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Road Access, Fertility and Child Health in Rural India

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Abstract

Expansion in access to public infrastructure can have varied, micro-level impacts. In this paper, we use quasi-random access to rural paved roads through a large-scale road-construction program in India to study how road access impacts fertility decisions and investments in child health. We find that increased access to paved roads at the district-level leads to a rise in fertility, improved investments in children—measured through breastfeeding duration and immunization—and lower infant mortality. We also investigate the potential labor market mechanisms that drive these effects, and heterogeneity in the impacts by plausibly exogenous variation in levels of female labor force participation (FLFP). We find that in districts with erstwhile lower levels of FLFP, the effects on fertility and child health are driven by paved road access causing women to drop out of the labour force, while men shift from unpaid work to paid work. On the other hand, in districts with higher FLFP due to women's involvement in agriculture, we find that the increase in fertility can be explained by women substituting away from (paid) employment towards full-time domestic work.

Keywords: Infrastructure, Fertility, Healthcare, Mortality, Labour markets, Gender norms, India

JEL Classification: I12, I15, O12, O15, O18, R23

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1 Introduction and Background

Rural infrastructure projects can determine key micro-level household decisions and outcomes such as employment (Dinkelman 2011), uptake of institutional healthcare (Aggarwal 2021), schooling (Khandker & Koolwal 2011) and poverty (Khandker et al. 2009; Duflo & Pande 2007). The 'Pradhan Mantri Gram Sadak Yojana' (henceforth PMGSY) is a large-scale public road construction program, launched in December 2000, that mandated the construction of all-weather roads connecting habitations within Indian villages with a population of at least 500 to the nearest market center.[1] We study the impact of the quasi-random access to paved roads on fertility, child health and women's employment. Other studies show that the PMGSY affected rural labor markets (Asher & Novosad 2020; Aggarwal 2018), diversified crop portfolios and agricultural outputs (Shamdasani 2021) and improved educational attainment (Adukia et al. 2020). Greater connectivity via paved roads also increased access to formal healthcare facilities, likelihood of institutional births and improved health inputs for both mothers and children (Aggarwal 2021). We provide the first evidence that this access to paved roads also influenced fertility and infant mortality, alongside health inputs in children. In doing so, we add to the relatively sparse literature on the supply-side determinants of fertility and child healthcare.

In general, large scale public infrastructure programs such as road construction, stand to shape household-level decisions on fertility through both demand and supply-side channels. They have an income effect – by reducing poverty and changing the economic ability to invest in children (Khandker et al. 2013, 2009; Gibson & Rozelle 2003; Lenz et al. 2017; Parikh et al. 2015; Saing 2018; Medeiros et al. 2021; Aggarwal 2018) and a substitution effect – manifesting through changes in employment opportunities and wages that affect the time allocation problem posed to adults in the household, and in particular, women (Dinkelman 2011; Lei et al. 2019; Sedai et al. 2021; Hjort & Poulsen 2019).[2] Simultaneously, they influence the supply-side dimension of healthcare by reducing transportation barriers and enabling access to extant—but not always reachable—facilities (Aggarwal 2021). Therefore, this confluence of factors can influence the willingness and ability of households to invest into their children's healthcare. We demonstrate how both the demand-side and supply-side determinants of fertility and child healthcare respond to these 'big-ticket' interventions, which can have both intended and unintended general equilibrium effects.

We draw upon a rich literature on the response of child health investments and fertility to erstwhile shocks that are akin to the demand-side effects of infrastructure. Cannonical models highlight how fertility is affected by the time allocation problem posed to women (Becker et al. 1960; Schultz 1969) and the investments made in children that determine their 'quality' (Becker & Lewis 1973). Similarly, there is a large, albeit mixed, literature on the implications of income shocks on fertility and child health.[3] Adsera and Menendez (2011) find evidence that fertility is pro-cyclical using data on 18 countries in Latin America, meaning that fertility declines during economic downturns. J. Kim and Prskawetz (2010) show that unemployment is linked to

[1]As of 2022, it has provided connectivity to over 90 percent of the 178,000 eligible habitations by building more than 780,000 kilometres of roads at a cost of $48 billion during its lifetime. See the World Bank brochure (2022) for more details.

[2]See Calderón and Servén (2014) for a summary of existing literature on the implications of infrastructure on economic growth and income inequality.

[3]Several papers note that the fertility response to economic fluctuations is pro-cyclical in currently rich countries (Sobotka et al. 2011; Currie & Schwandt 2014) – meaning that fertility declines with recessions (most commonly measured by increased unemployment in these contexts). Related literature documents that infant mortality and child health can be counter-cyclical. Children conceived during periods of high unemployment in the United States have reduced rates of infant mortality and very low or low birth weight (Dehejia & Lleras-Muney 2004).

higher fertility in Indonesia. Anukriti and Kumler (2019) find that in India, impacts of tariff cuts imposed by trade reforms differ by women's 'status' (income group, caste and education level). 'Low status' women experience increased employment, and simultaneously have higher fertility and lower child mortality (especially for female children) under tariff cuts, while the opposite is true in the case of 'high status' women. Ferreira and Schady (2009), review the existing literature and identify that in low income countries in Asia, Africa and middle-income countries in Latin America, infant mortality and child health is pro-cyclical. Baird et al. (2011), use individual level data on infant mortality from 59 countries to confirm that economic downturns lead to higher infant mortality. They also show that female children's outcomes are more sensitive to these shocks.[4]

Notably, the literature on the impact of public infrastructure on fertility and its determinants remains mixed. There is evidence from both India and other developing countries that rural electrification (Grimm et al. 2015; Grogan 2016; Sedai et al. 2021), access to high-speed internet (Hjort & Poulsen 2019) and cable TV (Jensen & Oster 2009) can drive down fertility over time. This development can arise through multiple channels, such as increased female employment (Lei et al. 2019) and greater awareness of family planning methods (Tasciotti et al. 2022). The former, in particular, is known as a contributor to reductions in fertility (Eswaran 2006). But infrastructure programs are also capable of raising male employment rates, which are associated with an increase in fertility (Eswaran 2006; Sobotka et al. 2011). Therefore, whenever infrastructure impacts employment across gender lines, the overall effect on fertility may be ambiguous. Along the same tangent, previous work has shown that improvements in life expectancy, such as from innovations in health technology viz. malaria eradication programs, can actually increase fertility (Apouey et al. 2018; Bhattacharjee & Dasgupta 2022) especially in the regions that have not fully undergone the demographic transition (Weil & Wilde 2009; Cervellati & Sunde 2011; Nandi et al. 2022).

Our study makes several contributions. First, we extend the growing literature on the economic consequences of public infrastructure programs by providing, to the best of our knowledge, the first causal evidence on the long-term effect of rural roads on fertility. Second, we characterize the labour market mechanisms that underpin the fertility response. Specifically, we study how norms around female labour force participation (FLFP) mediate the effect of access to paved roads on fertility.[5] We investigate the role of FLFP as a mediator using exogenous, geographical variation in soil texture that drives the extent of FLFP in agriculture.[6] We complement the work by Asher and Novosad (2020), Lei et al. (2019) and Aggarwal (2018) on the effect of PMGSY on employment outcomes. While the first two evaluate a 'treatment' effect that is local to the village, we offer a more agglomerated perspective by studying the effect at the district level. As such, we can identify the impact of rural roads on a (larger) collection of heterogenous labour markets that admit spatial reallocation of workers. In contrast to Aggarwal (2018) who also studies the effect on district-level employment, we additionally incorporate local norms around FLFP—proxied by the soil texture—into the analysis in order to

[4]Evidence on pro-cyclicality in infant mortality and child health is presented in Bhalotra (2010) for India, Cutler et al. (2002) for Mexico, and Paxson and Schady (2005) for Peru. Miller and Urdinola (2010) find evidence for counter-cyclicality in infant mortality during income shocks in coffee-growing Colombia.

[5]This is motivated by findings from the existing literature that women's labour force participation is associated with gains in child health and reductions in fertility (Murthi et al. 1995)

[6]The 'loamy' versus 'clayey'-ness of soil influences the extent to which deep tillage of soil is possible, which in turn affects the extent to which female labor is involved in the cultivation process. The loaminess of the soil determines the machine usage in land tilling. These machines are typically operated by men, and machine tilling further reduces the demand for downstream tasks such as weeding – an operation in which female specialization is more common (Afridi et al. 2020). Thus, higher levels of 'loaminess' is associated with lower FLFP (Carranza 2014).

pin down the underlying mechanisms. Thirdly, we provide evidence on the welfare-enhancing properties of rural roads by showcasing their effects on access to public healthcare and households' medical expenditure. Lastly, we add to the growing literature that looks at the impact of road access on human capital outcomes by including the impact of PMGSY on infant mortality. Furthermore, we demonstrate how household investments into child healthcare—through breastfeeding and immunization—change amidst the availability of paved roads and associated improvements in healthcare access. Lastly, examining the fertility response to road growth along with changes to child health scenario, we offer an insight into the implications of large-scale infrastructure programs such as PMGSY on the dynamics of demographic transition within developing economies.

We combine data from the National Family and Health Survey (NFHS) and the Employment and Unemployment Surveys conducted by the National Sample Survey Organisation (NSSO) with information on road construction in the Socioeconomic High-resolution Rural-Urban Geographic Platform for India (SHRUG). This allows us to use quasi-random variation in access to paved roads at the district level to study the effects of road access on a large set of maternal and child outcomes, including health, expenditure and employment. We also study heterogeneity by the extant norms around female labor force participation (FLFP), by combining the roads and health data with soil data from the Soils of India (2001) dataset. We use exogenous variation in the extent of deep-tillage possible[7] at the district level, which influences the extent of female involvement in the agricultural labour force, to study how the impact of road access might vary by the participation of women in the labour force.

Our analysis reveals that road access brings about an increase in fertility (measured by the probability of a child being born to a woman) and improvement in child health investments (by increasing the duration of breastfeeding and extent of child immunization rates). We find that infant mortality rates decline contemporaneously, suggesting that both the quality and quantity of children rise in response to rural roads. We show that while the impact of paved road access on fertility is mostly similar across districts with different levels of FLFP, the mechanisms that drive these effects might differ. In districts with relatively higher pre-program FLFP, i.e. *Low Loam* districts, the improvements in the quality of child rearing and increase in fertility appear to be driven by road access inducing mothers to drop out of the labour force and substitute away from employment towards full-time domestic work. This appears to be a byproduct of structural transformation whereby beneficiaries of rural roads move away from agricultural work. On the other hand, in districts with relatively lower levels of FLFP, i.e. *High Loam* districts, we find that unemployed women drop out of the labour force entirely, undertaking solely domestic work. Meanwhile, we observe an employment gains for men within these districts, which is a determinant of fertility (Rosenzweig & Evenson 1977). Moreover, we find that the increase in child health investments is comparatively smaller within the *High Loam* districts. This inter-district heterogeneity in investments appears to follow the pattern of change in FLFP, though we cannot claim that labour market outcomes are the sole drivers of this wedge. Moreover, we find that children in different types of regions benefit differently with respect to health investments. While children in *Low Loam* districts enjoy improved immunization outcomes, such as the ones established by Aggarwal (2021), their counterparts in *High Loam* districts benefit from greater breastfeeding. Correspondingly, we observe a

[7]We leverage the loamy and clayey content in surface soil at the district level to classify districts as *high* or *low* loam. Details on this construction and its use within the analysis are provided in Section 2

drop in the infant mortality rate within *Low Loam* districts. In addition, we find some evidence that the provision of rural roads can improve the supply-side of affordable healthcare. Specifically, we record a decrease in medical expenditure among households across the board, and find that at least in *Low Loam* districts this can be explained by improved access to public healthcare. As such, we provide evidence that rural roads can enhance welfare by reducing the out-of-pocket expenditure of affected households.

The rest of the paper is structured as follows. Section 2 explains the data sources and variable construction. Section 3 lays out the empirical strategy. Section 4 presents the main results. Section 5 discusses possible mechanisms. Section 6 concludes.

2 Data

2.1 Road Construction

We obtain data on road construction from the Socioeconomic High-resolution Rural-Urban Geographic Platform for India (SHRUG), which is a collection of datasets that encompass economic, demographic and electoral indicators at the village and town-level.[8] To measure baseline access to paved roads, we source data from the Village Directory of the 2001 Population Census, which records the type of road in each village. Data on the provisioning and construction of roads under PMGSY, over the period 2002-2017, is contained therein and sourced from the Online Management and Monitoring System (OMMS) for the program. A village *receives* a PMGSY road in year y if it did not have access to paved roads at the baseline, and construction was completed sometime within year y.

We aggregate the roads data to the district level, since that is the smallest geographical identifier that is available for all other datasets used in our analysis. The aggregation procedure follows a strategy much like Aggarwal (2018). For each district in any given year, we compute the cumulative share of the district's rural population—using data from the 2001 Population Census—that had received a new road under PMGSY until that year. Simply, we sum the population of all villages in the district that received a PMGSY road and divide this sum by the total rural population of the district. By construction, the outcome of this exercise, denoted as *Road Growth*, is increasing over time and bounded in the interval [0, 1].

2.2 Soil Texture

We gathered data on soil composition from Soils of India (2001), created and disseminated by the National Bureau of Soil Survey and Land Use Planning.[9] Their spatial data on soil surface texture, physiography and depth, among others, was mapped to Indian districts using the administrative boundaries as of the 2001 Population Census. We are able to do this matching for 564 out of the 584 districts at the time. Akin to prior work in this area that link soil texture with gender norms (Carranza 2014; Afridi et al. 2020; Dasgupta & Karandikar 2021), we construct a measure of the depth of soil tillage by using data on soil surface texture. In particular, soils with a larger share of loam content and correspondingly smaller share of clay content have deeper tillage. Therefore, like Afridi et al. (2020) we subtract for each district the fraction of clay content in

[8] The data can be obtained at: https://www.devdatalab.org/shrug

[9] We obtain the data from the replication dataset provided by Carranza (2014). We thank Abhiroop Mukhopadhyay for providing access to the district mapping (2001 Census) in this data.

its soil from the fraction of loam content. We then compute the median of this difference across all districts, and assign each district into one of two groups—*High Loam* or *Low Loam*—based on a comparison of their difference with the median. High Loam districts are those for whom the difference exceeds the median, and Low Loam districts are those for whom the difference is at most the median.

2.3 Healthcare and Health Outcomes

We use the National Family and Health Survey (NFHS) for child healthcare and health outcome data. The NFHS is a nationally representative survey administered by the Ministry of Health and Family Welfare (MoHFW) and the Indian Institute of Population Sciences (IIPS). We utilise three of the four rounds for which data are available: NFHS-1 (1992-93), NFHS-2 (1998-99) and NFHS-4 (2015-16). NFHS-3 could not be used because it lacks district identifiers. Our focus is on NFHS-4, which covers over 500,000 households across the country and is also representative at the district-level. The dataset contains questions on subjects such as fertility, mortality, family planning, immunization, nutrition, and maternal and child health. Crucially, within the NFHS, information on mortality, breastfeeding and immunization is available for all children aged 0-5 years in the household. Our outcomes of interest are fertility, breastfeeding, child immunization and infant mortality.

To compute *Fertility*, we use retrospective birth history in NFHS-4 by constructing a psuedo-panel wherein each observation corresponds to one year in the life of a woman. We only consider years where the woman was aged between 16 and 49, and we limit the timespan to post-PMGSY years, i.e. from 2002 until 2016. Then, for each woman-year combination, fertility is defined as a binary outcome that equals 1 if the woman gave birth in that year, and 0 otherwise. The remaining outcome variables are constructed from the child-level data in NFHS-4. *Breastfeeding Duration* is the number of months that the child has been breastfed. For immunization, we construct a *Vaccine Index* by using questions on the child's uptake of vaccines and supplements for Polio, BCG, Diptheria, Tetanus and Vitamin-A. Each of these responses is a binary variable that indicates whether the child had received that vaccine or supplement. Using the Generalised Least Squares approach to dimensionality reduction outlined by M. L. Anderson (2008), we build a summary index for immunization. Lastly, we define *Infant Mortality* as a binary outcome that equals 1 if the child died within twelve months of their birth, and 0 if they lived past the first year of birth.[10]

2.4 Other Data

To identify and understand the mechanisms behind the results on health investments and outcomes, we use the Employment and Unemployment Surveys conducted by the National Sample Survey Organisation (NSSO). The data comes from rounds 61 (2004-05), 64 (2007-08), 66 (2009-10) and 68 (2011-12) of the NSS and is representative at the district level. We evaluate the employment outcomes for all but a few individuals in the sample.[11] Since both the job classification and industry were available for employed individuals, we use these to construct second-order binary measures of employment such as work in agriculture or engagement in unpaid household work.

[10]It is coded as missing for children who are under the age of twelve months at the time of interview.

[11]We code this outcome as missing only for people who reported one of the following as their employment status: (i) begging or prostitution (ii) unable to work due to physical handicap (iii) pensioner or rentier.

Household consumption expenditure is recorded separately for various types of goods. We utilise information on annual consumption habits, i.e. over the last 365 days. We deflate the expenditure amounts using the consumer price index (CPI) with 2010 set as the base year. Our interest lies in two outcomes: (i) annual household expenditure (ii) the fraction of annual household expenditure that was spent on medical items.

2.5 Sample Characteristics

The main sample uses the birth recode of the NFHS and contains approximately 200,000 child births between 2010-16 across 621 out of 640 Indian districts.[12] Fertility data is constructed from the woman recode, which records data for 300,000 women in the same spatial and temporal frame. Data on household expenditure, employment patterns and prevalence of agricultural work is available for 618 of those districts. Table 1 presents the summary statistics on all of these outcomes, alongside relevant covariates.

The last column of table 1 reveals that *High Loam* districts had higher levels of fertility and infant mortality, although no difference emerges in health investments – breastfeeding and vaccination, alike. In terms of differences in womens' outcomes, the results are somewhat mixed. Notably, *Low Loam* districts contain fewer woman-headed households and the uptake of secondary education is lower among the women in these districts. On the other hand, women in *Low Loam* districts are more likely to be employed with pay in either salaried work or wage labour outside of the household enterprise. Correspondingly, they are also less likely to be engaged solely in domestic work. This suggests that the higher female labour force participation in *Low Loam* districts stems from employment in agriculture and allied areas, as shown by Carranza (2014). Hence, we argue that *Low Loam* districts exhibit norms that are more favourable towards women's employment but not necessarily more gender-equal.[13] However, previous work by S. Anderson and Eswaran (2009) reveals that women's bargaining power and control over household resources is tied to employment outside of family farms, i.e. paid work. Further, since we find that paid employment among women is more common in *Low Loam* districts, we can also expect that the average woman in these districts has higher bargaining power than her counterpart in *High Loam* districts.

We also note that while at the baseline road access does not significantly differ between *High Loam* and *Low Loam* districts, the intensity of PMGSY road construction is marginally higher among the latter. However, a visual inspection of Panel A in Figure 1 suggests road construction and soil texture do not strongly covary. If anything, *High Loam* districts are usually found clustered together in the northern and central states, alongside coastal regions in southern India. On the other hand, much of the road growth occurred in central regions of India — in states like Rajasthan, Madhya Pradesh, Bihar, Odisha and West Bengal. This is presented more extensively in Panel B of Figure 1, which illustrates the variation in road access at baseline and the intensity of road construction. Panel A shows that at the baseline road access follows mostly a symmetric distribution, with 369 of 618 districts being such that over half of their rural population received access to paved roads. The coverage of road construction under PMGSY seems to follow a Pareto-like distribution, as evident in panel B. In fact, within most districts less than 20 percent of rural residents received a road under the program. Nonetheless, there is variation in program intensity across both space and time that enables our analysis.

[12] NFHS-4 used the administrative boundaries from the 2011 Population Census. As of 2022, India has 737 districts.

[13] Women in *Low Loam* districts enjoy higher labour force participation due to agricultural employment, but this advantage does not extend to measures of household decision-making or educational attainment that are captured in the NFHS data.

3 Empirical Strategy

We use quasi-random improvements in access to paved roads at the district level to study how they affect households' fertility decisions, investment in child health and, by extension, the effects on infant mortality. Owing to the lack of village indicators in the NFHS data, all measures of road access are aggregated to the district-level for each program year up until 2016. The resultant measure is a (weakly) increasing function of time and hence, allows us to exploit both intra-district and inter-district variation. Our interest lies not just in studying the unconditional effect of roads on the aforementioned outcomes, but also in how differences in norms around FLFP mediate this effect.

To proxy for gender norms we leverage information on local soil texture to classify districts into either *High Loam* or *Low Loam*. This follows from the fact that districts with higher loam and lower clay content exhibit greater female labour force participation, primarily within the agricultural sector (Carranza 2014; Afridi et al. 2020). Our procedure for this classification is as indicated in section 2.2. [14]

3.1 Fertility

The estimating equation is given below, and is run separately for *High Loam* and *Low Loam* districts:

$$Y_{whvdt} = \beta_0 + \beta_1 Roads_{dt} + \gamma X_{wht} + \delta_v + \tau_t + \delta_v T + \epsilon_{whdt} \quad (1)$$

where each observation is an woman w in household h living in village v of district d and born in year t. X_{wht} is a vector of individual and household-level covariates including the woman's age in year t, her age during her first childbirth, her present level of education,[15] indicator variables for the household's religion and social group, household size, the household's wealth index ranking and ownership of agricultural land.

The key coefficient is β_1, which represents the marginal effect on Y of a percentage point increase in road access among rural residents of district *d* due to PMGSY. We expect β_1 to be downward-biased, and this an unavoidable artefact of aggregating the roads data to the district-level. Consider household h in the sample, residing in village v of some district d. It is entirely possible that none of the improvements to road connectivity within that district stem are local to village v, i.e. other villages receive all the PMGSY roads. In such cases, β_1 captures only indirect effects of road construction on household h, enabled by non-hyperlocal network and general equilibrium effects.

We cannot rule out contemporaneous changes to both demand and supply-side determinants of healthcare, such as interventions by district administrations and the availability of (new) local health centres, medical personnel and community health workers.[16] To account for them, we include village fixed effects (δ_v), year fixed effects (τ_t) and village-specific linear time trends ($\delta_d T$) in the estimating equation. Though the NFHS data does not include village identifiers, each primary sampling unit (PSU) in the sampling frame corresponds

[14]It bears mentioning that the results are robust to changes in the soil classification scheme, such as using the median level of loam content—as opposed to the difference between loam and clay content—as the criteria to categorise districts as *Low Loam* and *High Loam*

[15]Evidence from across the developing world indicates both mother's education (Drèze & Murthi 2001; J. Kim & Prskawetz 2010) and the infant mortality (Benefo & Schultz 1996) rate can explain downward trends in fertility.

[16]Interested researchers may want to look at recent work that employs machine learning to predict village-level healthcare supply using a subset of the NFHS data that can be fuzzily matched to the 2011 Population Census Village Directory (R. Kim et al. 2021).

to either a single village or a small cluster of neighbouring villages. For our analysis, we treat PSU-level fixed effects as equivalent to village fixed effects.

3.2 Child Healthcare

We employ the following variation of equation (1), evaluated on a sample of children aged 0-5 years and born during 2010-2016:

$$Y_{ihvdt} = \beta_0 + \beta_1 Roads_{dt} + \gamma X_{iht} + m + \delta_v + \tau_t + \delta_v T + \epsilon_{ihdt} \quad (2)$$

where each observation is some child i from household h living in village v of district d and born in year t. X_{iht} is a vector of individual covariates such as the child's gender, age and birth order[17] alongside household controls such as religion, social category, mother's age, mother's education, wealth index score, family size and whether the household is headed by a woman. Since the child's month of birth can affect the outcomes of interest, we also include birth month fixed effects and denote them by m. Like equation (1), we add village fixed effects (δ_v), year fixed effects (τ_t) and village-specific linear time trends ($\delta_v T$) to control for unobserved heterogeneity at the aggregated level.

4 Results

This section presents the results from specification (1) on female fertility and child healthcare. Based on our priors about the differences in female labor force participation across regions with different soil textures, we would expect to see lower rates of fertility and higher investments into child healthcare within *Low Loam* districts.

4.1 Fertility

We partition the available years into two intervals, namely 2002-09 and 2010-16, and focus on the latter. As such, our preferred specification for fertility involves equation (1) applied to the period between 2010 and 2016. The rationale for this is threefold. First, a large fraction of roads under PMGSY were built after 2009 and using this time period allows us to exploit maximum spatial variation in PMGSY-induced road connectivity.[18] Secondly, at the start of this time interval the program would have been in-effect for over nine years. This should provide households the requisite time to factor these road improvements into their own decision-making and hence enable us to study the long-term effects of roads on fertility. Additionally, fertility often responds to economic fluctuations with a lag (Sobotka et al. 2011). Therefore, if rural roads affect fertility through employment or income channels, then a delayed evaluation seems reasonable. Thirdly, we have data on both infant mortality and vaccination for children born between 2010-2016. Consequently, evaluating the fertility response during this period is informative about the 'quality-quantity trade-off' faced by households in family planning decisions. For instance, Kalemli-Ozcan (2003) argues that lower infant mortality rates reduce the uncertainty surrounding the number of surviving children, which can reduce household demand for

[17] Coffey and Spears (2021) show that the neonatal mortality rate falls systematically with birth order.

[18] Adukia et al. (2020) provide a time-disaggregated view of road construction under the program in Figure 1 - Panel A of their paper.

more children under convex preferences. Empirical analyses have also alluded to a relationship between infant mortality and fertility. Anukriti et al. (2022) show that reductions in postnatal infant mortality—arising due to households engaging in sex-selective abortions—led to reductions in overall fertility.[19] Further, evidence from the effects of innovation in health technology, for example the malaria eradication programs shows that a decrease in the incidence of disease leads to both lower infant mortality and higher fertility (Bhattacharjee & Dasgupta 2022; Apouey et al. 2018). Importantly, assessing how a policy affects both infant mortality and fertility is key to understanding its implications on demographic transition (Cervellati & Sunde 2011; Nandi et al. 2022).

Table 2 reveals how fertility responds to road construction. We observe a strong fertility response when using our preferred specification, whose results are presented in columns (4) and (5). In *Low Loam* districts, the marginal effect of road construction is a 0.25 percentage point increase in the probability of the average woman having a birth in any given year. Equivalently, in a random sample of 100 women during any year y, we would expect an additional 25 births. The effect is very similar in magnitude within *High Loam* districts. In fact, using the Chow Test for structural stability of coefficients, we are unable to reject the hypothesis that the marginal effect of roads on fertility is equal across the two types of districts. Our results for 2010-16 complement the findings of Aggarwal (2021) on the short and medium-term impact of PMGSY roads on fertility. We replicate her results in column (1), which shows that there better road connectivity had no noticeable effect on fertility until the long term. Further, in columns (2) and (3) we demonstrate that this null result does not vary across *Low Loam* and *High Loam* districts.

The difference in effect size between 2002-09 and 2010-16 could be indicative of two possibilities. The first is that post-2010, households have internalised the impacts of these new roads by factoring these impacts—such as on employment, healthcare and access to markets—into their decision-making. Note that this does not necessarily suggest that households respond to roads with a delay, although the fertility literature does show evidence of fertility changing only with a lag.[20] It could simply be that the gains (and losses) from road construction do not manifest in the immediate term, since the perturbations to the initial (general) equilibrium may only be resolved in the medium term. The second possibility is that perhaps the cumulative road construction is high enough only in the post-2010 period for its effects on fertility to be tangible.[21] Most likely, the two explanations of these results are linked, i.e. households may be responding with a lag and rural roads may need to cross certain thresholds before their effects are tangible.

The rise in fertility may delay the positive implications of rural roads for economic growth, which are borne out of increased human capital formation (Bloom, Kuhn, & Prettner 2019; Bloom, Canning, et al. 2019). This could occur if per-capita investments into children decline—perhaps on account of rising costs—and labour markets become tighter. In this respect the PMGSY program differs from prior infrastructure interventions elsewhere in the world, such as the rural electrification program in the Philippines, wherein a decrease

[19]However, consensus on the prevalence of the quality-quantity trade-off remains absent. Schultz (2007) suggests that it is mostly localised among high-income urban societies, i.e. not the beneficiaries of rural roads. Moreover, early stages of the demographic transition feature high fertility and high mortality (Lam & Marteleto 2008; Blue & Espenshade 2011; Canning et al. 2015). The latter introduces more uncertainty in the household's family planning decisions and pushes up fertility (Gozgor et al. 2021), thereby weakening the quality-quantity trade-off.

[20]For example, Sobotka et al. (2011) and Lovenheim and Mumford (2013) find that fertility responds to income shocks with a lag of between 1 and 3 years.

[21]We illustrate this graphically in Figure 2 in the Appendix, which shows that under half of the total road construction until 2016 had been completed by 2009.

in fertility and higher labour force participation was observed (Herrin 1979).

An obvious concern here is the existence of pre-trends in fertility. To address this, we adopt the placebo test used by Aggarwal (2021). For the placebo sample, we use fertility data from 1998-2000. These are the pre-PMGSY years that retain most of the size and variation of our main sample.[22] Since no PMGSY roads were built during these years, we assign the intensity of "treatment" to these years by using data from 2014-2016. We define a one-to-one mapping from each year y in 1998-2000 to its corollary y' in 2014-16. Then, for any district d, the roads measure in year y takes the same value as in year y'. For example, the level of road growth in 1998 is defined to be the same as that in 2014. Finally, we test the same specification as before, albeit on this placebo sample. Columns (6) and (7) present the results and demonstrate that there is no evidence of pre-trends in female fertility.

To check further heterogeneity, based on Anukriti and Kumler (2019) we look for subgroup level differences in the fertility response during 2010-2016 across three margins: (i) education (ii) social category and (iii) household wealth and present the results in Table 6 (see Appendix). In columns (1) and (2) we find that the fertility increase is larger among women with primary education. For context, fertility within the base group—women with no formal education—does not rise at all in *Low Loam* districts and rises only by 0.0023 percentage points in *High Loam* districts. No such change in fertility can be observed among women with higher levels of education, namely secondary and tertiary. From columns (3) and (4) we note that women in Scheduled Caste (SC) and Scheduled Tribe (ST) households in *Low Loam* districts are 0.00032 percentage points—ten percent of the coefficient for the base group—more likely to have a child in a given year. While the increase is not very large, this bears mentioning because women in SC and ST households have fewer children in the absence of PMGSY roads.[23] We posit that this may be due to *sanskritization*, whereby lower caste households emulate the behaviour of higher case households. Kingdon and Unni (2001) have previously documented this phenomenon in urban areas, while Eswaran et al. (2013) find weak evidence in support from rural regions within India. In columns (5) and (6) we see that wealthier households in *Low Loam* districts exhibited a weaker fertility response. Nevertheless, this wealth differential in fertility is extremely small from an economic standpoint.

4.2 Child Healthcare

We now turn to the healthcare investments made by households into their young children, for which we use equation (2). We present the relevant results in Panel A of Table (3).

Inspecting columns (1) and (2) we note that access to rural roads leads to more months of breastfeeding among children aged 0-5 years, but only in *High Loam* districts. The effect itself is rather small, with a 10 percentage point increase in district-level road connectivity leads to 3 more months of breastfeeding for the average child, i.e. a 20 percent increase over the mean. The fact that children in *High Loam* districts enjoy gains in breastfeeding, while their counterparts in *Low Loam* districts do not, is surprising upon first glance. After all, breastfeeding can contribute to lower infant mortality in the absence of clean water (Jayachandran & Kuziemko 2011), which means greater breastfeeding could be deemed an investment into the child's health.

[22]For reference, women in the main fertility sample were aged between 16-49, while this range shrunk to 16-35 in the placebo sample (16-33 for 1998). Since the age range is strictly increasing over time (until 2005), going back further in time would have reduced it even more and made the two samples less comparable.

[23]For reference, the coefficient on the *SC/ST* dummy is both negative and significant.

As such, one would expect to see greater investments in districts with higher FLFP, since the latter is known to positively drive the former (Eswaran 2006). We outline the underlying reason in section 6 by discussing the labour market mechanisms.

The result on immunization is captured in columns (3) and (4). Akin to Aggarwal (2021), on the whole we find that vaccination outcomes are boosted by better road connectivity, albeit only in *Low Loam* districts. The increase of 1.59 index points within these districts constitutes a 16 percent improvement over the mean. In section 6 we address this disparity in outcomes and find that changes in the relative availability of public healthcare—produced by rural roads—can explain this divergence.

Knowing that improved access to roads is linked to higher healthcare investments, we should also expect better health outcomes among the recipients of these roads. We adopt infant mortality as the outcome for this exercise since both breastfeeding (Jayachandran & Kuziemko 2011) and vaccination against infectious diseases (Aggarwal 2021) help build immunity and mitigate the risk of infant mortality. Based on columns (5) and (6), we can affirm that the infant mortality rate does decline in *Low Loam* districts amid improved availability of all-weather roads. Specifically, each percentage point of road growth can reduce the infant mortality rate by 1.2 percentage points. This translates into a 24 percent reduction over the mean, and suggests that better road connectivity could, in theory, drive down infant mortality rates to nearly-zero by itself. The lack of an observable effect in *High Loam* districts does not necessarily indicate an absence of a meaningful effect. For instance, Garg et al. (2022) find that the exodus of people in rural areas from agriculture due to the provision of rural roads has increased the incidence of farm fires in affected regions. They show that nearby downwind regions suffer from increased pollution due to these fires, which drives up infant mortality. The presence of such negative effects may counterbalance the erstwhile reduction in infant mortality due to additional breastfeeding in *High Loam* regions, thereby leading us to observe null effects.

Having established the results, we now check for pre-trends in the child health estimates by utilising a similar strategy as in the case of female fertility. The sample for this placebo test consists of child-level data from NFHS-1 and NFHS-2 that together cover the years 1988-2000. We injectively map each year in this period to its corollary in 2004-2016. Equivalently, for any district d the level of road growth in year $y \in [1988, 2000]$ is defined as the level of road growth within that district in year $y + 16$. The results of the placebo test are presented in Panel B of Table 3. In most cases we find no pre-trends in the measures of child healthcare, as can be verified from columns (1) through (6). The only exception is vaccination within *Low Loam* districts, where we record a negative pre-trend. Nonetheless, we remain confident in our results for these districts, since the observed effect in the main sample matches the findings of Aggarwal (2021) for the full set of districts.[24]

5 Mechanisms

We now turn to the mechanisms that could explain the observed increase in both fertility and child healthcare investments. For instance, better road connectivity could improve market linkages and create economic opportunities for nearby residents. This job creation could bring about a pro-cyclical response in fertility and a contemporaneous income effect may encourage households to spend more on child health. But if women gain employment due to roads, then it reduces their available time for childcare and this substitution effect would

[24]Notably the pre-trend disappears when we limit the placebo sample to just NFHS-2. However, we refrain from limiting the coverage of the placebo sample since it already suffers from lower sample size relative to the main sample.

manifest as reduced investments in child health. Another explanation is that rural roads facilitate easier access to both local and non-local healthcare facilities, especially during the monsoon season, when travelling on mud roads can become very difficult (Aggarwal 2021). This could boost the uptake of institutional care, which can include vaccination of young children. We separately evaluate the merit of both the explanations.

5.1 Employment

In Panel A of Table 4 we show how employment outcomes vary in response to road construction. For this, we use a specification that is a variation of equation (2):

$$Y_{ihdt} = \beta_0 + \beta_1 Roads_{dt} + \beta_2 Female_i + \beta_3 (Roads_{dt} \times Female_i) + \gamma X_{iht} + m + \delta_d + \tau_t + \delta_d T + \epsilon_{ihdt} \quad (3)$$

with each observation representing an individual i, aged between 16-60 years, belonging to household h in district d and interviewed in year t. The control vector X_{iht} comprises of indicators for the respondent's age, marital status, education, religion, social category, household's land ownership and the household's primary occupation. m denotes the fixed effects for the interview month, which are included because the predominance of agriculture leads to seasonality in employment and expenditure within rural India. Unlike the NFHS data, we have no way of including village-level fixed effects in this specification. Consequently, we use district fixed effects (δ_d), year fixed effects (τ_t) and district-specific linear time trends ($\delta_d T$).

We note that the incidence of employment responded very differently to road construction across regions with different soil texture. Consider first the case of *Low Loam* districts. Column (1) shows that while male employment does vary with PMGSY roads, women's employment declines by 4 percentage points following a 10 percentage point improvement in district-level road connectivity.[25] To understand why this might transpire, we look at the share of agricultural workers within the total stock of employed individuals in a district. For *Low Loam* districts, in column (3) we show that this share decreases amidst the availability of all-weather roads.[26] Further, column (5) shows that women are increasingly likely to drop out of the labour force entirely and shift to domestic work. All together, these results suggest that the availability of rural roads pushes women—predominantly those engaged within agriculture—away from the labour market and towards being engaged solely in domestic work. This resonates with the work of Asher and Novosad (2020), who find that PMGSY roads induced structural transformation in beneficiary villages wherein residents substituted away from agricultural work to non-farm employment. Although in this case the decline in FLFP may be explained by the affected women's inability or unwillingness to move to other sectors.

Prior work has shown that a drop in FLFP intensifies the bargaining power asymmetry within Indian households, i.e. the preferences of men become more dominant in household decisions (Dyson & Moore 1983). Moreover, there is evidence that Indian men prefer more children than less (Eswaran 2006). In this context, we assert that the increase in fertility within *Low Loam* districts may be borne out of the reduction in women's labour market participation and a subsequent decline in their relative bargaining power. Alternatively, dropping out of the labour force relaxes the "budget" constraint faced by women in the time allocation

[25] The net effect of roads on women is given by $\beta_1 + \beta_3$. We run a post-estimation test with the null hypothesis that $\beta_1 + \beta_3 = 0$ and obtain a p-value of 0.019, which is significant at the 5 percent level.

[26] The t-test for $\beta_1 + \beta_3 = 0$ returns a p-value of 0.078, which is presented in the table footer and is significant at the 10 percent level.

problem between labour, leisure and household work (Becker et al. 1960) and reduces the opportunity cost of childbearing (Schultz 2006). Since mothers prefer larger investments into children to ensure their survival (Eswaran 2006), it follows that increased availability of time enables them to carry out these investments—such as immunization visits—that are reflected in lower infant mortality rates in *Low Loam* districts.

In stark contrast, column (2) shows that in *High Loam* districts, men are more likely to be employed following improvements in road access, while there is no net effect for women. Specifically, each percentage point increase in road connectivity is associated with a 0.4 percentage point rise in the share of employed men within the labour force. Column (4) suggests that among employed people there were no significant flows either into or from agriculture, so this increased propensity of employed may not be driven by sectoral reallocation. Similarly, based on column (6) we conclude that this movement of men into the employment does not stem from the set of men who were engaged purely in household work. Rather, we conclude that it is the men who were previously either unemployed or in education that move into employment after the construction of roads.[27] In any case, these results suggest that rural roads can exacerbate the gender gap in employment within these districts, since men gain while women do not. This issue assumes greater importance because the unconditional gender gap (in employment) within *High Loam* districts was already 10 percentage points larger than their *Low Loam* counterparts.

Another driver of fertility across both *Low Loam* and *High Loam* districts may be the pecuniary contribution of children, which rises when children and adolescents participate in the labour market (Rosenzweig & Evenson 1977). After all, increased employment among children raises their economic value to the utility-maximising household (Becker 1974), thereby placing an upward pressure on family size. This is particularly relevant because Aggarwal (2018) finds that following the provision of PMGSY roads, children aged 14-20 are more likely to drop out of education and enter the labour force, ostensibly to work in sectors such as retail. Our finding is also consistent with previous evidence that when the pathway for children to enter the labour force is eased, both child labour and fertility are likely to increase (Levy 1985).

Our results on labour market outcomes complement prior work on rural roads and employment in India. Asher and Novosad (2020) employ a discontinuity design on a village-level dataset, spanning the entire country, and find evidence of sectoral reallocation but no effects on overall employment. Contrariwise, Lei et al. (2019) find the availability of paved roads in the village leads to higher FLFP in regions with more gender-equal social norms.[28] Since we find the opposite effect, it is entirely possible that soil texture—and the boost it can provide to women's participation in the labour market via agriculture—does not, by itself, make social norms more gender-equal. It is then an open question as to how the two interact, i.e. perhaps women in more gender-equal villages with less loamy soil could benefit *even more* from rural roads than women elsewhere. Notably, Aggarwal (2018) uses the same empirical strategy as us and her results on the country-wide sample indicate that employment is invariant to the provision of PMGSY roads. We are able to reconfirm this finding on the full sample, i.e. when the sample is not split into *Low Loam* and *High Loam*. This underscores the importance of local norms (or contexts) surrounding FLFP as a mediator of the gains (or losses) to employment from the advent of paved roads, since divergent effects across subgroups can produce a null effect in the

[27] One plausible destination for these men may be work in large-scale agriculture, given that Shamdasani (2021) documents an increase in labour use within agriculture following the provision of PMGSY roads. This may involve migration and spatial reallocation of agriculture, since other work has documented a decline in the prevalence of agriculture in villages that received PMGSY roads(Asher & Novosad 2020) and (Garg et al. 2022).

[28] They define more gender-equal villages as those that do not practice the *purdah*.

aggregate.

Additionally, we assuage concerns about pre-trends in the employment results by conducting placebo tests using data from NSS Rounds 50 (1993-1994) and 55 (1999-2000). The procedure is much like the one employed in section 4, with districts in these rounds assigned a level of 'road growth' from 2002-2004 (for round 50) and 2008-2009 (for round 55). Simply, each year in [1993, 2000] was mapped to its corollary in [2002, 2009]. We present the results in Table 5 and find no evidence of pre-trends across any of the employment outcomes (see Appendix).

5.2 Household Expenditure

We now consider how household expenditure—especially the allocation towards medical goods and services—evolve in response to provision of rural roads. The specification for this purpose akin to equation (3), albeit on a sample of households rather than individuals. Correspondingly, we retain all the household-level covariates but not the person-level controls. The results are presented in Panel B of Table 4. From columns (1) and (2) we can infer that medical expenditure, as a share of total household expenditure, declines amid improvements in road connectivity. The effect is stronger in *Low Loam* districts, where each percentage point of road growth is linked to a 2 percentage point drop in this share. For comparison, the effect size in *High Loam* districts is only two-thirds as large. However, looking at the share itself is insufficient, because a large enough increase in total expenditure would mean that in nominal terms, households spend more on healthcare post-road construction. As such, we consider how the total annual per-capita expenditure (APCE), expressed as a logarithm, changes with rural roads. Columns (3) and (4) present the results, and it is immediate to see that the APCE rises only within *Low Loam* districts. However, the quantum of increase is less than one percent, while the share of expenditure allocated to medical goods and services declines by approximately eight percent. Thus, households across the board reduce their medical expenditure following the provision of roads.

There are both demand-side and supply-side explanations for why households might spend less on healthcare. For the demand-side, it could be that higher investments by households into their children's health, through breastfeeding and immunization, may reduce the need to seek (costly) institutional care. Though our data on these outcomes pertains to a later timeline, Aggarwal (2021) shows that both uptake of antenatal care and immunization also rose in response to roads built under the PMGSY during its initial years. Therefore, households may be spending less on healthcare simply because they have less reason to do so. Similarly, reductions in medical expenditure may also be driven by increased affordability of care, such as through the government-sponsored health schemes like the Janani Suraksha Yojana (JSY) that provided cash payments to women as incentives to seek institutional assistance during childbirth. Aggarwal (2021) finds that households are more likely to use public healthcare following the provision of PMGSY roads. This is relevant because using public healthcare reduces these households' out-of-pocket expenditure. Therefore, if rural roads facilitate greater access to public healthcare for residents of *Low Loam* districts than their *High Loam* counterparts, then we might expect that the greater reduction in medical expenditure could be due to increased affordability.

5.3 Access To Public Healthcare

Next, we ask whether rural roads reduced the transport barriers faced by households in accessing government healthcare. This is straightforward because the NFHS Woman Questionnaire includes this question.[29] Columns (5) and (6) of Panel B in Table 4 illustrate the results. Before describing the result, we must add a caveat: the specification we use is akin to equation (1), but we are now limited to only one time period — the interview year.[30] This naturally restricts us from using district-specific fixed effects, in lieu of which we use state fixed effects. With this caveat in mind, we find that in *Low Loam* each percentage point of road growth led to a 2.4 percentage point drop in the probability of a woman reporting that government healthcare was too far. A much smaller and non-significant decrease of 0.2 percentage points in this probability is observed for *High Loam* districts. This lends credence to our argument in the preceding subsection, i.e. medical expenditure decreases more in *Low Loam* districts because rural roads enable easier access to public healthcare. As an aside, this can also explain the increased uptake of child vaccination.

6 Discussion and Conclusion

Road connectivity, particularly in erstwhile isolated regions, can be the harbinger of great change. It can bring about sectoral reallocation of workers (Asher & Novosad 2020), enrich households' consumption baskets (Aggarwal 2018), raise uptake of immunization and institutional care for in-utero children (Aggarwal 2021) and facilitate access to education for young children (Adukia et al. 2020). But not all changes may be desirable. The availability of all-weather rural roads encourages movement of workers out of agriculture, with the resultant shortfall of agricultural labour increasing the propensity of farm fires and raising air pollution levels (Garg et al. 2022). Amidst these developments we ask how these roads can shape households' decisions on fertility, which can greatly influence the partial equilibrium effects discussed just above. For instance, while greater immunization can reduce infant mortality, a concurrent rise in fertility can slow down the manifestation of these gains because larger cohort sizes entail reduced per-capita investments (Canning et al. 2015; Karra et al. 2017). Similarly, the documented increase in employment among adolescents (Aggarwal 2018) can raise the 'economic value' of children and consequently, drive fertility upwards. Given the extensive interlinkages between fertility and the outcomes that have been studied previously within this recent literature, one might reasonably argue that evaluating the response of fertility to roads can be instructive in an attempt to understand the wide-ranging consequences of public infrastructure.

While Aggarwal (2021) shows the lack of any short and medium-term effects of rural roads on fertility, we focus on the long-term effects. We establish that the provision of paved rural roads engenders a tangible increase in fertility during the long-term. To the best of our knowledge, this is a novel finding. Further, we use local soil texture to proxy for heterogenous norms surrounding female labour force participation (FLFP) and find that while these norms do not affect the intensity of the fertility response, they do affect the underlying mechanisms that drive this response. In particular, we show that in districts with shallower tillage (*Low Loam*) women are more likely to be employed pre-PMGSY, with the bulk of this employment stemming from agriculture. However, the structural transformation (Asher & Novosad 2020) brought forth by rural roads

[29] The survey text reads "Why don't members of your household generally go to a government facility when they are sick?".

[30] This is because the NFHS is a cross-sectional survey, and each district was surveyed exclusively in either 2015 or 2016.

generates a shift in employment away from agriculture. This decline of the agricultural sector drives women in these regions to drop out of the labour force and engage solely in domestic work. We also observe a contemporaneous rise in the average household's incomes during this time, and therefore cannot rule out an income effect that may be driving down FLFP. On the other hand, in regions with deeper tillage (*High Loam*), the advent of all-weather roads engenders higher male employment and a decline in unemployed women, who drop out of the labour force. Across both types of regions, these employment dynamics decrease both the relative bargaining power of women (S. Anderson & Eswaran 2009) and the opportunity cost of having children (Becker et al. 1960). Hence, we posit that labour market developments can explain the observed increase in fertility.

We also provide new results for the interaction between rural roads and child healthcare. Specifically, we build upon the work of Aggarwal (2021), who outlines how antenatal care, in-hospital births and child immunization respond to rural roads during the short and medium-term. We extend the scope of outcomes to include breastfeeding and infant mortality. To begin with, we demonstrate that children in *Low Loam* districts enjoy improvements in vaccination along the extensive margin. We show that these improvements can be rationalised by PMGSY roads facilitating access to public healthcare for rural households in districts that receive these roads. Crucially, we establish that these investments in immunization also translate into reductions in infant mortality. Moreover, we find evidence of greater breastfeeding of young children in *High Loam* districts. The degree of this increase suggests that road connectivity can shrink the pre-existing gap in the mean duration of breastfeeding between children in *Low Loam* and *High Loam* districts. We believe these gains in breastfeeding are tied to the greater reduction in FLFP within *High Loam* regions, which allows women to allocate greater time towards childcare.

From a policy perspective, the effects of rural roads on child healthcare clearly provide evidence for positive social externalities. These benefits are likely to compound over time, since better health translates into improved educational attainment (Alderman et al. 2006; Bobonis et al. 2006), labour supply (Baird et al. 2016) and demographic transition (Cervellati & Sunde 2011) which has implications for both spatial and intergenerational mobility (Ahlburg 1998). However, if the improvements in the 'quality' of children through reduced mortality and increased health investments do not coincide with lower fertility, the benefits from these improvements may be dampened in the short-run. Given that we find an increase in long-term fertility that can be attributed to the PMGSY, one may argue that the gains in downstream outcomes such as infant mortality—and even child anthropometry—may manifest only with a delay. The positive effects of rural roads on households' access to public healthcare, and the concurrent decline in healthcare expenditure, suggests that rural roads can help resolve the supply-side constraints in the last-mile delivery of child healthcare. In fact, across the developing world, the provision of all-weather roads has been linked to reductions in poverty (Gibson & Rozelle 2003; Dercon et al. 2009; Khandker et al. 2009; Khandker & Koolwal 2011). Nonetheless, as our results on the labour market consequences of rural roads demonstrate, the effects of roads extend beyond healthcare. The resultant decline in FLFP stands to worsen not just women's intra-household bargaining power, but also threaten their human capital formation and widen the extant gender gap in the labour market. The mixed nature of our results underscores the need to study the multifaceted consequences, intended or otherwise, of massive infrastructure programs such as the PMGSY and to ascertain their impact on socioeconomic welfare.

References

Adsera, A., & Menendez, A. (2011). Fertility changes in latin america in periods of economic uncertainty. *Population studies*, *65*(1), 37–56.

Adukia, A., Asher, S., & Novosad, P. (2020). Educational investment responses to economic opportunity: evidence from indian road construction. *American Economic Journal: Applied Economics*, *12*(1), 348–76.

Afridi, F., Bishnu, M., & Mahajan, K. (2020). Gendering technological change: Evidence from agricultural mechanization. *SSRN*.

Aggarwal, S. (2018). Do rural roads create pathways out of poverty? evidence from india. *Journal of Development Economics*, *133*, 375-395. doi: https://doi.org/10.1016/j.jdeveco.2018.01.004

Aggarwal, S. (2021). The long road to health: Healthcare utilization impacts of a road pavement policy in rural india. *Journal of Development Economics*, *151*, 102667.

Ahlburg, D. (1998). Intergenerational transmission of health. *The American Economic Review*, *88*(2), 265–270.

Alderman, H., Hoddinott, J., & Kinsey, B. (2006). Long term consequences of early childhood malnutrition. *Oxford economic papers*, *58*(3), 450–474.

Anderson, M. L. (2008). Multiple inference and gender differences in the effects of early intervention: A reevaluation of the abecedarian, perry preschool, and early training projects. *Journal of the American statistical Association*, *103*(484), 1481–1495.

Anderson, S., & Eswaran, M. (2009). What determines female autonomy? evidence from bangladesh. *Journal of Development Economics*, *90*(2), 179–191.

Anukriti, S., Bhalotra, S., & Tam, E. H. (2022). On the quantity and quality of girls: Fertility, parental investments and mortality. *The Economic Journal*, *132*(641), 1–36.

Anukriti, S., & Kumler, T. J. (2019). Women's worth: Trade, female income, and fertility in india. *Economic Development and Cultural Change*, *67*(3), 687–724.

Apouey, B., Picone, G., & Wilde, J. (2018). The economics of malaria prevention. In *Oxford research encyclopedia of economics and finance.*

Asher, S., & Novosad, P. (2020). Rural roads and local economic development. *American economic review*, *110*(3), 797–823.

Baird, S., Friedman, J., & Schady, N. (2011). Aggregate income shocks and infant mortality in the developing world. *Review of Economics and statistics*, *93*(3), 847–856.

Baird, S., Hicks, J. H., Kremer, M., & Miguel, E. (2016). Worms at work: Long-run impacts of a child health investment. *The quarterly journal of economics*, *131*(4), 1637–1680.

Becker, G. S. (1974). A theory of social interactions. *Journal of political economy*, *82*(6), 1063–1093.

Becker, G. S., & Lewis, H. G. (1973). On the interaction between the quantity and quality of children. *Journal of political Economy*, *81*(2, Part 2), S279–S288.

Becker, G. S., et al. (1960). An economic analysis of fertility. demographic and economic change in developed countries. In *Nber conference series* (Vol. 11, pp. 209–231).

Benefo, K., & Schultz, T. P. (1996). Fertility and child mortality in cote d'ivoire and ghana. *The World Bank Economic Review*, *10*(1), 123–158.

Bhalotra, S. (2010). Fatal fluctuations? cyclicality in infant mortality in india. *Journal of Development Economics*, *93*(1), 7–19.

Bhattacharjee, S., & Dasgupta, A. (2022). Disease eradication, infant mortality and fertility response: Evidence from malaria eradication in india. *The Journal of Development Studies*, *Forthcoming*.

Bloom, D. E., Canning, D., Kotschy, R., Prettner, K., & Schünemann, J. J. (2019). *Health and economic growth: reconciling the micro and macro evidence* (Tech. Rep.). National Bureau of Economic Research.

Bloom, D. E., Kuhn, M., & Prettner, K. (2019). Health and economic growth. In *Oxford research encyclopedia of economics and finance.*

Blue, L., & Espenshade, T. J. (2011). Population momentum across the demographic transition. *Population and development review*, *37*(4), 721–747.

Bobonis, G. J., Miguel, E., & Puri-Sharma, C. (2006). Anemia and school participation. *Journal of Human resources*, *41*(4), 692–721.

Calderón, C., & Servén, L. (2014). Infrastructure, growth, and inequality: An overview. *World Bank Policy Research Working Paper*(7034).

Canning, D., Raja, S., & Yazbeck, A. S. (2015). *Africa's demographic transition: Dividend or disaster?* (A. S. Yazbeck, D. Canning, & S. Raja, Eds.). The World Bank. Retrieved from https://elibrary.worldbank.org/doi/abs/10.1596/978-1-4648-0489-2 doi: 10.1596/978-1-4648-0489-2

Carranza, E. (2014). Soil endowments, female labor force participation, and the demographic deficit of women in india. *American Economic Journal: Applied Economics*, *6*(4), 197-225.

Cervellati, M., & Sunde, U. (2011). Life expectancy and economic growth: the role of the demographic transition. *Journal of economic growth*, *16*(2), 99–133.

Coffey, D., & Spears, D. (2021). Neonatal death in india: birth order in a context of maternal undernutrition. *The Economic Journal*, *131*(638), 2478–2507.

Currie, J., & Schwandt, H. (2014). Short-and long-term effects of unemployment on fertility. *Proceedings of the National Academy of Sciences*, *111*(41), 14734–14739.

Cutler, D. M., Knaul, F., Lozano, R., Méndez, O., & Zurita, B. (2002). Financial crisis, health outcomes and ageing: Mexico in the 1980s and 1990s. *Journal of Public Economics*, *84*(2), 279–303.

Dasgupta, A., & Karandikar, A. (2021). *Gender-gap in learning outcomes under rainfall shocks: The role of gender norms* (Discussion Paper Series in Economics No. 70). Ashoka University, Department of Economics.

Dehejia, R., & Lleras-Muney, A. (2004). Booms, busts, and babies' health. *The Quarterly journal of economics*, *119*(3), 1091–1130.

Dercon, S., Gilligan, D. O., Hoddinott, J., & Woldehanna, T. (2009). The impact of agricultural extension and roads on poverty and consumption growth in fifteen ethiopian villages. *American Journal of Agricultural Economics*, *91*(4), 1007–1021.

Dinkelman, T. (2011). The effects of rural electrification on employment: New evidence from south africa. *American Economic Review*, *101*(7), 3078-3108.

Drèze, J., & Murthi, M. (2001). Fertility, education, and development: evidence from india. *Population and development Review*, *27*(1), 33–63.

Duflo, E., & Pande, R. (2007). Dams. *The Quarterly Journal of Economics*, *122*(2), 601–646.

Dyson, T., & Moore, M. (1983). On kinship structure, female autonomy, and demographic behavior in india. *Population and development review*, 35–60.

Eswaran, M. (2006). Fertility in developing countries. *Understanding poverty, (Part 1)*, 143-160.

Eswaran, M., Ramaswami, B., & Wadhwa, W. (2013). Status, caste, and the time allocation of women in rural india. *Economic Development and Cultural Change*, *61*(2), 311–333.

Ferreira, F. H., & Schady, N. (2009). Aggregate economic shocks, child schooling, and child health. *The World Bank Research Observer*, *24*(2), 147–181.

Garg, T., Jagnani, M., & Pullabhotla, H. K. (2022). Structural transformation and environmental externalities.

Gibson, J., & Rozelle, S. (2003). Poverty and access to roads in papua new guinea. *Economic Development and Cultural Change*, *52*(1), 159-185.

Gozgor, G., Bilgin, M. H., & Rangazas, P. (2021). Economic uncertainty and fertility. *Journal of Human Capital*, *15*(3), 373–399.

Grimm, M., Sparrow, R., & Tasciotti, L. (2015). Does electrification spur the fertility transition? evidence from indonesia. *Demography*, *52*(5), 1773–1796.

Grogan, L. (2016). Household electrification, fertility, and employment: evidence from hydroelectric dam construction in colombia. *Journal of Human Capital*, *10*(1), 109–158.

Herrin, A. N. (1979). Rural electrification and fertility change in the southern philippines. *Population and Development Review*, 61–86.

Hjort, J., & Poulsen, J. (2019). The arrival of fast internet and employment in africa. *American Economic Review*, *109*(3), 1032-1079.

Jayachandran, S., & Kuziemko, I. (2011). Why do mothers breastfeed girls less than boys? evidence and implications for child health in india. *The Quarterly journal of economics*, *126*(3), 1485–1538.

Jensen, R., & Oster, E. (2009). The power of tv: Cable television and women's status in india. *The Quarterly Journal of Economics*, *124*(3), 1057-1094.

Kalemli-Ozcan, S. (2003). A stochastic model of mortality, fertility, and human capital investment. *Journal of Development Economics*, *70*(1), 103–118.

Karra, M., Canning, D., & Wilde, J. (2017). The effect of fertility decline on economic growth in africa: A macrosimulation model. *Population and development review*, *43*, 237–263.

Khandker, S. R., Bakht, Z., & Koolwal., G. B. (2009). The poverty impact of rural roads: Evidence from bangladesh. *Economic Development and Cultural Change*, *57*(4), 685-722.

Khandker, S. R., Barnes, D. F., & Samad, H. A. (2013). Welfare impacts of rural electrification: A panel data analysis from vietnam. *Economic Development and Cultural Change*, *61*(3), 659-692.

Khandker, S. R., & Koolwal, G. B. (2011). Estimating the long-term impacts of rural roads: a dynamic panel approach. *World Bank Policy Research Working Paper*(5867).

Kim, J., & Prskawetz, A. (2010). External shocks, household consumption and fertility in indonesia. *Population research and policy review*, *29*(4), 503–526.

Kim, R., Bijral, A. S., Xu, Y., Zhang, X., Blossom, J. C., Swaminathan, A., … others (2021). Precision mapping child undernutrition for nearly 600,000 inhabited census villages in india. *Proceedings of the National Academy of Sciences*, *118*(18), e2025865118.

Kingdon, G. G., & Unni, J. (2001). Education and women's labour market outcomes in india. *Education Economics*, *9*(2), 173–195.

Lam, D., & Marteleto, L. (2008). Stages of the demographic transition from a child's perspective: Family size, cohort size, and children's resources. *Population and development review*, *34*(2), 225–252.

Lei, L., Desai, S., & Vanneman, R. (2019). The impact of transportation infrastructure on women's employment in india. *Feminist economics*, *25*(4), 94–125.

Lenz, L., Munyehirwe, A., Peters, J., & Sievert, M. (2017). Does large-scale infrastructure investment alleviate poverty? impacts of rwanda's electricity access roll-out program. *World Development*, *89*, 88-110.

Levy, V. (1985). Cropping pattern, mechanization, child labor, and fertility behavior in a farming economy: Rural egypt. *Economic Development and Cultural Change*, *33*(4), 777–791.

Lovenheim, M. F., & Mumford, K. J. (2013). Do family wealth shocks affect fertility choices? evidence from the housing market. *Review of Economics and Statistics*, *95*(2), 464–475.

Medeiros, V., Saulo Marques Ribeiro, R., & Vasconcelos Maia do Amaral, P. (2021). Infrastructure and household poverty in brazil: A regional approach using multilevel models. *World Development*, *137*, 147-163.

Miller, G., & Urdinola, B. P. (2010). Cyclicality, mortality, and the value of time: The case of coffee price fluctuations and child survival in colombia. *Journal of Political Economy*, *118*(1), 113–155.

Murthi, M., Guio, A.-C., & Dreze, J. (1995). Mortality, fertility, and gender bias in india: A district-level analysis. *Population and development review*, 745–782.

Nandi, A., Summan, A., Ngô, D., & Bloom, D. E. (2022). Childhood vaccinations and demographic transition: Long-term evidence from india.

Parikh, P., Fu, K., Parikh, H., McRobie, A., & George, G. (2015). Infrastructure provision, gender, and poverty in indian slums. *World Development*, *66*, 468-486.

Paxson, C., & Schady, N. (2005). Child health and economic crisis in peru. *The World bank economic review*, *19*(2), 203–223.

Rosenzweig, M. R., & Evenson, R. (1977). Fertility, schooling, and the economic contribution of children of rural india: An econometric analysis. *Econometrica: journal of the Econometric Society*, 1065–1079.

Saing, C. H. (2018). Rural electrification in cambodia: does it improve the welfare of households? *Oxford Development Studies*, *46*(2), 147-163.

Schultz, T. P. (1969). An economic model of family planning and fertility. *Journal of Political Economy*, *77*(2), 153–180.

Schultz, T. P. (2006). Fertility and income. *Understanding poverty*, 125–142.

Schultz, T. P. (2007). Population policies, fertility, women's human capital, and child quality. *Handbook of development economics*, *4*, 3249–3303.

Sedai, A. K., Vasudevan, R., Pena, A. A., & Miller, R. (2021). Does reliable electrification reduce gender differences? evidence from india. *Journal of Economic Behavior & Organization*, *185*, 580–601.

Shamdasani, Y. (2021). Rural road infrastructure & agricultural production: Evidence from india. *Journal of Development Economics*, *152*, 102686.

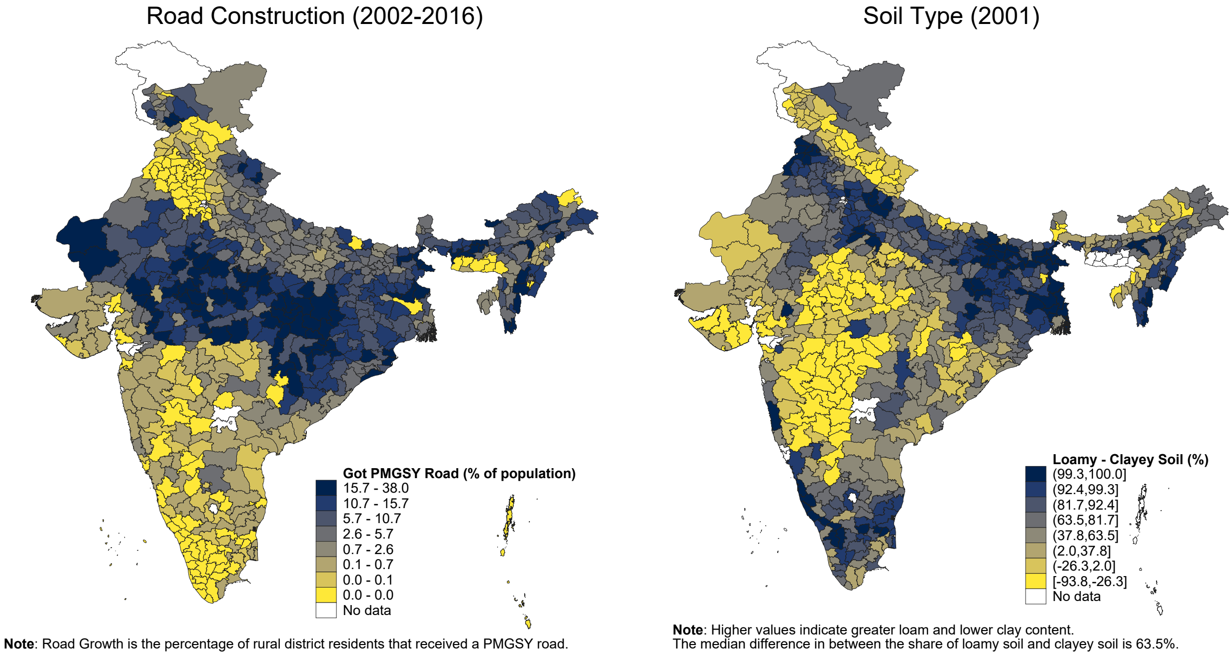
Sobotka, T., Skirbekk, V., & Philipov, D. (2011). Economic recession and fertility in the developed world. *Population and development review*, *37*(2), 267–306.

Tasciotti, L., Sulehria, F., & Wagner, N. (2022). Fertility, electricity and television: is there a link? evidence from pakistan, 1990–2018. *Journal of Demographic Economics*, 1–28.

Weil, D. N., & Wilde, J. (2009). How relevant is malthus for economic development today? *American Economic Review*, *99*(2), 255–60.

Figures and Tables

Figure 1: (A.) District-wise breakdown of road growth and soil type



(B.) Distribution of baseline road access and road growth

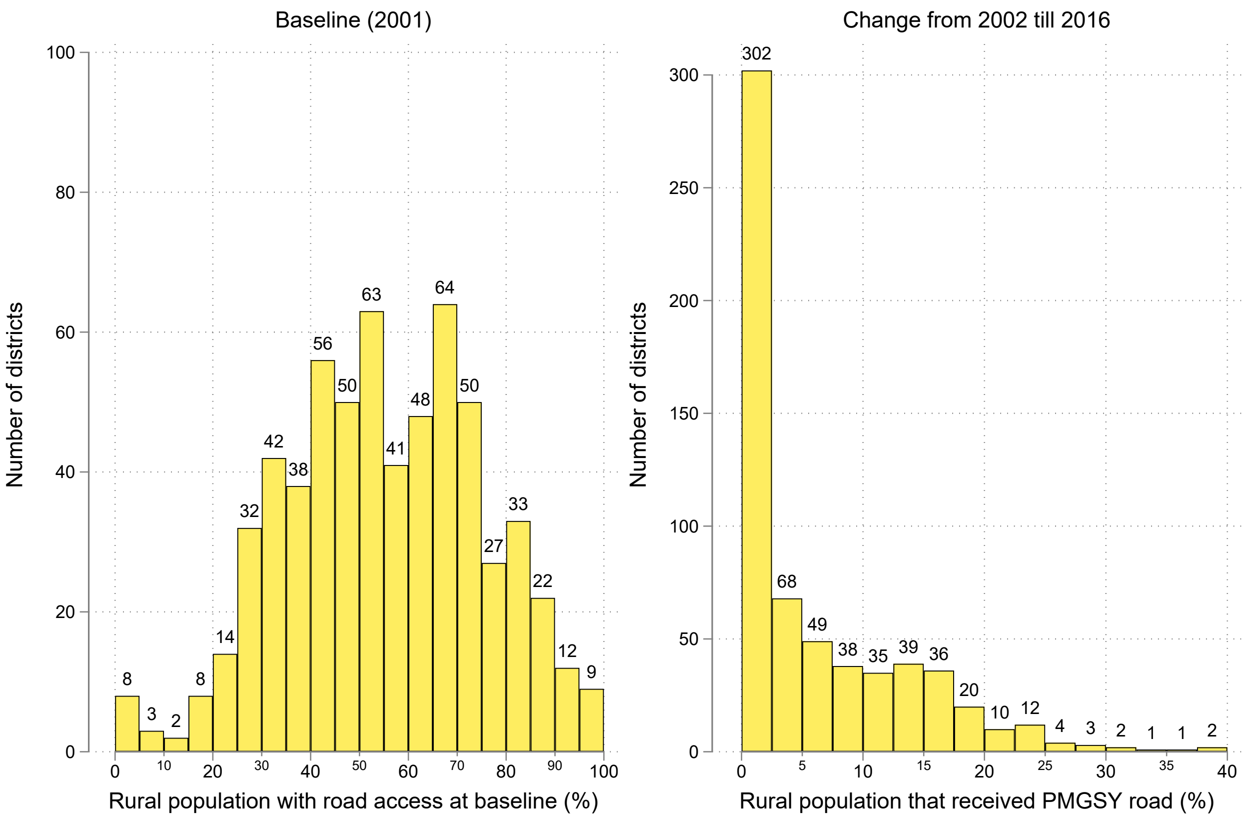


Table 1: Sample averages of health outcomes and covariates by soil texture of district

	All Districts	Low Loam	High Loam	(Low-High)
Panel A: Health and maternal care (NFHS-4)				
Fertility (total births / years in reference period)	0.1426	0.1399	0.1464	-0.0065***
Infant mortality	0.0488	0.0471	0.0523	-0.0052**
Adequate food (age 0-23 months)	0.5916	0.5831	0.5978	-0.0147
Breastfeeding duration (months)	15.2578	15.1316	15.4589	-0.3273
Vaccine index	9.4491	9.4860	9.4034	0.0826
Height-For-Age z-score (age 0-5 years)	-1.4342	-1.4197	-1.4722	0.0526
Weight-For-Age z-score (age 0-5 years)	-1.5062	-1.5220	-1.5095	-0.0125
Members in household	6.3737	6.3812	6.3998	-0.0186
Household wealth quintile (1=poorest, 5=wealthiest)	2.5590	2.5812	2.4825	0.0987
Household food consumption index (higher = better)	-0.0031	-0.0195	0.0015	-0.0210
Household treats drinking water	0.3724	0.4429	0.2844	0.1584***
Hindu household	0.7448	0.7814	0.7213	0.0601**
Muslim household	0.1204	0.1212	0.1235	-0.0023
SC or ST household	0.4188	0.4128	0.4137	-0.0009
Female head of household	0.1140	0.0959	0.1275	-0.0316***
Mother completed primary education	0.4700	0.4598	0.4711	-0.0113
Mother completed secondary education	0.1616	0.1474	0.1685	-0.0211**
Mother completed tertiary education	0.0615	0.0563	0.0643	-0.0080
Total children ever born to woman	2.2284	2.1967	2.2714	-0.0747**
Woman's age at first childbirth (years)	20.2505	20.1806	20.2535	-0.0729
Woman's bmi as % of who reference median	118.1248	117.6351	118.2171	-0.5820
Distance to healthcare facility was an issue	0.6580	0.6618	0.6564	0.0055
Govt. healthcare was too far	0.4579	0.4505	0.4739	-0.0234**
Govt. healthcare was of poor quality	0.4653	0.4540	0.4840	-0.0299**
Population with road access at baseline (%)	55.5423	56.7992	54.7056	2.0936
Population that received PMGSY road until 2016 (%)	5.4929	6.0433	5.2949	0.7484
Panel B: Employment and expenditure (NSS Rounds 61-68)				
Share of people with paid employment	0.5159	0.5352	0.4936	0.0416***
Share of women with paid employment	0.2084	0.2428	0.1742	0.0686***
Share of women involved only in household work	0.3185	0.2801	0.3691	-0.0890***
Person's age (years)	27.0144	27.3130	26.7653	0.5477**
Share of agricultural households	0.5996	0.6300	0.5923	0.0376***
Household size	5.6494	5.5611	5.7541	-0.1930***
Log(Annual household expenditure on all items)	19861.3947	19425.0479	19778.6070	-353.5591
Share of annual expenditure on medical items	1.8328	1.9251	1.8018	0.1233

Notes: For each district *d*, the % share of (loamy - clayey) soil is computed. This is compared to the median level of (loamy - clayey) soil across all districts. The soil dummy is coded as 1 if a district's share of (loamy - clayey) soil is above median. Otherwise, it is set to 0. | Source: Soils of India (2001), NFHS-4 (2015-16) and PMGSY data (SHRUG) | * 0.1 ** 0.05 *** 0.01

Table 2: Impact of Road Construction on Fertility

	Fertility (2002-09)			Fertility (2010-16)		Fertility (1998-00)	
	All	Low Loam	High Loam	Low Loam	High Loam	Low Loam	High Loam
Road Growth	-0.025	-0.021	-0.023	0.25**	0.26***	0.22	1.93
	(0.044)	(0.055)	(0.069)	(0.10)	(0.074)	(1.59)	(1.69)
Observations	2192975	1054680	1083983	947681	982783	271263	277047
Outcome Mean	0.14	0.13	0.15	0.094	0.10	0.17	0.19
Outcome Std. Dev.	0.35	0.34	0.35	0.29	0.31	0.38	0.39
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* 0.1 ** 0.05 *** 0.01 | **Notes**: All specifications use Village FE, a Year FE and Village-level Linear Time Trends. Standard errors are clustered at the Village level. | *Had a Birth* is a binary outcome takes value=1 for woman w in year y if she gave a birth during that year, and 0 otherwise.

Table 3: Impact of Road Construction on Child Healthcare

Panel A: Main Sample	Breastfeeding (Months)		Vaccination Index		Infant Mortality	
	Low Loam	High Loam	Low Loam	High Loam	Low Loam	High Loam
Road Growth	0.18	0.31***	1.59**	0.16	-0.012**	-0.0026
	(0.20)	(0.12)	(0.75)	(0.40)	(0.0051)	(0.0022)
Observations	64699	72286	83892	96214	72223	83625
Outcome Mean	15.8	16.4	10.7	11.0	0.050	0.056
Outcome Std. Dev.	12.5	13.0	56.0	55.0	0.22	0.23
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Placebo Test	Breastfeeding (Months)		Vaccination Index		Infant Mortality	
	Low Loam	High Loam	Low Loam	High Loam	Low Loam	High Loam
Road Growth	0.020	0.020	-0.68**	-0.16	-0.00030	-0.00013
	(0.014)	(0.013)	(0.27)	(0.20)	(0.00070)	(0.00075)
Observations	22774	26740	22883	26860	18652	22264
Outcome Mean	15.2	15.5	-30.5	-48.4	0.093	0.098
Outcome Std. Dev.	9.85	10.1	81.9	79.9	0.29	0.30
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

* 0.1 ** 0.05 *** 0.01 | **Notes**: Specifications in Panel A use Birth Month FE, Village FE, Year FE and Village-level Linear Time Trends. Standard errors are clustered at the Village level. Specifications in Panel B use Birth Month FE, State FE, Year FE and (State x Year) FE. Standard errors for these specifications are clustered at the Village level. The use of State fixed effects is motivated by four factors: (i) several districts were constructed between NFHS-1 and NFHS-2 (ii) the new districts often do not have a one-to-one mapping to the old districts (iii) many districts are not sampled within NFHS-1 and NFHS-2 (iv) the data is representative only at the state level, with many districts featuring a very low sample size. We use states since they are geographically consistent across the two rounds (when using the state boundaries from the 1991 Census). | *Breastfeeding Duration* is a discrete outcome that records, for each child, the number of months he or she was breastfed. The *Vaccine Index* is a composite indicator that is computed via an Inverse Covariance Weighting (ICW) of multiple vaccine indicators present within the NFHS data. These indicators are first standardized, and then their ICW matrix is used to calculate the Vaccine Index score. The indicators cover vaccines for: Measles, Tetanus, Diptheria, Polio (3 shots); along with records of Vitamin-A supplements. *Infant Mortality* is a binary outcome. It takes value = 1 if the child died within the first 12 months of birth, and 0 otherwise.

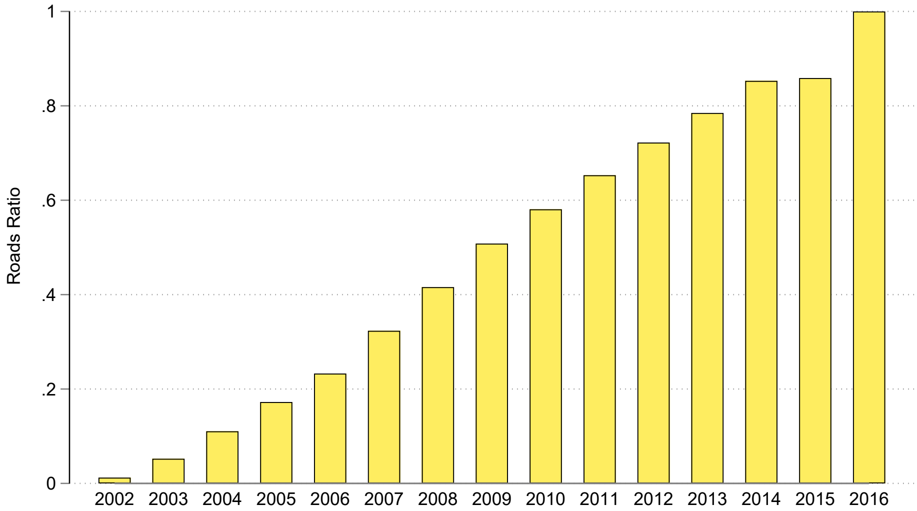
Table 4: Impact of Road Construction on Employment, Expenditure and Healthcare Access

Panel A:	Paid Employment		Agricultural Work		Only HH Work	
Employment Patterns	Low Loam	High Loam	Low Loam	High Loam	Low Loam	High Loam
Road Growth	0.17	0.41*	-0.050	-0.098	-0.59*	-0.26
	(0.19)	(0.23)	(0.30)	(0.28)	(0.33)	(0.29)
Female	-0.54***	-0.64***	0.048***	-0.0078	0.18***	0.33***
	(0.0099)	(0.011)	(0.0098)	(0.012)	(0.013)	(0.017)
Female × Road Growth	-0.55***	-0.41**	-0.63***	-0.42*	1.31***	0.96***
	(0.12)	(0.18)	(0.12)	(0.22)	(0.18)	(0.30)
Observations	343680	358864	177793	171479	343680	358864
Outcome Mean	0.53	0.48	0.61	0.53	0.12	0.19
Outcome Std. Dev.	0.50	0.50	0.49	0.50	0.32	0.39
P-value for $\beta_1 + \beta_3 = 0$	0.043	0.98	0.036	0.14	0.034	0.032
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Panel B:	Medical Exp.		Log(Annual Exp.)		Govt. Healthcare Far	
Expenditure and Access	Low Loam	High Loam	Low Loam	High Loam	Low Loam	High Loam
Road Growth	-2.78***	-1.17**	0.042**	0.0093	-0.0024**	-0.00045
	(0.70)	(0.54)	(0.016)	(0.0087)	(0.0012)	(0.0012)
Observations	15327	14370	94050	96127	66796	94670
Outcome Mean	35.7	34.6	7.04	7.00	0.45	0.49
Outcome Std. Dev.	25.1	25.6	1.07	1.04	0.50	0.50
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

* 0.1 ** 0.05 *** 0.01 | **Notes**: All specifications in Panel A and Columns (1) through (4) of Panel B use Month FE, District FE, Year FE and District-level Linear Time Trends. Only Columns (5) and (6) of Panel B use State FE and State-level Linear Time Trends. Standard errors are clustered at the district level. | *Employed* is a binary variable that is set = 1 if the respondent is employed and 0 if they are not employed and in the labour force. *Agricultural Work* is a binary variable that is set = 1 if the respondent worked in the agricultural sector at the time of survey, and 0 if they worked elsewhere. *Only HH Work* is a binary variable that takes value = 1 if the respondent undertakes only unpaid household work, and 0 otherwise. Both variables are set to missing for respondents who chose the following categories: Pensioners / Rentiers, Unable to work due to disability, Others (begging etc). | *Medical* refers to the household's annual medical expenditure as a share of annual total expenditure. *Log(Annual Expenditure)* refers to the natural log of the household's total annual expenditure on the following categories: medical, schooling and educational articles, clothing and durable goods. *Govt. Healthcare Far* takes value=1 if the woman reported not using government healthcare because it was too far, and 0 otherwise.

Appendix

Figure 2: Road construction under PMGSY as a fraction of total work done until 2016



Note: *Roads Ratio* in year *y* = mean road growth in year *y* / mean road growth in 2016.
The ratio captures the share of total PMGSY road work that occured up until year *y*.

Table 5: Impact of Road Construction on Employment (Placebo)

	Paid Employment		Agricultural Work		Only HH Work	
	Low Loam	High Loam	Low Loam	High Loam	Low Loam	High Loam
Road Growth	0.0021	0.0035	-0.000066	-0.00013	-0.0039	-0.0062
	(0.0034)	(0.0077)	(0.0047)	(0.011)	(0.0050)	(0.012)
Female	-0.55***	-0.67***	0.085***	0.045***	0.16***	0.34***
	(0.014)	(0.013)	(0.010)	(0.011)	(0.015)	(0.021)
Female × Road Growth	-0.0019	-0.0025	-0.0078***	-0.0026	0.0048*	0.0016
	(0.0022)	(0.0028)	(0.0018)	(0.0033)	(0.0026)	(0.0055)
Observations	106767	138440	55026	64099	106767	138440
Outcome Mean	0.57	0.49	0.66	0.60	0.089	0.18
Outcome Std. Dev.	0.50	0.50	0.47	0.49	0.28	0.38
P-Value for $\beta_1 + \beta_3 = 0$	0.96	0.90	0.094	0.79	0.82	0.70
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

* 0.1 ** 0.05 *** 0.01 | **Notes**: All specifications use Quarter FE, Stratum FE, Year FE and Stratum-specific Linear Time Trends. Errors are clustered at the Stratum level. *Employed* is a binary variable that is set = 1 if the respondent is employed at the time of survey and 0 if they are not employed and in the labour force. *Agricultural Work* is a binary variable that is set = 1 if the respondent worked in the agricultural sector at the time of survey, and 0 if they worked elsewhere. *Only HH Work* is a binary variable that takes value = 1 if the respondent undertakes only unpaid household work, and 0 otherwise. Both variables are set to missing for respondents who chose the following categories: Pensioners / Rentiers, Unable to work due to disability, Others (begging etc).

Table 6: Impact of Road Construction on Fertility (2010-16) by Subgroup

	Fertility x Education		Fertility x Caste		Fertility x Income	
	Low Loam	High Loam	Low	High	Low	High
Road Growth	0.0027	0.0023**	0.0027	0.0025***	0.0031	0.0024**
	(0.0025)	(0.00092)	(0.0025)	(0.00091)	(0.0025)	(0.00093)
Road Growth × Prim. Educ.	0.00046***	0.00081***				
	(0.00014)	(0.00018)				
Road Growth × Sec. Educ.	-0.00023	-0.0000084				
	(0.00018)	(0.00021)				
Road Growth × Ter. Educ.	-0.000076	-0.00012				
	(0.00025)	(0.00028)				
Road Growth × SC/ST HH			0.00032***	-0.00013		
			(0.000096)	(0.00010)		
Road Growth × Wealth Q.					-0.00012***	0.000046
					(0.000038)	(0.000058)
Observations	969509	1003953	969509	1003953	969509	1003953
Outcome Mean	0.094	0.10	0.094	0.10	0.094	0.10
Outcome Std. Dev.	0.29	0.31	0.29	0.31	0.29	0.31
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

* 0.1 ** 0.05 *** 0.01 | **Notes**: All specifications use District FE, Year FE and District-level Linear Time Trends. Standard errors are clustered at the district level. | *Fertility* is a binary outcome takes value=1 for woman w in year y if she gave a birth during that year, and 0 otherwise.