horticulture	30.7	163	13.7	6	21.8	56	10.2	2
Crop diversification (Herfindahl Index)	0.63	1,744	0.57	313	0.63	469	0.56	117

Note: For area of cultivated land and crop diversification, an observation is a farmer. For crop yield, an observation is a crop cultivated by a farmer. Food grains include arhar, barley, gram, horse-gram, jowar, maize, pulses, masoor, millet, moong, moth, pulse, ragi, rice/paddy, soybeans, urad, and wheat. Cash crops include cotton; dry chilies; oilseeds (sesamum, rapeseed and mustard, linseed, and groundnut); guar seed; sugarcane; and tobacco. Horticulture includes apples, arecanut, onions, potatoes, and vegetables.

Chapter 5 Impact of PMGSY on Wealth and Human Capital Accumulation

Improved rural connectivity provides long-term and sustained boost in the living standards of rural people. Improved access to economic opportunities increases income, allowing people to increase consumption and wealth accumulation. Improved connectivity facilitates access to schools and health services, which contributes to human capital accumulation. These benefits of improved rural connectivity can translate into long-term poverty reduction.

This chapter presents the results of the difference-in-differences analysis on the impact of PMGSY roads on wealth, education, and health outcomes. It begins with a review of the literature on these outcomes.

Review of the Literature

Lower transport costs improve access to labor, inputs and outputs markets, increasing income (Escobal and Ponce 2002, Jacoby and Minten 2009, Cuong 2011); raising per capita consumption and improving the livelihoods of rural households (Emran and Hou 2013); and reducing poverty (Dercon and others 2008; Khandker, Bakht, and Koolwal 2009). These effects increase households' asset holdings, which reduces their vulnerability (Krishna and others 2004, Barrett and Swallow 2006, Carter and Barrett 2006). Reducing vulnerability is especially important in environments in which credit and insurance markets do not work for the rural poor, and households rely on their assets to smooth consumption and ensure survival in the face of repeated shocks (Carter and Barrett 2006).

By reducing the time it takes to travel to school, enhanced road access can potentially improve schooling outcomes. Khandker, Bakht, and Koolwal (2009) and Khandker and Koolwal (2011) find positive short- and long-run impacts on schooling—for both boys and girls—of a rural road construction program in Bangladesh, mainly because the connections to new markets increased schooling investment by increasing both household income and the returns to education.

Adukia, Asher, and Novosad (2019) find a positive causal impact of PMGSY all-weather roads on both the enrollment and the educational performance of middle-school children. Consistent with the standard human capital investment model, the effects are larger for roads that are more likely to raise the returns to education and smaller for roads that are more likely to raise the opportunity cost of schooling. However, roads can also increase access to outside job opportunities, which may increase the opportunity cost of schooling, discouraging human capital investment. Aggarwal (2018) and Mukherjee (2012) find that the presence of PMGSY roads increased middle-school enrollment as well as dropout rates for high school students.

Access to roads can also improve health-seeking behavior and health outcomes through multiple channels. Reductions in transportation cost and travel time (Adhvaryu and Nyshadham 2012), improvements in health care supply, and increases in household income and awareness promote health-seeking behavior.

Using a fuzzy regression discontinuity design, Banerjee and Sachdeva (2015) show a positive impact of road access on the use of preventative healthcare services (antenatal care, trained health personnel–assisted delivery, modern contraception, health insurance, and water treatment) by women and households in villages connected by PMGSY. Both demand- and supply-side factors were at play. The authors find improvements in awareness about public healthcare programs, health care supply, and social interaction, both within and between villages.

Consistent with increases in the inputs to the health production function, Bell and van Dillen (2015) find positive effects on health outcomes for a sample of villages in upland Orissa. The provision of an all-weather road led to reductions in the likelihood of an individual in a typical village connected by PMGSY falling sick and the duration of disabling illness. Improved market access had a positive impact on household nutrition in rural Ethiopia (Stifel and Minten 2015). In rural Georgia, road rehabilitation improved access to emergency medical services by cutting the time required for an ambulance to arrive by one third (Lokshin and Yemtsov 2005).

Results of This Study

Impact on Wealth

Two wealth indexes were constructed to assess the impact of PMGSY roads on the socioeconomic status of households. The first uses principal component analysis, the methodology adopted by Gwatkin and others (2000), Filmer and Pritchett (2001), and McKenzie (2005). The second uses the equal weights method, as adopted by Montgomery and others (2000).

The indexes are based on four types of variables: small asset ownership, large asset ownership, water source characteristics, and dwelling characteristics (table 5.1). Several of these variables were also used in the socioeconomic index Filmer and Pritchett (2001) created for India. The data were standardized, in order to be able to use the same unit for all index questions. For each of the assets, water sources, or dwelling characteristics shown in table 5.1, a value of 1 was assigned if the household had it; a value of 0 was assigned if it did not.[1]

Table 5.1 Wealth index based on principal component analysis

Variable	*Mean*	*Standard deviation*	*Weight*	*Bottom 40%*	*Middle 40%*	*Top 20%*
Ownership of small assets						
Mattress	0.76	0.43	0.16	0.58	0.81	1.00
Pressure cooker	0.44	0.50	0.37	0.03	0.57	0.98
Chair	0.59	0.49	0.35	0.15	0.82	1.00

Table	0.44	0.50	0.37	0.03	0.57	0.98
Watch or clock	0.65	0.48	0.17	0.47	0.71	0.90
Bicycle	0.30	0.46	-0.06	0.37	0.29	0.19
Radio	0.11	0.31	0.04	0.06	0.14	0.15
Sewing machine	0.28	0.45	0.26	0.03	0.31	0.73
Mobile telephone	0.70	0.46	0.21	0.47	0.79	0.98
Ownership of large assets						
Motorcycle	0.28	0.45	0.13	0.15	0.32	0.45
Refrigerator	0.17	0.38	0.21	0.01	0.11	0.64
Car	0.04	0.19	0.05	0.00	0.01	0.16
Water source						
Improved water source	0.79	0.41	0.11	0.68	0.81	0.97
Five minutes or less to fetch water	0.41	0.49	0.28	0.13	0.45	0.89
Dwelling characteristics						
Latrine inside house	0.52	0.50	0.30	0.22	0.60	0.98
Kitchen in separate room	0.50	0.50	0.31	0.16	0.60	0.98
Main cooking fuel not biomass	0.15	0.36	0.17	0.02	0.09	0.55
Dwelling of mixed or high-quality materials	0.65	0.48	0.25	0.37	0.78	0.97

Ownership of some assets is more widespread than others. Seventy percent of households own a mobile phone and almost 80 percent have improved water source.[2] But only 21 percent own a refrigerator and 17 percent use a fuel other than biomass for cooking.

The weights from the principal component analysis in table 5.1 show the importance of each variable in constructing the index. For example, owning a sewing machine increases the household wealth index by a larger margin than owning a mobile phone. Richer households have higher rates of asset ownership and lower rates of "negative" assets (using biomass as the main cooking fuel, for example).

The richest 20 percent of households (as defined by the index) have higher rates of all but one of the outcomes, bicycle ownership, which is negatively related with ownership of other assets, dwelling characteristics, and water source. Other studies have also found a negative weight for bicycle ownership (see Vyas and Kumaranayake 2006).

The equal weights index is a much simpler measure of wealth. It assigns a weight of 1 to each asset, water source, and dwelling characteristic listed in table 5.1; it then adds up all the factors to create the index. This index ranges from 0 to 18, where 0 means that the household has none of the factors listed in table 5.1 and 18 means that it has all of the them. Annex table 5A.1 presents the mean of the two indexes for each group of habitation by year.

Table 5.2 illustrates the impact of PMGSY roads on the wealth indexes. The coefficients show that they had a positive effect on the average wealth of households. The average wealth indexes increased in both groups of habitations over time, but households in habitations connected after 2009 experienced larger increases than households connected before 2009. Using the equal weights wealth index as the dependent variable reveals that households connected after 2009 added about one more asset than households that were already connected by 2009—an increase of 0.24 standard deviations or a 12.4 percent with respect to the median wealth in the sample. Using the principal component analysis, the average increase in wealth was equivalent to adding a pressure cooker and a radio to the household's assets.[3] However, the coefficients in model 3 for the principal component analysis is just below the standard 90 percent level of statistical significance.

Table 5.2 Impact of PMGSY roads on household wealth

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Wealth index, principal component analysis	0.226*	0.193	0.196
	(0.13)	(0.14)	(0.13)
Wealth index, equal weights	1.011**	0.831	0.868*
	(0.51)	(0.52)	(0.49)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
** $p < 0.05$, * $p < 0.1$.

The terrain of the locality affected the impact of roads on household wealth (table 5.3). Households in hillier habitations experienced decreases in their average wealth; households in flatter habitations experienced increases. The coefficient for the terrain interaction effect on wealth index calculated using principal component analysis of –0.162 (model 3) implies that in habitations with terrain ruggedness two standard deviations above the mean, household wealth index decreased by 0.36, which represents a 25 percent decrease with respect to the median wealth in the sample.[4] In the flattest habitation in the sample, the household wealth index increased by 0.3, which represents a 21 percent increase with respect to the median wealth in the sample.[5]

Table 5.3 Differential impact of PMGSY roads on household wealth based on distance and terrain

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Wealth index based on principal component analysis			
Distance interaction effect	–0.001	0.002	–0.002
	(0.01)	(0.01)	(0.01)
Terrain ruggedness interaction effect	–0.154***	–0.151***	–0.162***
	(0.06)	(0.06)	(0.05)
Wealth index based on equal weights method			
Distance interaction effect	0.002	0.010	–0.006
	(0.05)	(0.05)	(0.04)
Terrain ruggedness interaction effect	–0.622***	–0.609***	–0.658***
	(0.22)	(0.22)	(0.20)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects.
*** $p < 0.01$.

Impact on Education

Years of completed schooling increased across all levels of education in the habitations surveyed between 2009 and 2017. The analysis stratifies students in the sample into three groups based on their level of schooling, age, and when their habitations were connected to PMGSY roads. Ages 6–11 correspond to primary school, 11–16 to middle school, and 16–20 to high school.[6] For the middle and high school samples, the analysis considers only students with some schooling. Annex table 5A.2 presents the summary statistics.

PMGSY roads had a positive impact on schooling. On average, children who were in middle or high school at the time their habitation was connected had about 0.7 more years of schooling in 2017 as a result of PMGSY roads that were built about three years earlier (table 5.4). The additional years of schooling represent about a 9 percent increase in the years of middle and high school relative to the average at baseline for habitations connected after 2009. The difference-in-difference analysis does not find any statistically significant average effect on years of schooling for children in primary school. There was no significant differential impact on girls. Both girls and boys benefited equally from the construction of PMGSY roads (table 5.5).

Table 5.4 Impact of PMGSY roads on years of completed schooling

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Primary school	–0.021	0.053	–0.066
	(0.27)	(0.29)	(0.27)
Middle school	0.641**	0.653**	0.681***
	(0.25)	(0.26)	(0.25)

High school	0.697**	0.735**	0.748***
	(0.31)	(0.30)	(0.28)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Middle and high school include the intensive margin only.
*** p < 0.01, ** p < 0.05.

Table 5.5 Differential impact of PMGSY roads on years of schooling of girls

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Primary school	–0.604	–0.468	–0.615
	(0.48)	(0.51)	(0.50)
Middle school	0.451	0.500	0.401
	(0.35)	(0.36)	(0.33)
High school	0.419	0.387	0.454
	(0.54)	(0.54)	(0.53)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Middle and high school include the intensive margin only.

PMGSY roads had a positive and significant effect on years of completed schooling for children in primary school in hill areas, with the effect stronger the more rugged the terrain (table 5.6). The coefficient for the terrain interaction effect on years of completed primary school of 0.367 (model 3) implies that in habitations with terrain ruggedness two standard deviations above the mean, completed schooling for children in primary school increased by 1.2 years more than in habitations with average terrain ruggedness. The strong and significant average effects on children in middle and high school were unaffected by terrain ruggedness or distance to the nearest urban agglomeration (table 5.6).

Table 5.6 Differential impact of PMGSY roads on years of completed schooling based on distance and terrain

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Primary school			
Terrain ruggedness interaction	0.412***	0.433***	0.367***
	(0.08)	(0.07)	(0.09)
Distance interaction	–0.014	–0.033	–0.008
	(0.03)	(0.03)	(0.03)
Middle school			
Terrain ruggedness interaction	0.079	0.152	0.067
	(0.12)	(0.12)	(0.12)
Distance interaction	–0.000	–0.019	0.008
	(0.04)	(0.04)	(0.04)
High school			

Terrain ruggedness interaction	–0.063	–0.069	–0.098
	(0.13)	(0.14)	(0.13)
Distance interaction	–0.033	–0.037	–0.006
	(0.03)	(0.03)	(0.03)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Middle and high school include the intensive margin only.
*** $p < 0.01$.

Impact on Health

Health-seeking behavior improved between 2009 and 2017 across all the habitations surveyed. In 2017 the average share of male and female household members that went to the local or regional town for medical treatment was higher than in 2009 (see table 5A.3 for summary statistics). The average share of babies delivered at home also decreased between 2009 and 2017, and the average number of children in the household that received OPV-BCG-polio-DPT-measles vaccines increased.

PMGSY roads had a positive impact on health-seeking behavior. The difference-in-difference analysis indicates a potentially positive effect on the propensity of household members to seek medical treatment in town; however, the coefficients are not statistically significant (see table 5.7). The analysis finds a strong and statistically significant decrease in the propensity for at-home child delivery of more than 14 percentage points. The reduction represents a 30 percent decrease in the share of babies delivered at home relative to the average at baseline for habitations that were connected after 2009. The reduction in delivery at home was greater in habitations farther away from urban agglomerations than in the average habitation (table 5.8). The effect was weaker in habitations in hillier areas than in flatter areas.

Table 5.7 Impact of PMGSY roads on health-seeking behavior

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Went to town for treatment (share)			
Male	0.100	0.119	0.109
	(0.08)	(0.09)	(0.08)
Female	0.029	0.047	0.038
	(0.08)	(0.08)	(0.08)
Baby delivered at home (share)	–0.147**	–0.170**	–0.144**
	(0.07)	(0.07)	(0.06)
Number of children in household immunized	0.161	0.058	0.187
	(0.18)	(0.20)	(0.18)
Share of children in household under four immunized	0.161**	0.191**	0.155**
	(0.08)	(0.09)	(0.08)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Immunization refers to OPV-BCG-polio-DPT-measles vaccines.
** $p < 0.05$.

Table 5.8 Differential impact of PMGSY roads on health-seeking behavior based on distance and terrain

	Model 1	*Model 2*	*Model 3*
Outcome variable	*No controls*	*Village-level controls*	*Household-level controls*
Baby delivered at home (share)			
Distance interaction effect	–0.019**	–0.017**	–0.018**
	(0.01)	(0.01)	(0.01)
Terrain ruggedness interaction effect	0.046**	0.049**	0.044**
	(0.02)	(0.02)	(0.02)
Share of children in household under four immunized			
Distance interaction effect	0.015*	0.012	0.015*
	(0.01)	(0.01)	(0.01)
Terrain ruggedness interaction effect	–0.020	–0.020	–0.019
	(0.01)	(0.02)	(0.01)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Immunization refers to OPV-BCG-polio-DPT-measles vaccines.
** $p < 0.05$, * $p < 0.1$.

The impact of PMGSY roads on child immunization was insignificant when considering all children. The analysis finds a positive, albeit not statistically significant, impact of rural roads on immunization, measured by the number of all children in the household receiving OPV-BCG-polio-DPT-measles vaccines. It is possible that children who do not receive vaccines at the proper age do not receive them later. The availability of vaccination history (whether the child was vaccinated) for all children in the household as recorded at endline (this information is not available at baseline) allows a different identification strategy.

PMGSY roads had a strong and significant impact on immunization of children under age four. Given that 80 percent of the treatment habitations were connected in or after 2014, children born in this period were more likely to benefit than children born just before 2014 (in habitations connected after 2009). Therefore, differences in immunization take-up between children under four and older children in 2017 in the habitations connected after 2009 provide an alternative estimate of the treatment effect, after netting out the same differences estimated in the habitations connected before 2009 to account for any cohort effect. Thanks to PMGSY, the share of children under the age of four that received immunization increased by 15.5–19.0 percentage points, depending on the specification. The improvement in immunization was greater in habitations farther away from urban agglomerations than in the average habitation (see table 5.8). Among children under four, there was no significant differential impact of PMGSY roads on immunizations for girls versus boys (table 5.9).

Table 5.9 Differential impact of PMGSY roads on immunization of girls

Outcome variable	*Model 1* No controls	*Model 2* Village-level controls	*Model 3* Household-level controls
Share of children in household under four immunized	–0.189	–0.181	–0.189
	(0.15)	(0.15)	(0.15)

Note: All regressions are ordinary least squares. Standard errors are in parentheses, clustered at the habitation level. All models include state fixed effects. Immunization refers to OPV-BCG-polio-DPT-measles vaccines.

Robustness Checks

The results on wealth are robust to different specifications. Using district fixed effects and no fixed effects for each outcome variable had little effect on the results from the three models (without controls, with village-level controls, and with household-level controls). The statistical significance of the coefficient for the principal component analysis index was just below 90 percent when tested with district fixed effects. The results on education and health outcomes are also robust to different specifications.

Concluding Remarks

The analysis presented in this chapter finds a small but positive effect on wealth, but it is statistically significant only under some specifications. Asher and Novosad (2018) do not find a significant effect on asset ownership. Further research in this area would help understand the link between improved employment outcomes and asset accumulation, helping policy makers design complementary interventions to increase the benefits of PMGSY.

PMGSY roads had a positive impact on schooling in rural areas, with boys and girls benefiting equally. School attendance is a necessary but not sufficient condition for capital accumulation. The survey used in the study did not collect data on educational performance. Using data on educational performance, Adukia, Asher, and Novosad (2019) find a positive causal impact of PMGSY all-weather roads on both enrollment and educational performance for middle-school children. Aggarwal (2018) and Mukherjee (2012) find that the presence of roads can increase both middle-school enrollment and dropout rates for high school students. The analysis presented in chapters 4 and 5 indicate that a very small proportion of students got part-time jobs after their habitations were connected, but doing so did not translate into dropping out of school. Overall, these results are in line with the results of other research.

Women were more likely to travel to medical facilities to deliver their babies after their habitations were connected with all-weather roads. Roads also increased the share of young children receiving vaccinations. Other studies also show positive impacts of PMGSY on health-seeking behavior and outcomes (see Bell and van Dillen 2015 and Banerjee and Sachdeva 2015).

The impacts on wealth and human capital accumulation could potentially be the most important benefits of the program, as they set the foundations for long-lasting poverty reduction in rural India. Only time will tell if that is the case.

Notes

[1] In the principal component analysis, the covariance matrix was used and only the first component generated retained, a common practice for creating socioeconomic indexes. The first component had an eigenvalue of 1.1 and explained 31 percent of the variation.

[2] The definition of improved water source comes from the Millennium Development Goals (MDGs). It includes water piped into a dwelling, piped to a yard or plot, a public tap or stand pipe, a handpump, a tube well or bore well, a protected well, a protecting spring, and rainwater.

[3] The sum of the weight times the standard deviation for a pressure cooker and a radio is almost 0.196 (see table 5.1).

[4] The decrease is equivalent to 0.37 standard deviations.

[5] The increase is equivalent to 0.31 standard deviations.

[6] Among control (treatment) habitations, 87 percent (80 percent) got connected in the two (three) years preceding the baseline (endline) survey. Children 6–11 years old in the two (three) years before the baseline (endline) survey are considered treated while in primary school. People 11–16 and 16–20 are considered treated while in middle and high school, respectively.

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Annex 5A Summary Statistics

Table 5A.1 Summary statistics on wealth indexes, 2009 and 2017

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variables	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Wealth index based on principal component analysis	1.49	1,862	1.04	315	1.68	1,914	1.53	391
Wealth index based on equal weights approach	6.90	1,862	5.23	315	7.43	1,914	6.98	391

Table 5A.2 Summary statistics on years of completed schooling, 2009 and 2017

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Boys and girls								
Primary school	4.0	2,134	4.3	341	4.8	1,470	5.1	250
Middle school	7.4	1,920	7.2	383	8.5	1,571	8.9	354
High school	9.1	1,237	8.6	224	10.1	1,193	10.4	292
Girls								
Primary school	3.9	918	4.1	156	4.8	738	4.7	117
Middle school	7.2	713	7.2	176	8.3	771	9.2	160
High school	8.8	400	8.1	84	9.9	506	10.3	132

Table 5A.3 Summary statistics on health outcomes, 2009 and 2017

	2009				*2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Traveled to town for treatment (share)								
Male	0.49	1,223	0.34	197	0.64	949	0.62	196

Female	0.49	1,222	0.34	197	0.67	1,054	0.58	228
Baby delivered at home (share)	0.33	2,226	0.47	414	0.26	764	0.25	128
Number of children in household immunized	0.9	714	1.0	123	1.4	533	1.6	87

Note: Immunization refers to OPV-BCG-polio-DPT-measles vaccines.

Table 5A.4 Summary statistics on immunization of children under four

	Four or older in 2017				*Under four in 2017*			
	Control habitations		*Treatment habitations*		*Control habitations*		*Treatment habitations*	
Outcome variable	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Share of children in household under four immunized	0.84	337	0.72	57	0.91	585	0.95	113
Share of girls in household under four immunized	0.82	153	0.82	27	0.913	276	0.963	54

Note: Immunization refers to OPV-BCG-polio-DPT-measles vaccines.