Brown University - Department of Economics

The Effect of Rural Road Development on Hospital Births:

Evidence from India

Author:

Renuka Diwan

Advisor:

Professor Bryce Steinberg

Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Economics and Computer Science with Honors

May 1, 2019

Abstract

This paper aims to estimate the effect of improvements in transport infrastructure in rural areas on health outcomes such as births occurring in hospital versus at home. In 2000, the Central Government of India launched the Prime Minister's Rural Road Scheme program which aimed to provide all-weather connectivity to rural villages on a national scale. In 2013, a secondary scheme was employed to improve intra-village road systems and improve access to important village institutions. I exploit the timing of this secondary road construction as a source of exogenous variation in access to hospitals by using district level data on road construction and household level panel data on births, place of delivery and reasons for home delivery. I find that although there is an increase in percentage of births occurring in hospital over time, the construction of Through routes does not seem to impact percentage of births in hospital significantly in treatment districts. However, treatment districts display a lower number of households citing that the reason for home delivery was the hospital being too far or a lack of transport. These findings show that there may be other factors causing households to choose to deliver at home.

Contents

Acknowledgements

I would like to thank Professor John Savage for his additional help and guidance throughout this process from the Brown University Department of Computer Science. Additionally, I would like to thank my advisor Professor Bryce Steinberg for all her mentorship throughout the research process and writing of this thesis.

1. Introduction

Transport infrastructure is increasingly known to have a large-scale impact on economic development [2; 5]. Although the majority of literature has focused on large-scale transport infrastructure projects, understanding the effect of rural roads has become more prominent given their importance in providing access to important village institutions. The effect of rural road development on school access and market access has already been documented to some degree, but the effects of road development on access to hospitals and health centers, are less well understood.

In this paper, I exploit variation in a program which constructed rural roads on a large-scale in India to estimate causal effects of improved transport infrastructure on household access to hospitals or health centers. Using data on birth records and records on rural road improvement after the year 2000, I test whether or not the construction and maintenance of Through Routes, broadly defined as roads within villages, increases the percentage of births occurring in hospital. I also analyze reasons for home delivery and the effect of roads on households choosing to deliver at home. I focus in particular on households choosing to deliver at home because the nearest hospital is too far or they lack the necessary transportation.

The roads data used is from a road construction program, called the Pradhan Mantri Gram Sadak Yojana (PMGSY), also known as the Prime Minister's Rural Roads Scheme [8]. Through this program, the central government of India has aimed to provide all-weather access on a national scale to unconnected rural villages. This program has been extremely successful in providing mobility and connectivity to habitations through the construction of Link Routes, or inter-village roads. However, after these new roads were implemented, the importance of maintaining both new and old roads arose, particularly for roads within villages, due to their role in providing access to schools, hospitals and other institutions. Thus, a secondary scheme was proposed, hereafter referred to as PMGSY-II, with the specific objective to upgrade rural roads based on their potential to provide transportation to rural

Growth Centers and Rural Hubs [15].

For data concerning hospital births, I used the Demographic and Health Survey (DHS) conducted in India from 2015 to 2016 [9]. Within the DHS data, I used the data on birth history for each household. For births that occurred during the interval 2010-2016, the women were asked their place of delivery and reasons for choosing to deliver at home. For each place of delivery, I identified it as either a hospital birth or a home birth and calculated percentage of hospital births and reason for home delivery for each year and treatment cohort.

This paper focuses in particular on variation in implementing the secondary rural roads scheme, since the selected roads to construct or upgrade under PMGSY-II were primarily intra-village roads. This implies that theoretically the roads implemented in the PMGSY-II scheme are expected to have a large impact on hospital access and by extension, hospital births. Using differences-in-differences estimation, I exploit the variation in states receiving these roads at the district level, testing to see whether districts that received secondary scheme roads had different hospital birth outcomes compared to districts that had yet to receive program roads under the PMGSY-II scheme. A treated district is any district that received roads sanctioned under the first wave of the PMGSY-II scheme, which occurred in the year 2013. Finally, I ensure I focus on only on rural effects by disregarding births that are specified to have occurred in in urban areas. This was done since the roads under the roads scheme were intended to be built exclusively in rural areas.

Overall, I find that the construction of Through Routes in the first wave of the PMGSY-II scheme in 2013 had a negligible impact on percentage of births occurring in hospital. The primary motivator in the increase of births occurring in hospital appears to be time, especially when comparing current place of delivery trends to pre-trends from the 1998-99 DHS India Survey. Furthermore, districts that have completed the primary road development stage and have been chosen to receive Through Routes, show a pre-existing significantly higher percentage of births that occur in hospitals starting in 2010. This is also evident in the

pre-trends, although the difference is seen at a lesser degree in the earlier years available in the data.

Thus, the addition of further road maintenance aimed towards Through Routes does not increase hospital birth percentages to a degree significantly higher when compared to control districts, indicating that extra road construction did not have a significant effect on percentage of hospital births. Yet, when comparing reasons for home delivery across regions, I find that citation of the reason "too far/no transport" as a reason for a home birth is seen to a lesser degree in treatment districts than control districts after 2013. Although the time trends shows that increasing numbers of people are aware of the distance to the hospital being a factor in their decision to deliver at home, the increase in citation of this reason is much smaller in Treated districts, to a statistically significant degree.

This paper adds to a growing literature of papers studying barriers to hospital delivery and reasons for preferring home delivery. Often, the current literature focuses on socioeconomic inequalities as indicators of hospital delivery. Studies in China from 1988-2008 show that trends in hospital births are often heavily influenced by financial barriers that vary across socioeconomic region [6]. Similarly, in Bangladesh, poverty is the most cited reason for choosing to deliver at home [11]. Finally, in Nepal, physical distance to a maternity hospital is shown to be predictor for place of delivery, along with other socioeconomic factors [18]. Additionally, this paper adds to a growing literature of economic research on better transportation infrastructure, much of it fueled by the PMGSY roads scheme. With the depth of data available on the roads, there are a growing number of papers analyzing the impacts of rural roads on topics such as the effect on rural market access and crop diversity [17] and the effect on school enrollment [13]. Lastly, a paper studying rural India aimed to study distance and health outcomes, and looked specifically at whether additional kilometers of distance decrease the probability of institutional delivery. They found that each additional kilometer of distance from a health facility decreases chances of institutional delivery by 4.4% [12].

I add to this literature by studying transport infrastructure and its specific relation to

health outcomes, such as hospital delivery. Using comprehensive data on births from India, along with a natural experiment in road development, this paper seeks to find the particular relationship of road growth and maintenance in rural areas to the household choice of place of delivery of children. The majority of these studies focus on socioeconomic factors as a primary force in guiding household choices, while I seek to isolate the role that barriers in transportation may have on this decision.

This paper proceeds as follows. Section 2 covers details on the setting of the experiment and provides further detail on the PMGSY road development program. Section 3 describes the data and outlines summary statistics. Section 4 outlines the empirical strategy. Section 5 delineates the results of the research. Section 6 discusses possible implications of the results. Section 7 presents robustness checks, and Section 8 is the conclusion.

2. Background

The Pradhan Mantri Gram Sadak Yojana program was implemented on December 25, 2000 with the specific mission of providing all-weather access to eligible unconnected habitations as a strategy for alleviating poverty. The program first connected villages with large populations, and then followed with villages with smaller populations ranked lower. As of April 2018, the PMGSY-I has managed to provide connectivity to 85.37% of the eligible habitations, and the government foresees achieving their final target for connectivity in road networks in 2019. Thus far, the program has been on a national scale, and has affected all 640 of India's Census 2011 districts.

After completion of the primary stage, analysis showed that existing and newly constructed roads were not being maintained properly, and were falling into disrepair. Thus, the secondary PMGSY-II scheme was implemented to ensure proper maintenance of existing roads, as well as improve access to local village institutions. The goal was to provide efficiency in access to people, goods, and services [15].

A Link Route is specified in the PMGSY guidelines as a road connecting a single habitation or a group of habitations to Through Routes. A Through Route is a road that acts as a confluence of two or more Link Routes and emerges on to a major road or to a market center. Furthermore, a Through Route is specifically expected to terminate or run through a Rural Hub or Growth Center. A Growth Center is defined as an area with a relatively centralized population, while a Rural Hub is a large Growth Center, characterized by intersections of Through Routes. Both often have important village institutions such as markets, schools and hospitals in close vicinity. Informally, we can state that Link Routes attempt to connect villages, and are inter-village roads, while Through Routes run within villages and are intra-village roads. The PMGSY-II focuses on these intra-village roads [15].

In cases where districts in certain states were deemed eligible for the secondary scheme, a primary round was sanctioned in 2013 under a new ranking system which took hospitals and other village institutions under consideration. A village in a district that received PMGSY-II roads sanctioned in 2013 had essentially met the criteria for Link Routes, and could now shift focus onto Through Routes which would benefit villages with access to Rural Hubs and Growth Centers. Thus, PMGSY-II roads can be considered intra-village roads that had a role in providing transportation to such village institutions such as hospitals.

The order in which these secondary scheme roads were implemented followed a scoring system which took into account these village attributes including population, educational facilities, medical and veterinary facilities, other transport infrastructure, and market and administrative centers. The secondary scheme program roads were then either upgraded or constructed according to this scoring system.

3. Data

This paper uses data from three sources: the PMGSY rural roads database, the 2011 Indian Population Census, and the Demographic and Health Surveys (DHS) in India from the years

1998-99 and 2015-16.

PMGSY Data. [8] The PMGSY data was obtained from the Online Management & Monitoring System (OMMS), a system utilized by the Indian administration to compile the PMGSY program information on past and current road works. The information goes down to the village level and includes information on the population size and connectivity status of the habitation, which in turn determine eligibility for the program. Data from the PMGSY-II scheme module was used to specify which districts were treated in 2013. Additionally, information from the PMGSY-I and PMGSY-II modules was used to calculate road lengths from the program schemes.

2011 Census Data. [3] I used the most recent Indian Population census, which took place in the year 2011 to augment the research. This contains population demographic information at the village level such as population size, gender and caste ratios, literacy rates, and employment breakdown. There is also information available on the various facilities and institutions present in the villages such as schools, banks, and electricity. Additionally, there is data on each district including population size, area size, and population density, allowing the empirical strategy to take into account different district and state characteristics.

DHS Survey India Data. The Demographic Health Survey, also referred to as the India National Family Health Survey (NFHS) has been conducted four times by the Government of India Ministry of Health and Family Welfare. The datasets used in this paper specifically are from the second and fourth round India surveys which took place in 1998-99 and 2015-16. Note that while these surveys were conducted during 1998-99 and 2015-16 respectively, the births data contains information on births that happened in previous years, up to the years the surveys were conducted.

The DHS was designed to provide estimates of indicators of family and household welfare. For each household surveyed, information on family demographics including age, sex, marital status, and schooling was collected along with household characteristics such as source of water, toilet facilities, fuel, construction materials, and ownership of goods such as cars.

2015-16 Survey. [9] In the 2015-16 survey, 601,509 total households were interviewed, and additional interviews from 699,686 eligible women covering 640 districts were additionally included in another panel dataset called the Women's Questionnaire. This was of particular interest to this paper since it collected information on eligible women from ages 15-49. This questionnaire asked questions focused on reproductive health including information on birth history, sexual activity, contraception, menstrual hygiene, and maternal and child health before and after delivery. I combine this panel data set with the household dataset to get information at the household level for each birth.

I can thus identify the district of each birth, and use specific household and district characteristics to group. The analysis is intended to take into account all districts across India according to the 2011 Census, but only those births marked as "rural" are considered as affected by the PMGSY road implementation.

Additionally, only the women with a recorded birth within the period 2010-2016 were asked about place of delivery and reasons for delivery at home if that was the case. This means we do not have concerns about respondant recall, but it limits the number of data points available. Any birth prior to 2010 does not have information on place of delivery or hospital access, limiting the scope of the analysis. Lastly, the data from 2016 shows a markedly lower number of births, indicating the survey was potentially completed only partway through the year, and is also disregarded. This leaves us with 227,578 total observations with useable data. In summary, the final subset of data used is births that occurred between the years of 2010 and 2015 (inclusive of those years) in rural districts.

1998-99 Survey. [10] The data from the 1998-99 DHS Survey was used to graph pretrends for the same districts that were later treated with Through Routes. This survey took place even before the primary PMGSY-I scheme which implemented the Link Routes. However, the panel data set were more limited in scope with the number of households interviewed being 91,196, and the number of women being 89,199.

Using these datasets, I have compiled some summary statistics. Table 1 details the various

health facilities and home options available to households for delivery. It then contains the percentage of household births in each place of delivery, and categorizes the observations by area of residence: urban or rural.

Table 2 summarizes the data by grouping births in all health facility options versus home options and comparing these percentages by place of residence. These two columns show that urban households have a higher percentage of births in hospital, and a lower percentage of households citing the hospital is too far or a lack of transport, compared to rural areas. In total, 72.4% of rural households had place of delivery listed as a hospital or other health facility.

Table 3 details various methods of transportation used to travel to a health facility for delivery. The majority of household use either an ambulance or a car, although a notable percentage also use a tractor or similar machine. The use of vehicles was not used as a control in the analysis as the ownership of a vehicle is endogenous. It is possible that households chose to purchase a method of transportation after the construction of program roads in their district.

Table 4 details various reasons for home delivery. Note that the survey allowed multiple responses or a no response to all answers to this question, and are not conditional on home delivery. Thus, the percentages of the reasons cited do not add up to 100%. "Too Far/No Transport" is cited as a reason for home delivery 4.64% of the time, and is the second most popular reason for a household choosing a birth at home.

4. Empirical Strategy

I estimate the effects of improved rural road infrastructure on a set of birth outcomes in a differences-in-differences framework. Differences-in-differences estimation aims to estimate the effect of a specific intervention or treatment by comparing outcomes between the Treatment group, a population that received intervention, and Control group, the population that

did not receive intervention, before and after the treatment, with additional controls for other influential characteristics. There are some key underlying assumptions that must be made when using a differences-in-differences estimation model, including a parallel trends assumption. In the absence of treatment, I assume that both Control and Treatment groups would trend similarly, and have a constant difference in outcome over a period a time [4]. Although I cannot test for this specifically, it can be seen that prior to Treatment, the trend for hospital births was parallel, which is reassuring. For too far/no transport, the parallel trends are less reassuring, but continue to strongly diverge post 2013.

For this paper, to estimate the impacts of roads on health outcomes, I compare districts before and after 2013, and divide districts into Treatment and Control districts based on whether or not they receive Through Route program roads from the PMGSY-II in 2013.

4.1. Treatment & Control Specification

To construct a Treatment group and Control group, I exploit variation in PMGSY scheme deployment and timing of road sanctioning and completion. As stated, road construction for the PMGSY-II scheme was determined by certain village factors including population, location of village institutions, and points in inter and intra-village road networks. Certain districts were then chosen to receive roads for the primary round of the PMGSY-II scheme in 2013 based on these factors. Thus, we see exogenous variation in road construction due to the system of ranking and sanctioning the program roads.

I exploited the addition of the secondary PMGSY-II scheme to separate out districts that received Through Route roads. The states that were affected in 2013 by the PMGSY-II were Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Telangana and Uttar Pradesh. To narrow the analysis further, the specific districts from each of these that were affected by the road construction were then assigned to the Treatment group.

Exploiting the secondary scheme of the PMGSY program over the primary scheme has two specific advantages.

Firstly, the primary scheme was implemented from the year 2000 to present day, and covers the majority of rural India. Thus, there may be a lack of significant variation in the primary scheme rollout by the time the DHS survey was conducted in 2015. At the district level, each district was required to update the requirements of the PMGSY program until there were no more unconnected roads. Thus, by the time the birth data records begin in 2010, there were already potentially a vast amount of districts that had completed a significant portion of road construction, limiting the control group under the primary scheme.

The secondary scheme was announced only in 2012, and roads were then sanctioned in 2013, for these specific seven states. This allowed for a more reliable source of variation in program road construction since the PMGSY-II states had not only completed the primary stage of the PMGSY, but would then receive further road construction. Furthermore, the timing of road sanctions and completion coincided with the available data on place of delivery and citation of reason for home delivery from the DHS 2015-16.

Secondly, the distinction of Link routes and Through routes in the goals of PMGSY-I and PMGSY-II aids us in focusing on exactly what we aim to test - access to hospitals. As stated, a Growth Center defined by the PMGSY administration is an area of relatively centralized population. This means it provides rural socio-economic services for the area, which includes hospitals and health centers specifically. This stipulation in the ranking for the PMGSY-II roads indicates that the road construction is expected to improve access to hospitals, and thus, it again allows us to identify districts with roads specific to the health outcome variable we wish to test.

Once the Treatment villages are identified, we can identify the complementary Control group i.e. the districts that did not receive roads under the the PMGSY-II scheme in 2013.

4.2. Empirical Specification

Using differences-in-differences estimation, I create a regression estimation to compare the changes in outcomes in treatment groups that receive roadwork in the primary PMGSY-II round in 2013 to changes in outcomes in control groups that have received PMGSY roads, but have yet to receive PMGSY II roads.

The basic regression estimation takes the following form:

$$y_{idt} = \alpha + \beta_1 Post + \beta_2 Treatment + \beta_3 Post * Treatment + \rho_i + \gamma_{dt} + \epsilon$$

where y_{idt} are outcome variables for woman in household i, in district d, at time t. Post is an indicator reflecting whether the time period is before or after the initial round of PMGSY-II roadwork and takes on values of 0 or 1. Treatment is an indicator for whether or not the district received PMGSY-II roads and also takes on values of either 0 or 1. Our main analysis centers around β_3, the differences-in-differences coefficient of interest on the interaction between the two terms; it can be seen as Post X Treatment. Any household specific or pregnancy specific characteristics are absorbed by ρ_i. Controls used include characteristics such as education level of mother, religion, caste or tribe, use of contraceptive, height percentile, age of mother, and sex of child.

Any fixed differences between districts that are constant over time are absorbed by including district fixed effects. Additionally, we use year fixed effects to account for differences in time-trends, and so γ_{dt} controls for both district and time effects. Thus, we eliminate bias from unobservable characteristics that change over time but are constant over districts and also control for factors that differ across districts but are constant over time [7].

5. Results

I begin first by testing whether or not the baseline assumption that as time passes, the percentage of births occurring in a hospital or health facility increases over time. In Fig. 1,

we see that there is a distinct upward trend in the percentage of births in hospital across both control and treatment districts across years. Treatment districts have a 70.01% rate of births in hospital in 2010, and Control districts have a rate of 65.22%. Both increase with similar magnitudes with peak hospital births occurring in 2015 at 83.27% for Treatment and 74.40% for Control.

Table 5 shows that the time trend is statistically significant as post treatment in 2013, the increase in births in hospital is significant. This is signified by the Time variable in Column (2), where we see after controlling for various factors of health, there is an overall 7.77% increase in births in hospitals after the year 2013. This is statistically significant at the 1% level.

We see from the figures that treated districts are more likely to have a birth in hospital before and after treatment. Figure 1 shows that the treatment line is higher than the control line from the onset in 2010. The gap between the parallel lines for Control and Treatment districts is clearly visible in Figure 1. However, the parallel trends assumption is very consistent with the figure.

Table 5 also shows the results from our OLS differences-in-differences regression. The coefficient in column (2) for Treated shows that there is a negligible change, close to 0.0, in percentage of births in hospital after 2013 for districts that were treated, compared to control. This differences-in-differences indicator on variation in percentage of births in hospital over time across districts treated by PMGSY-II roads in 2013 and not-treated districts is not statistically significant. Both cohorts follow the same time trend with respect to percentage of births in hospital, without a significant difference in Treatment districts post the treatment in 2013.

Next, we see that "Too far/No Transport" as a reason cited for home delivery actually increases each year across all districts. Figure 2 shows both treated and control district households citing that the hospital is too far or a lack of transportation for the reason for giving birth at their own home, parent home, or other home. The parallel trends assumption

is slightly less robust here, given that the figure shows the Treatment and Control districts may begin to diverge earlier than 2013, but the continued strong divergence post treatment in 2013 is robust.

Column (4) of Table 5 shows that after 2013, the Time variable coefficient displays a significant increase of 3.97% in citation of "Too Far/No Transport". This is significant at the 1% level. Figure 2 shows that treated districts even before 2013 tend to cite "Too Far/No Transport" as a reason for home birth less often than control districts, and continue to do so to an increasing degree post 2013.

Column (4) of Table 5 also shows the differences-in-differences indicator for citation of "Too Far/No Transport" as a reason for home delivery is -1.30%. This is significant at the 1% significance level, and implies that households in districts post treatment are less likely to cite this as a reason than control households even though the overall trend is an increase in citations. Figure 2 corroborates this and shows that treated district households cite this reason less often than not-treated district households, and do not increase as sharply as not-treated districts do in citing this reason after 2013 PMGSY-II treatments. We can see a much sharper upward increase in the not treated districts, while treated districts show a lower percentage and a lower increase in citation of this reason. The effect on "Too Far/No Transport" is negative in treatment districts after 2013 treatment. Notably, the addition of controls does not change this value much, implying that the presence of a car or truck in the household has little bearing on the citation of "Too Far/No Transport," although controls have a significant bearing on percentage of births in hospital.

The magnitudes of our treatment are important to understanding these results. Essentially, we see 161 Treated districts that can be matched in PMGSY data and DHS data. Out of 640 total districts, this means we have percentage of districts treated to be 0.2515625. Approximately 1 in 4 districts was treated under the PMGSY-II in 2013. However, each district was treated to a different degree, dependant on the population density and existing roads. On average, the districts each received 54.32296 kilometers of roads, with a range of

5 kms to 150 kms.

The confidence intervals seen here imply that size effects can be ruled out. With observations from 254928 households, we have a confidence interval [-0.00818, 0.00807]. Since this interval includes zero, we can most likely rule out a sizable increase in hospital births due to the road development since we see such a narrow margin. We can additionally say that for an additional road, we can rule out that this caused more than 2000 additional births at a hospital with 95% confidence.

6. Potential Mechanisms

I find overall that although in the treated districts there is a far higher percentage of births that occur in hospitals, the difference marginally exists after 1995 and widens after 2010. This implies that although the PMGSY-II roads were chosen to provide further access to institutions such as hospitals, they were implemented in areas that were already seeing a larger percentage of households choosing to give birth in a hospital. This is perhaps due to earlier completion of the primary stage of the PMGSY program. It is possible that the primary scheme that provided Link Routes had an additional effect outside of the available data and is thus not being captured.

There is also an increasing trend in percentage of births in hospitals across all districts, but this trend is not significantly more pronounced in treatment districts after 2013. This indicates that either roads sanctioned did not significantly change access to hospitals, or the effects were not felt immediately due to lag in construction time. The initial round of PMGSY-II possibly did not effect enough roads to be influential on a district wide level.

It is possible that the addition of roads does not significantly impact the decision to give birth at home or in a hospital, although it is stated as a reason for home delivery 4.64% of the time. It is possible the primary mechanism for increase in percentage of hospital births is beyond the data such as changing perceptions of hospitals and what is customary for a

household.

There is a significant difference in the citation of "Too Far/No Transport" as a barrier to hospital delivery in treatment districts. Although there is a general upward trend in citation of this reason among rural households, there is a far steeper increase in districts that did not receive PMGSY-II road treatment. In the districts that received treatment from the secondary scheme, the increase in "Too Far/No Transport" was far less pronounced. A possible explanation for this is the obstacle of physical distance and lack of transportation access was potentially mitigated after 2013 in districts treated by the PMGSY-II scheme. Thus, households that would have chosen to give birth in a hospital were then given access. However, since the actual percentage of births occurring in a hospital did not change, another reason might have counteracted the effect.

Additionally, the number of households claiming an institution is too far increases over time, regardless of road construction. This could imply that although road quality and maintenance increases, since the distance to the hospital does not change for the household, the household could simply perceive the distance as increasing due to the new road construction.

Finally, it is possible that the respondents could not be speaking truthfully or with complete understanding of their actions. Perhaps households claim the hospital is too far with the expectation that more hospitals or roads will be constructed, even if it will not change their final decision of place of delivery.

7. Robustness

7.1. Pre-Trends

To test robustness of these results, I look at data from the 1998-99 DHS Survey which took place before the PMGSY program began in 2000. The pre-trends of the data are the trends in outcome prior to any treatment, and are necessary to look at to make sure our parallel trends assumption for the differences-in-differences estimation holds. Thus we look at the

two different cohorts before any treatment began in 2013, as well as before the start of the PMGSY as a whole in 2000.

Figure 3 is a graph showing the trend for percentage of births in hospital from 1996 to 1999 and then from 2010 to 2012. The year 1995 was omitted due to a very small number of observations. Overall, the increase in births in hospital over time is visible even in these pre-trends. Notably, the percentages of births in hospital are very low, with an average of around 24% as opposed to 72% in the 2015-16 Survey data. The districts are separated by their future treatment, although it is clear that prior to any PMGSY road development, the two cohorts are almost identical in magnitude as well.

Figure 4 is a graph showing the trend for home delivery due to hospitals being too far or households lacking transport from 1996 to 1999. The year 1995 was omitted due to a very small number of observations. Here we also see an increase in households citing this reason as a cause for home delivery, although there is a small dip in 1998. The parallel trends are also mainly consistent here, but there is some divergence from 1996 to 1997. Furthermore, even before any road construction, districts that will be treated with PMGSY-II roads in 2013 cite this reason far less that control districts. However, it is consistent with the graph from Figure 2, showing similar parallel trends. Between the two surveys, we expect to see a decrease in citation of this reason by households, although it consistently remains between 0.02 and 0.05 for the majority (exception in 1999).

These pre-trend figures are convincing in their display of parallel trends, and notable in their changes in magnitude compared to results for both outcome variables from 2015-16 data.

7.2. Additional Regression

Additionally, the results from the primary regression estimation are robust when compared to additional regression estimations. Table 6 shows that even without year fixed effects, we see very similar results. The Time coefficient for hospital births in Column (2) is significant,

showing an increase of 4.18% births in hospital after 2013. The differences-in-differences coefficient in row Treated under Column (2) shows a similar lack of statistical significance, with the confidence interval containing the value zero.

Meanwhile, the coefficients for Too Far/No Transport under Column (4) are similar to the primary results as well. Time is significant with an increase of 2.35% more people citing this as a reason for choosing to deliver at home. Yet, Treated displays that 1.33% fewer households cite this as a reason for home delivery from districts that received intervention. Overall, the results of the variation on the estimation closely mimic the results in Table 5.

8. Conclusion

Overall, I find that the construction of Through routes in 2013 under the secondary PMGSY-II scheme does not increase the percentage of births occurring in hospital to a significant degree. Both the Control and Treatment groups show the same parallel trends over time, and thus the differences-in-differences estimate is insignificant for this outcome variable.

However, we see that there is a difference in citation of reason for home delivery. Households claiming that the hospital is too far, or citing a lack of transport, are far less prevalent in districts that received treatment, as opposed to control districts. This implies that although there are fewer people comparatively stating this reason, there are still an increasing number of people citing this reason and others for choosing to deliver at home.

We also see some interesting facets of the data, such as the gap in Treatment and Control districts prior to 2013 for percentage of hospital births, and the gap prior to 2000 for citation of reason for home delivery between the cohorts. Further research can be done here documenting the road construction from PMGSY-I to see whether the primary scheme had an effect on either of the two outcome variables. Other reasons for choosing to deliver at home can also be studied in more depth, to see if there is one that counteracts the difference in households citing "Too Far/ No Transport" as their primary reason for home delivery.

9. Figures

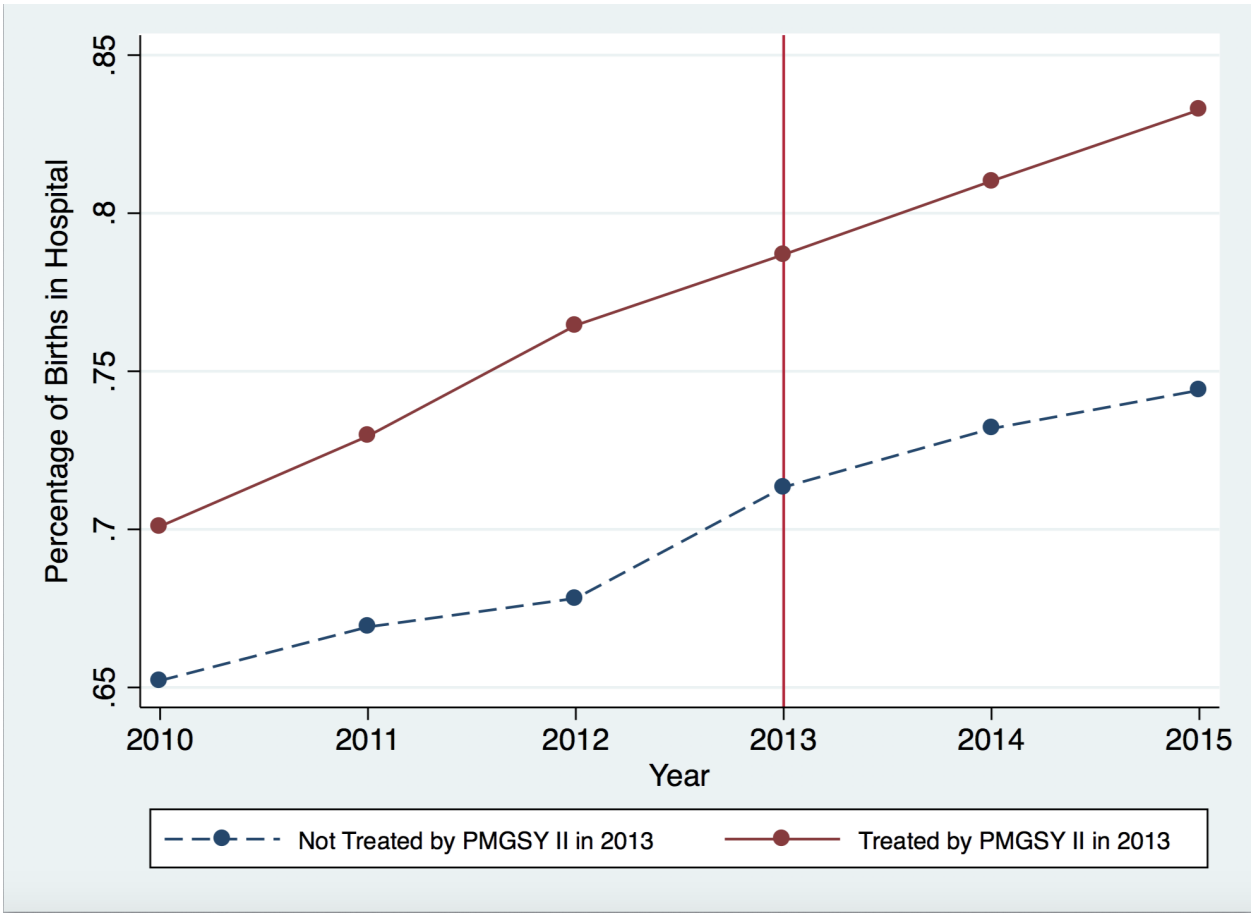

Fig. 1. Percentage of Births In Hospital by Year.

Data Source: PMGSY Road Data from OMMS and DHS Survey 2015-16 India

Note–This graph displays the trend for percentage of births in hospital from the years 2010 to 2015 in rural areas. The red represents the percentages from the treated districts, while the blue represents the control districts. The vertical red line marks the year of treatment.

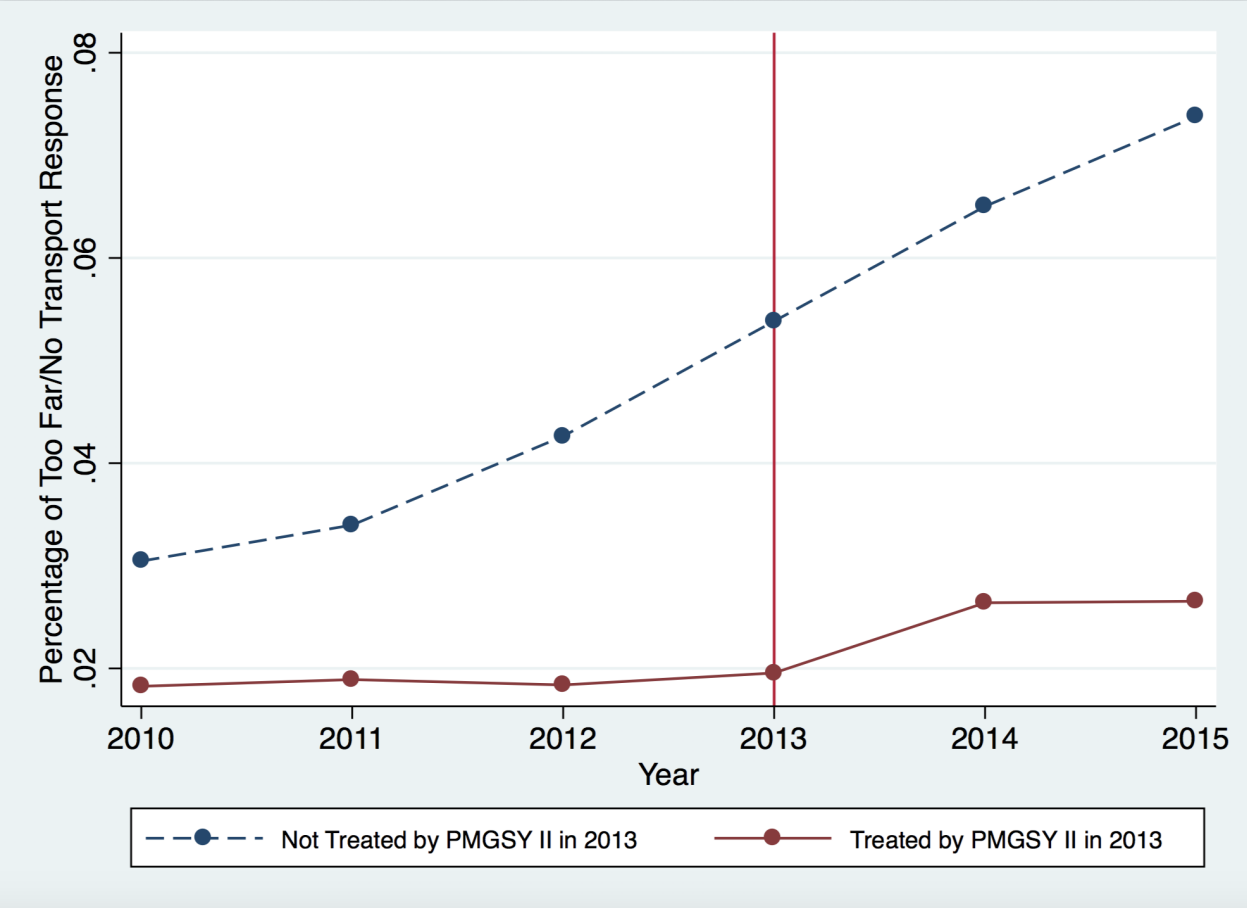

Fig. 2. Percentage of Too Far/No Transport Response by Year.

Data Source: PMGSY Road Data from OMMS and DHS Survey 2015-16 India

Note–This graph shows the trend for percentage of rural households citing "Too Far/No Transport" as the reason for home delivery from the years 2010 to 2015. The red shows the treated districts, while the blue shows the untreated districts. The vertical line marks the year of treatment. The percentages are not conditional on home delivery and thus the axis for percentages ranges from 0% to 10%.

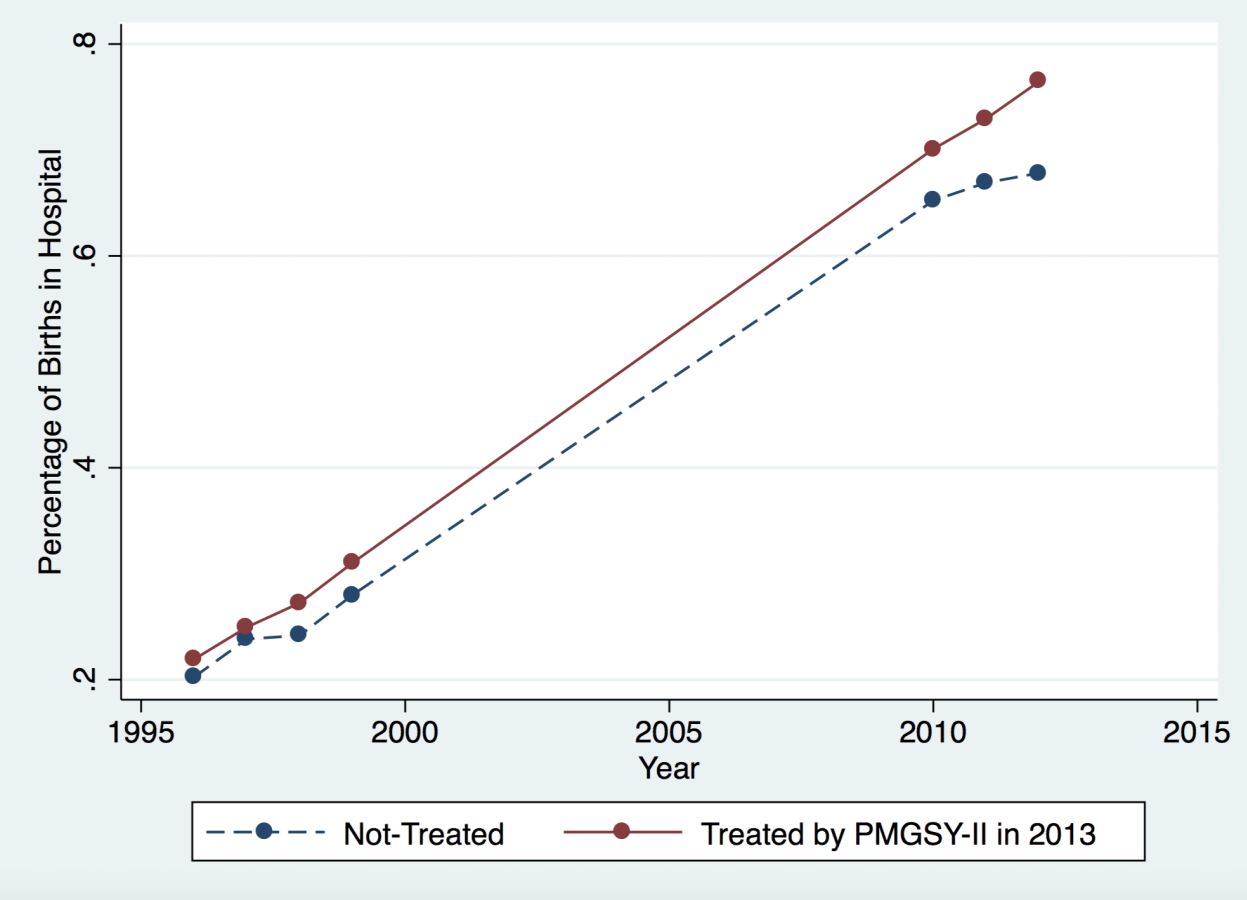

Fig. 3. Percentage of Hospital Births by Year Prior to Treatment.

Data Source: PMGSY Road Data from OMMS and DHS Survey 1998-99 and DHS SUrvey 2015-16 India

Note–This graph shows the trends for percentage of births in hospital in rural areas from 1996 to 1999 prior to the PMGSY program, and then from 2010 to 2012, prior to treatment in 2013 by the PMGSY II. There do not exist observations for the years in between the two surveys, although the expected trend has been graphed.

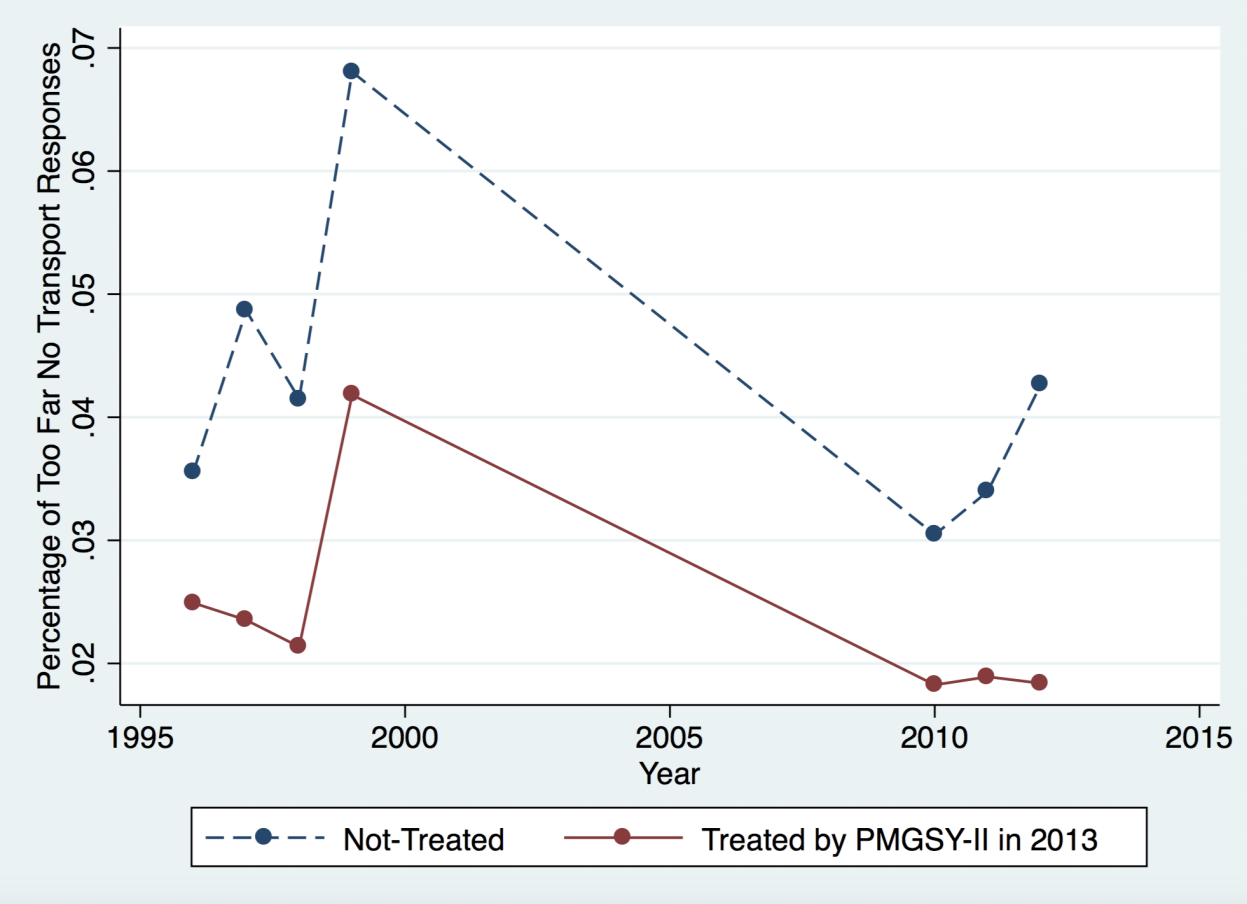

Fig. 4. Percentage of Too Far/No Transport Responses by Year Prior to Treatment.

Data Source: PMGSY Road Data from OMMS and DHS Survey 1998-99 and DHS Survey 2015-16 India

Note–This graph shows the trends for citation of reason Too Far/No Transport for home delivery in rural areas from 1996 to 1999 prior to the PMGSY program, and then from 2010 to 2012, prior to treatment in 2013 by the PMGSY II. There do not exist observations for the years in between the two surveys, although the expected trend has been graphed.

10. Tables

Table 1: Summary Statistics - Place of Delivery

	Public Hospital	Private Hospital	NGO Hospital	Own Home	Parent Home	Other Home	Other	Total	Observations
Residence									
Urban	50.15	36.55	0.87	11.67	1.39	0.23	0.18	100.0	61,353
	(0.20)	(0.19)	(0.037)	(0.13)	(0.047)	(0.019)	(0. 017)		
Rural	55.65	16.42	0.33	25.03	2.68	0.22	0.4	100.0	198,116
	(0.11)	(0.083)	(0.013)	(0.097)	(0.036)	(0.011)	(0.014)		

Data Source: DHS Survey 2015-16 India

Note–This table tabulates summary statistics for various places of delivery. It presents percentages for each facility and home and compares households by type of residence being either urban or rural. Standard deviations reported in parentheses.

Table 2: Summary Statistics - Combined Percentages

	Hospital Births	Too Far/No Transport	Observations
Residence			
Urban	87.57	0.89	61,353
	(0.13)	(0.038)	
Rural	72.4	4.64	198,116
	(0.10)	(0.11)	

Data Source: DHS Survey 2015-16 India

Note–This table shows summary statistics of percentage of births that were delivered in any kind of health facility, categorized by type of residence, urban or rural. It also presents the percentage of households that chose to deliver at home because the hospital was too far, or they lacked transport. Standard deviations reported in parentheses.

Table 3: Methods of Transportation

Transport Used to Go to Facility For Delivery	Percent	SD
Car	32.16	(0.12)
Ambulance	28.76	(0.11)
Tractor	22.88	(0.11)
Motorcycle/Scooter	7.03	(0.068)
Bus/Train	3.67	(0.047)
On Foot	2.96	(0.047)
Cart	0.78	(0.024)
Other	1.76	(0.038)
Total	100.0	

Data Source: DHS Survey 2015-16 India

Note–This table shows summary statistics for methods of transportation to the hospital or health facility for rural households only. The total number of household respondents was 105,970, percentages were calculated from that total. Standard deviations reported in parentheses.

Table 4: Reasons for Home Delivery

Reason	Percent	SD
Not Necessary	7.37	(0.059)
Too Far/No Transport	4.64	(0.047)
Cost Too Much	3.12	(0.039)
Not Allowed	2.72	(0.037)
Not Open	1.78	(0.030)
Don't Trust Facility	0.96	(0.022)
Not Customary	0.77	(0.020)
No Female Provider	0.53	(0.016)
Other	1.48	(0.027)

Data Source: DHS Survey 2015-16 India
Note–This table shows summary statistics for various reasons women delivered at home. Note that multiple responses were permitted for this question, and thus the total does not sum to 100%. Households responded either yes or no for each reason. The total number of rural household respondents was 198,166, percentages were calculated from that total. Standard deviations reported in parentheses.

Table 5: Differences in Differences Estimation

	Hospital Births		Too Far/No Transport	
	(1)	(2)	(3)	(4)
Time	0.108***	0.0744***	0.0293***	0.0397***
	(0.00528)	(0.00508)	(0.00292)	(0.00329)
Treated	-0.00116	-0.000218	-0.0129***	-0.0130***
	(0.00423)	(0.00414)	(0.00204)	(0.00205)
C	0.693***	23.86***	0.0247***	-3.386***
	(0.00406)	(3.149)	(0.00177)	(1.246)
P-value	(0.784)	(0.958)	(0.000)	(0.000)
Confidence Interval	[-0.00947,0.00715]	[-0.00835,0.00791]	[-0.0169,-0.00895]	[-0.0170,-0.00893]
District Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Controls	NO	YES	NO	YES
Mean Dependent Variable	0.7543482	0.7538193	0.0366181	0.0367423
Observations	250159	246380	250832	247045

Data Source: PMGSY Road Data from OMMS and DHS Survey 2015-16 India
Note–This table shows coefficients from OLS regression of PMGSY II treatment on hospital births and citation of reason for home delivery. Controls are figures on maternal and child health and demographic features: height, age and weight of mother, education, religion, caste or tribe, contraceptive use, sex of child, weight of child. Estimation includes district and year fixed effects. Robust standard errors, clustered at the district level, are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01

Table 6: Differences in Differences Estimation Without Year FE

	Hospital Births		Too Far/No Transport	
	(1)	(2)	(3)	(4)
Time	0.0602***	0.0418***	0.0185***	0.0235***
	(0.00227)	(0.00224)	(0.00162)	(0.00179)
Treated	-0.000789	-0.0000550	-0.0133***	-0.0133***
	(0.00421)	(0.00414)	(0.00204)	(0.00206)
C	0.720***	23.45***	0.0286***	-3.481**
	(0.00110)	(3.152)	(0.000737)	(1.285)
P-value	(0.851)	(0.989)	(0.000)	(0.000)
Confidence Interval	[-0.00905, 0.00747]	[-0.00818, 0.00807]	[-0.0173,-0.00925]	[-0.0174,-0.00928]
District Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	NO	NO	NO	NO
Controls	NO	YES	NO	YES
Mean Dependent Variable	0.754781	0.7542718	0.0374876	0.0376084
Observations	258838	254928	259526	255608

Data Source: PMGSY Road Data from OMMS and DHS Survey 2015-16 India
Note–This table shows coefficients from OLS regression of PMGSY II treatment on hospital births and citation of reason for home delivery. Controls are figures on maternal and child health and demographic features: height, age and weight of mother, education, religion, caste or tribe, contraceptive use, sex of child, weight of child. Estimation includes district fixed effects. Robust standard errors, clustered at the district level, are reported in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

References

[1] Assorted Reports of Pradhan Mantri Gram Sadak Yojana, India.

[2] Banerjee, Abhijit, Esther Duflo, and Nancy Qian. 2012. On the Road: Access to Transportation Infrastructure and Economic Growth in China. National Bureau of Economic Research. doi:10.3386/w17897.

[3] Census of India Village Directory, 2011.

[4] Difference-in-Difference Estimation. 2019. Search the Website. Accessed May 1. https://www.mailman.columbia.edu/research/population-health-methods/difference-difference-estimation.

[5] Donaldson, Dave. 2010. Railroads of the Raj: Estimating the Impact of Transportation Infrastructure. American Economic Review . doi:10.3386/w16487.

[6] Feng, Xing Lin, Ling Xu, Yan Guo, and Carine Ronsmans. 2011. Socioeconomic Inequalities in Hospital Births in China between 1988 and 2008. Bulletin of the World Health Organization 89 (6): 43241. doi:10.2471/blt.10.085274.

[7] Hanck, Christoph, Martin Arnold, Alexander Gerber, and Martin Schmelzer. 2019. Introduction to Econometrics with R. 10.4 Regression with Time Fixed Effects. March 12. https://www.econometrics-with-r.org/10-4-regression-with-time-fixed-effects.html.

[8] http://pmgsy.nic.in/.

[9] "International Institute for Population Sciences - IIPS/India and ICF. 2017. National Family Health Survey NFHS-4, 2015-16: India. Mumbai: IIPS."

[10] "International Institute for Population Sciences - IIPS/India and ORC Macro. 2000. National Family Health Survey (NFHS-2), 199899: India. Mumbai, India: IIPS and ORC Macro."

[11] Khatri, Resham Bahadur, Tara Prasad Dangi, Rupesh Gautam, Khadka Narayan Shrestha, and Caroline S. E. Homer. 2017. Barriers to Utilization of Childbirth Ser-

vices of a Rural Birthing Center in Nepal: A Qualitative Study. Plos One 12 (5). doi:10.1371/journal.pone.0177602.

[12] Kumar, Santosh, Emily Dansereau, and Christopher Murray. 2012. Does Distance Matter for Institutional Delivery in Rural India: An Instrumental Variable Approach. SSRN Electronic Journal. doi:10.2139/ssrn.2243709.

[13] Mukherjee, Mukta. 2012. Do Better Roads Increase School Enrollment? Evidence from a Unique Road Policy in India. SSRN Electronic Journal. doi:10.2139/ssrn.2207761.

[14] "PMGSY (2001a). Manual for the Preparation of District Rural Road Plans. Http://pmgsy.nic. In/pmg61.asp."

[15] "PMGSY (2001). PMGSY Schemes and Guidelines. http://www.pmgsy.nic.in/pmg31.asp

[16] "PMGSY (2001b). Operations Manual. Http://pmgsy.nic.in/opmn1.htm."

[17] Shamdasani, Yogita. 2016. Rural Road Infrastructure and Agricultural Production: Evidence from India. Department of Economics, Columbia, USA.

[18] Wagle, Rajendra Raj, Svend Sabroe, and Birgitte Bruun Nielsen. 2004. Socioeconomic and Physical Distance to the Maternity Hospital as Predictors for Place of Delivery: an Observation Study from Nepal. BMC Pregnancy and Childbirth 4 (1). doi:10.1186/1471-2393-4-8.