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journal homepage: www.elsevier.com/locate/jpubePaving the road to re-election[☆]Camille Boudot-Reddy^a, André Butler^{b,*}^a Birkbeck, University of London, United Kingdom^b University of Cambridge, United Kingdom

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ABSTRACT

The prevailing view in the economic literature is that voters are particularly myopic, encouraging governments to leverage short-term re-election strategies. Under such conditions, public capital investment with long-term rewards – despite its central role in the process of sustained economic development – may be neglected. In the context of India's rural road construction programme, this study evaluates the role which large-scale public infrastructure initiatives have on the electoral accountability mechanism. Using a *fuzzy* regression discontinuity design with newly-digitised village-level voting outcomes from the 2014 general election, the results provide evidence of electoral support attributed to the political alliance which spearheaded the programme. This support is sustained over two electoral cycles, with significant spillover effects in villages within 2 km of a newly built road.

1. Introduction

In 2017, 1 billion people lived more than 2 km from a paved road, 1.2 billion had no electricity, and 1 in 3 people lacked access to clean drinking water (UNICEF, 2020; World Bank Group, 2016, 2017). Analysis by the McKinsey Global Institute suggests that the world needs to invest an average of \$3.3 trillion annually just to sustain current economic growth rates. Emerging economies, with the largest unexploited efficiency gains from greater infrastructure investment, account for 60% of that need (Gardner and Henry, 2021; McKinsey Global Institute, 2016). Despite the evident necessity to expand public infrastructure the scheduled investment to take place globally from 2015 to 2030 is only \$2.2 trillion, resulting in what has been coined as the “global infrastructure gap” (Gardner and Henry, 2021). The role of financial support has received significant attention in the literature as a constraint to investment (Engel et al., 2022; Fay et al., 2021). In contrast, limited research has been devoted to understanding the political incentives for large government led infrastructure development initiatives.

Governments at all levels are known to make extensive use of well timed short-run re-election strategies. Evidence from vote-buying (Finan and Schechter, 2012), increasing budget surplus (Brender and

Drazen, 2008) and programme expenditures (Brollo and Nannicini, 2012) in election years all suggest that these provide substantial rewards at the ballot box. This phenomenon may lead governments to turn towards short-run policies with immediate electoral returns at the expense of programmes whose benefits may only accrue in the medium to long-run. For instance, infrastructure development including transport, water, and electricity, may under such a democratic accountability mechanism receive sub-optimal investment.

In this paper, we provide causal evidence on the effect of exposure to a rural road building programme implemented by the Government of India – which brought paved roads to nearly 200,000 villages between 2000 to 2014 at a cost of almost \$40 billion – on voting behaviour over two electoral cycles. While programmes aimed at improving public infrastructure have been implemented by governments around the world, evaluating the causal impact of access to these interventions on electoral outcomes is often challenging. This is partly due to the fact that governments are known to leverage their power to target public goods towards specific groups and locations (Banerjee and Somanathan, 2007; Burgess et al., 2015; Lehne et al., 2018; Mahadevan, 2019). In order to address this source of endogeneity and accurately ascertain a

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causal interpretation, we focus our analysis on the construction of rural roads under the Pradhan Mantri Gram Sadak Yojana (Prime Minister's Village Road Programme, or PMGSY). A key feature of this programme implementation was to target the location of roads to villages with a population exceeding two discrete thresholds (500 and 1000). We estimate that this policy guideline causes villages just above these thresholds to be 22 percentage points more likely to have received a road by the time of the 2014 general election. We exploit this exogenous source of variation in centrally planned road construction in a *fuzzy* regression discontinuity design.

We compile data on voting outcomes from close to one million polling-stations across 18 of India's most populated states for the 2014 general election. Using geocomputing techniques, we then match the location of polling-stations to villages. Importantly for our empirical approach this newly-digitised dataset enables us to leverage the *village* as our unit of analysis; corresponding to the administrative unit used by the government to target road construction across the country. We combine this information with data from the Population Censuses of 2001 and 2011, which describe village-level demographics and amenities. Information on road construction under the programme comes from the PMGSY portal.

The rural roads programme was launched in 2000 with road construction taking-off in 2002. While the programme was initiated by the Bharatiya Janata Party (BJP), it was the Indian National Congress (INC) led coalition, the United Progressive Alliance (UPA), that took control of implementing the programme following their success in the 2004 general elections. By the time of the 2014 general election, the UPA had been in power for two five-year mandates and overseen new road construction to nearly 200,000 villages across the country. In this paper, we are primarily interested in shedding light on voter response to this large-scale capital investment from the *national government*. A priori, the effect is ambiguous. If content with improved access to rural roads from the PMGSY, they may choose to assign their votes to the incumbent UPA which largely spearheaded the programme. This effect however may be small or even reversed if voters do not perceive any benefits from the programme or believe that it was poorly implemented. Alternatively, voters may reward programme origination instead of implementation, in which case there would be an increase in the share of votes cast to the BJP led coalition, the National Democratic Alliance (NDA). Finally, they may place responsibility with individual members of parliament and hence reward their local elected representative irrespective of political alliance.

We estimate that the PMGSY significantly increased access to roads in treatment villages by approximately 22 percentage points. Replicating the work of Asher and Novosad (2020) who evaluate the impact of the PMGSY on the structural transformation of the village economy, we find a significant improvement in local transportation services – access to public bus services and private autorickshaws increased by 13.5 and 12.7 percentage points respectively – but no significant effects on predicted consumption. Interestingly, despite limited observable economic impact, we find that the direct beneficiaries of the rural road programme reward the political alliance which implemented the PMGSY and brought a road to their village. Specifically, a new road causes a statistically significant 7.3 percentage points increase in votes allotted to the UPA. This vote dividend appears to be sustained even for roads built in the previous electoral cycle suggesting that voters continue to incorporate the programme in their accountability mechanism in the medium-term. We also find significant spillover effects in non-beneficiary villages within a 2 km radius of a newly constructed road. Interestingly, villagers only appear to reward the UPA when the incumbent candidate stands for re-election. While we find that incumbency does not alter the probability of receiving a road, politicians may have actively used the successful implementation of the scheme in their re-election campaign and/or voters may take the provision of a public good as a signal of politician quality to be rewarded.

This paper is related to a large body of research dedicated to understanding how voters make decisions. The majority of this work has concentrated on the presence of political budget cycles. Explained using a simple retrospective voting behaviour under asymmetric information (Nordhaus, 1975), this literature suggests that voters use economic conditions immediately preceding elections as a signal of the government's ability (Healy and Lenz, 2014). In an analysis of 350 elections across 74 democracies, Brender and Drazen (2008) find that macroeconomic growth and budgetary surplus in an election year significantly improve the incumbent government's chance at re-election. This phenomenon has been found to be especially salient in the context of developing countries (Brender and Drazen, 2005; Shi and Svensson, 2006). Our paper extends this literature by considering the response of voters to government led infrastructure development initiatives which unlike business cycles, are based on medium to long-run impacts.

Recently, a number of studies have aimed to evaluate the electoral outcomes from large government led poverty-alleviation programmes. Broadly, evidence from conditional cash transfer (CCT) schemes suggest that voters value these initiatives and reward the incumbent.¹ For instance, Manacorda et al. (2011) find that beneficiary households from such a programme in Uruguay are 11 to 14% more likely to vote for the incumbent; with these results persisting even after the programme ends. In an evaluation of the Mexican Progresa programme, De La O (2013) find that participation mobilised beneficiaries to vote and reward the incumbent. Set apart from the context of CCTs, Zimmermann (2021) investigates electoral gains from India's public-works programme and finds that voter support declines with length of programme exposure as the electorate hold the government accountable for the quality of implementation. In this paper, we consider a different type of government led anti-poverty programme, that of infrastructure development. Importantly, unlike CCTs and the public-works programme, large-scale infrastructure initiatives do not involve hand-outs and hence may be harder for individuals to perceive the direct benefits and/or attribute these to the government.

Specifically addressing the question of voting behaviour in response to infrastructure development are two recent papers by Akbulut-Yuksel et al. (2023) and Goyal (2024). In the context of an express-way construction in Turkey, Akbulut-Yuksel et al. (2023) find that this public good provision significantly increased the vote share to the ruling party. Our study corroborates this accountability mechanism when considering rural road construction in India, and furthers the investigation by considering the electoral gains both over time as well as spatial spillovers into non-beneficiary villages. Conversely – also evaluating the case of road expansion in India under the PMGSY – Goyal (2024) finds that this programme did not boost electoral support for the ruling party. The author uses a constituency-level instrument which while it leverages pre-consolidated electoral data at both state and national elections, has the caveat of averaging over all villages (including those with road upgrades and from states that did not adhere to the guidelines). In contrast, while we are limited to the 2014 national election due to data restrictions locating polling booths to villages, our identification preserves the direct implementation guidelines of the programme and identifies the impact among direct beneficiaries where we expect voting behaviour to be affected.

Finally, our paper fits closely with a growing literature documenting the value of democracies in driving economic growth (Acemoglu et al., 2019).² Specifically, in a global analysis of electrification using satellite

¹ For studies evaluating electoral returns from CCT schemes, refer to Baez et al. (2012) in Colombia, De La O (2013) in Mexico, Manacorda et al. (2011) in Uruguay, and Labonne (2013) in Philippines.

² Papers investigating the link between democracy and growth have focused on the role of the democratic process on growth (Acemoglu et al., 2019), public infrastructure investment (Min, 2008), curbing corruption (Ferraz and Finan, 2011), and policy choices (Besley et al., 2010).

imagery of night light, Min (2008) demonstrates that democratisation leads to a significant reduction in unelectrified population centres. In this paper, we seek to verify whether voters reward governments for promoting public capital investment. Given the mounting evidence highlighting the value of infrastructure in improving economic outcomes – construction of bridges in Nicaragua improved labour market participation (Brooks and Donovan, 2020), access to rural roads in India increased investment in human capital (Adukia et al., 2020), irrigation infrastructure through dams and canal networks significantly reduced poverty levels and promoted structural change (Duflo and Pande, 2007; Asher et al., 2022; Blakeslee et al., 2021) – there is a clear need to link the role which public infrastructure investment plays in the electoral accountability mechanism.

The rest of the paper is structured as follows. Section 2 describes the electoral system in India, as well as the policy implementation of the rural road building programme. Our data sources are explained in Section 3 and the empirical strategy including graphical evidence is presented in Section 4. Section 5 contains results on the impact of rural roads on the political economy. Finally, Section 6 concludes.

2. Background

2.1. India's political system and the 2014 general election

India's electoral system is a first-past-the-post: in each parliamentary constituency the candidate with the most votes wins the seat within the lower house known as the *Lok Sabha*. The Election Commission of India (ECI) is an independent institution, responsible for ensuring a fair and transparent contest. The ECI has the power to hold political parties to account according to a strict code of conduct in the weeks prior to an election. This electoral code includes stipulations to ensure the incumbent does not hold a disproportionate advantage. For instance, the ECI could prohibit governments from implementing programmes that were not announced prior to the election being called. Furthermore, for the 2014 general election, a limit on election expenditure by an individual candidate was set to Rupees 7 million (equivalent to \$88,000) in the largest states and to Rupees 5.4 million (equivalent to \$68,000) in smaller states and union territories.

During the 2014 general election of India, there were two main political alliances that were declared before the day of the vote. Firstly, the incumbent United Progressive Alliance (UPA) which had won the two previous general elections (2004 and 2009). The UPA was led by the Indian National Congress (INC) and 10 smaller parties with mostly regional strongholds.³ The second alliance was that of the main opposition National Democratic Alliance (NDA). The NDA was led by the Bharatiya Janata Party (BJP), alongside 22 smaller parties.⁴ Alongside these main alliances, most parliamentary constituency are also contested by smaller parties and independent candidates. A total of 8251 candidates contested the 543 elected *Lok Sabha* seats.

For administrative and security reasons the election to the 16th *Lok Sabha* was held in nine phases from April 7 to May 12 of 2014. As in each election, monitors were randomly assigned to polling stations and only informed of their assignment the day before the election,

³ The smaller UPA member parties for the 2014 general election include: Rashtriya Janata Dal, Nationalist Congress Party, Rashtriya Lok Dal, Jharkhand Mukti Morcha, Jammu & Kashmir National Conference, Mahan Dal, Indian Union Muslim League, Socialist Janata, Kerala Congress, Bodoland People's Front.

⁴ The smaller NDA member parties for the 2014 general election included: Telugu Desam Party, Shiv Sena, Desiya Murpokku Dravida Kazhagam, Shiromani Akali Dal, Pattali Makkal Katchi, Marumalarchi Dravida Munnetra Kazhagam, Lok Janshakti Party, Rashtriya Lok Samta Party, Apna Dal, Haryana Janhit Congress, Swabhimani Paksha, Indhiya Jananayaga Katchi, Puthiya Needhi Katchi, Kongunadu Makkal Desia Katchi, All India N.R. Congress, Republican Party of India, Rashtriya Samaj Paksha, Revolutionary Socialist Party (Bolshevik), Kerala Congress (Nationalist), National People's Party, Naga People's Front, and Mizo National Front.

hence limiting susceptibility to manipulation. On the day of the election ballots were cast using electronic voting machines. The index finger of each voter was marked with indelible ink so as to avoid voter fraud.

There were 834 million registered voters, making it the largest election in history at the time. Approximately 66% of the electorate turned out to vote. The results of the election were announced on May 16. The BJP received 31% of the vote and won 282 seats, while its NDA coalition won a total of 336 seats. It was the first time since 1984 that a party had won enough seats to govern without the support of other parties. In contrast, the INC received only 19.3% of the vote and won 44 seats. The wider INC-led UPA coalition won a total of 59 seats, making it the worst-ever performance of this alliance since independence.

2.2. The Pradhan Mantri Gram Sadak Yojana

In the year 2000 the Indian government launched the Pradhan Mantri Gram Sadak Yojana (PMGSY), also known as the Prime Minister's Village Roads Scheme. Primarily, the purpose of this programme was to provide all-weather paved roads to unconnected villages across India. In practice however, the programme also upgraded low quality paved roads to already connected villages (see Figure A1 for a summary of road completion, disaggregated by new and upgraded roads, under the PMGSY between 2000 to 2014). Although the BJP-led NDA alliance was the mastermind behind this scheme, in 2004 the INC-led UPA alliance won a majority rule of the *Lok Sabha* and oversaw implementation of the programme over the following decade. During this period over 400,000 kilometres of road were constructed. The initiative benefited 185,000 villages of which 107,000 – encompassing a population of over 30 million people – had previously lacked an all-weather road. Funded by a combination of income from taxes, central government support, and loans from the Asian Development Bank and World Bank, the programme cost almost \$40 billion.

Overseen by the federal Ministry of Rural Development, guidelines were issued by the National Rural Roads Development Authority on the selection of villages due to benefit from this programme. Using arbitrary thresholds based on the 2001 Population Census of India, construction of new roads were first targeted to villages with a population greater than 1000, followed by villages with a population greater than 500, and finally villages with a population greater than 250.⁵ Implementation of the PMGSY was delegated to state governments allowing them to adapt these guidelines based on their specific requirements. For example, a state that had already connected all villages at a given target population could proceed directly to a smaller population threshold. Furthermore, the prioritisation guidelines also included the scope for practical concerns. For instance, smaller villages could be connected if they lay in the path of a priority village and groups of villages within 500 metres of each other could combine their populations to attain the eligibility thresholds.⁶ As such, while a village's population relative to the threshold would have significantly influenced the probability of receiving a new road, the programme allocation was not definitive.

3. Data

In order to explore whether exposure to public infrastructure investment plays a role in the electoral accountability mechanism, we have digitised polling-station data on voting outcomes from India's 2014 general election. We combine this information with contemporaneous data on road construction under the PMGSY, as well as other features

⁵ The population thresholds were in fact set at the habitation level; a unit of aggregation below that of the village. However in practice habitation populations were pooled to the village level. We aggregate to the village level in order to closely match the implementation of the programme and because this aligns with the data on all other outcomes of interest.

⁶ For further details on the guidelines of this programme, refer to National Rural Roads Development Agency (2005).

Table 1
Summary statistics and balance of village characteristics at baseline.

Variable	Full sample (1)	Below threshold (2)	Over threshold (3)	Difference in means (4)	p -value on difference (5)	RD estimate (6)	p -value on RD estimate (7)
Panel A: Amenities							
Primary school (<i>binary</i>)	0.954	0.949	0.960	0.011	0.01	-0.003	0.93
Medical centre (<i>binary</i>)	0.159	0.147	0.172	0.025	0.00	-0.055	0.40
Electricity (<i>binary</i>)	0.423	0.406	0.441	0.034	0.00	0.129	0.15
Distance from nearest town (km)	26.983	26.943	27.028	0.085	0.85	-4.582	0.25
Panel B: Agricultural sector							
Agricultural land area (<i>ln</i>)	5.149	5.096	5.208	0.112	0.00	0.018	0.89
Agricultural land irrigated (<i>share</i>)	0.280	0.275	0.286	0.011	0.05	0.054	0.29
Panel C: Demographics							
Literacy (<i>share</i>)	0.456	0.453	0.460	0.008	0.01	0.005	0.85
Scheduled caste (<i>share</i>)	0.142	0.141	0.143	0.002	0.54	-0.009	0.77
Landownership (<i>share</i>)	0.737	0.738	0.735	-0.003	0.55	0.020	0.64
Subsistence agriculture (<i>share</i>)	0.434	0.438	0.430	-0.007	0.15	0.037	0.43
HH income above Rs.250/month (<i>share</i>)	0.759	0.758	0.759	0.001	0.82	-0.052	0.29
N	10 425	5513	4912				

Notes: The table presents summary statistics and balance tests for village characteristics measured at baseline. Data on these baseline covariates is obtained from the 2001 Population Census of India (variables covering village amenities, agricultural sector indicators, share of the population that are literate, and belonging to a scheduled caste) and the 2002 Below Poverty Line Census (variables on demographics including share of the population that own land, rely on subsistence agriculture, and with a HH income above Rs.250/month). Columns 1–3 show the unconditional mean for all villages, villages below the population threshold, and villages above the population threshold respectively. Column 4 presents the difference in means between Columns 2 and 3. Column 5 shows the p -value for the difference in means. Column 6 reports the regression discontinuity estimates capturing the effect of being above the population threshold on the baseline covariate. The specification includes baseline village-level controls (with the covariate of interest omitted from the vector of controls) and constituency-cutoff fixed effects (see Section 4 for details). Finally Column 7 presents the p -value for the regression discontinuity estimates. Using the final sample of villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold).

of the rural economy at the village-level. On average we observe our outcome variables six years following road completion, hence capturing the short to medium term impact of benefiting from the programme. This section describes in detail how we compiled the dataset, while Table 1 provides summary statistics describing the average village in our final sample prior to the onset of the PMGSY initiative.

3.1. Voting

Data on votes to the federal government for the 2014 general election come from the Election Commission of India (ECI). Documents – known as a Form-20 (see Figure A2 for an example) – are made publicly available by the Commission for each parliamentary constituency.⁷ These documents contain information on the name of all candidates, their party affiliation, and the number of votes they received at each polling-station.⁸ Unfortunately, information on the number of eligible voters is largely missing and hence we cannot include voter turnout as an outcome of interest in our analysis. We digitised data from all the Form-20s for eighteen of India's largest states; accounting for approximately 89% of the population.^{9,10} This creates a dataset covering close to 800,000 polling-stations.

Since variation induced by the PMGSY programme is across villages it is essential to capture all voting outcomes at this aggregation level.

⁷ Links to the Form-20 documents for each state can be found here: <https://eci.gov.in/statistical-report/link-to-form-20/>.

⁸ There is also some information on the background of the candidate including gender, age, and caste. However this level of detail is not complete across all constituencies.

⁹ Data from searchable PDFs was extracted using R – a software environment for statistical computing and graphics. Information from non-searchable PDFs was extracted using Transkribus – a platform for text recognition, image analysis, and structure recognition of historical documents. In the case of poor quality PDFs which could not be analysed using Transkribus, the data was manually digitised.

¹⁰ The eighteen states for which voting data was digitised include: Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, and West Bengal.

We leverage the work of Susewind (2014) to obtain Global Position System (GPS) coordinates of all the polling-stations active during the 2014 general election.^{11,12} A recent evaluation of whether resource scarcity enhances the scope for targeted spending in India by Mahadevan and Shenoy (2023) also uses these coordinates to aggregate voting data at the Gram Panchayat level.

Combining village boundary shapefiles offered by the Socioeconomic High-resolution Rural-Urban Geographic (SHRUG) Dataset on India (Asher et al., 2021), along with the GPS coordinates of polling-stations, we create a village-level match.¹³ Specifically, we attribute vote counts to a village if the polling-station falls within the village boundary. For villages without polling-stations, we make use of a nearest neighbour assignment method and assign votes from a polling-station within a 2 km radius of a village. This criteria corresponds closely to the ECI guidelines stating that no voter should be more than 2 km away from a polling station. Furthermore, in a robustness test we show that our results are consistent when limiting the sample to villages with a polling-station within their boundary. Finally, we sum all the votes assigned to a village. We calculate our outcome variables to capture the share of votes cast to the main political parties, as well as the parliamentary constituency incumbent.

¹¹ GIS shapefiles for India's parliamentary constituencies including polling-station location co-ordinates are available from: <https://pub.uni-bielefeld.de/record/2674065>. We match the data from the Form-20 to the GPS coordinates based on a polling station number. To ensure that the match is as precise as possible, we drop data from parliamentary constituencies where the total number of polling stations is inconsistent between the two datasets (the number of polling booths matched in 80% of cases).

¹² Polling-station numbers are not consistent across election years. As a result it is necessary to have access to the electoral rolls used for each election in order to obtain information on booth location. Unfortunately, to the best of our knowledge, archives of electoral rolls are not publicly available which limits our analysis of the impact of the PMGSY on voting outcomes to the 2014 national election.

¹³ The SHRUG datasets, codebooks, and references, can be found at: <http://www.devdata.org/shrug>. In this paper, we made use of the SHRUG, Version 2.0.

New road construction under the PMGSY programme began in the year 2000. Therefore, after receiving a new road voters were potentially exposed to two general elections (in 2004 and 2009) before our observed voting outcome in the 2014 general election. Unfortunately, to the best of our knowledge, geo-located polling booth data for the 2004 and 2009 elections which would allow us to aggregate voting outcomes at the village level is not available. However in order to explore whether shifts in voting behaviour due to the programme are persistent over multiple elections or transitory, we conduct a heterogeneity analysis by splitting our treatment sample into villages that received a road before and after the 2009 general election.

3.2. Consumption

In order to investigate whether the rural roads programme had an effect on the local economy we consider a range of indicators aimed at capturing shifts in consumption. Night light, measured by satellites as the pixel luminosity in a geographic polygon, is now widely used as a proxy for economic activity when direct measures are otherwise unavailable (Henderson et al., 2011). We calculate the average of total night light for a village over a three-year period, from 2011 to 2013. As a more direct measure, we leverage predicted consumption and poverty rate at the village-level, imputed using household micro-data collected by the India Human Development Survey-II in 2012 (refer to Appendix B for further detail on how these indicators are predicted and a discussion of the literature on the methodology). Finally, we look at an index of asset ownership as well as each individual major asset independently, as recorded by the Socio Economic Caste Census of India in 2012. Each of these indicator is available on the SHRUG.

3.3. Rural roads

Information on rural road construction under the PMGSY programme was first scraped by Asher and Novosad (2020) from the official PMGSY portal in order to evaluate the impact of rural roads on the local development of the village economy.¹⁴ We leverage this information, made publicly available by the authors on the SHRUG Dataset on India in order to identify villages treated by the programme. For each village connected by a new paved road the dataset also details the date for when the contract was awarded, as well as the date of completion, disaggregated by new versus upgraded roads. We are primarily interested in capturing the effect of benefiting from a new road, hence we limit our sample to villages that did not have a paved road in 2001. While evaluating the effect from a road upgrade would have also been interesting, we find that the construction of these did not strictly follow the policy rule to generate a discontinuity at the eligibility threshold and therefore are not included in our analysis.¹⁵

The PMGSY programme was initiated by the NDA alliance in 2000. This government however lost the 2004 elections and the majority of roads were therefore completed under the leadership of the UPA alliance between 2004 to 2014.¹⁶ Consequently, we exclude villages that received a new road prior to 2005. Fig. 1 reports the number of new roads built under the PMGSY between 2004 to 2014 among our sample of villages. By the 2014 general election of India, treated villages would have had access to a new road for an average of six years.

So as to verify whether the programme had an effect on transportation, we complement the information on road construction with

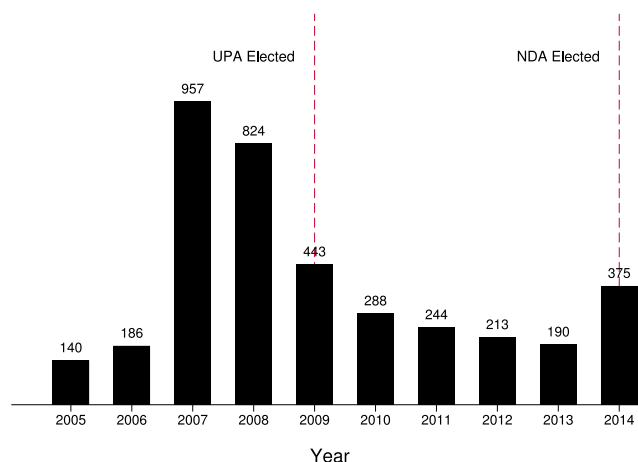


Fig. 1. Roads completed under the PMGSY by year.

Notes: This figure shows road completion under the PMGSY initiative between 2005 to 2014, as well as the timing of general elections over this period. The bars represent the number of new roads completed under the PMGSY in each year (exact counts are reported above the bars). The dashed lines mark the years in which a general election was conducted, with the winning political coalition reported alongside. Using the final sample of 10,425 villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold).

data on road usage. Specifically, we consider the regular availability of transport services at the village by 2011. Recorded as part of the Population Census of India and made available on the SHRUG, we can measure the presence of buses (both private and public), vans, taxis, and auto-rickshaws.

3.4. Pre-programme village characteristics

In order to verify that villages on either side of the eligibility threshold were similar prior to the onset of the PMGSY programme we leverage data from the 2001 Population Census compiled as part of the SHRUG. This enables us to capture village level amenities – such as presence of a primary school and electrification, demographics – including literacy and share of the population belonging to the Scheduled Castes, as well as prevalence of the agricultural sector – including share of land area cultivated and irrigated. For variables specific to household income and assets we make use of the 2002 Below Poverty Line Census. These variables are also used as village level controls in our empirical analysis.

3.5. Population

The Population Census of India, compiled as part of the SHRUG, provides information on village demographics. We use data from the 2001 Census to capture our assignment variable – village population. This enables us to replicate the precise policy rule used by the Government of India when targeting the construction of new rural roads across the country as part of the PMGSY programme. Accordingly, we consider villages with a population greater than the stipulated threshold as treated – that is, prioritised to receive a new road.

Asher and Novosad (2020) collaborated closely with the National Rural Roads Development Agency to identify state specific compliance with the PMGSY guidelines. Following their precedent, we restrict our sample for analysis to the six states that strictly adhered to the population thresholds (in parentheses) stipulated by the PMGSY: Chhattisgarh (500, 1000), Gujarat (500), Madhya Pradesh (500, 1000), Maharashtra (500), Orissa (500), and Rajasthan (500). Furthermore, we limit the sample of villages to those that had populations within the optimal bandwidth (84) from a treatment threshold. This gives us a final sample of 10,425 villages with non-missing information across all our outcomes of interest.

¹⁴ Information on the programme guidelines, reports, and identities of newly connected villages can also be accessed from the official PMGSY portal: <http://omms.nic.in/>.

¹⁵ Results from these tests are not reported in the manuscript, but are available on request.

¹⁶ Figure A1 documents all roads built since 2000.

4. Empirical approach

Estimating the impact of large-scale public infrastructure initiatives on voting behaviour is challenging due to concerns of endogeneity. Given the large budgets required for such programmes, the decision of where to allocate the investment is unlikely to be random. For instance, public goods may be targeted to the most productive villages. Or conversely, towards villages that are lagging economically. Any naive correlation estimates between public infrastructure investment and voting behaviour will therefore be an over or underestimate of the true effects. In order to identify exogenous variation in public capital investment, we exploit the Government of India PMGSY programme implementation guidelines aimed explicitly at expanding rural road construction across the country based on arbitrary population eligibility thresholds. This section details our proposed empirical approach – *fuzzy* Regression Discontinuity (RD) Design, alongside graphical evidence and estimation results corroborating the validity of this method.

4.1. Regression discontinuity design

The PMGSY programme used arbitrary village population thresholds to prioritise road construction (described in Section 2). These eligibility rules however, were not definitive. As such, we employ a *fuzzy* RD design to estimate a change in voting behaviour caused by exposure to a new road built under the PMGSY government initiative. Specifically, we use the following two stage least squares specification with optimal bandwidth local linear regression (Gelman and Imbens, 2019; Calonico et al., 2020):

$$Road_{vcs} = \gamma_0 + \gamma_1(pop_{vcs} \geq T_s) + \gamma_2(pop_{vcs} - T_s) + \gamma_3(pop_{vcs} - T_s).(pop_{vcs} \geq T_s) + \nu X_{vcs} + \mu_c + \nu_{vcs} \tag{1}$$

$$Y_{vcs} = \beta_0 + \beta_1 Road_{vcs} + \beta_2(pop_{vcs} - T_s) + \beta_3(pop_{vcs} - T_s).(pop_{vcs} \geq T_s) + \sigma X_{vcs} + \eta_c + \varepsilon_{vcs} \tag{2}$$

Y_{vcs} is the outcome of interest for village v in constituency c in state s . $Road_{vcs}$ is a binary indicator which takes the value one if village v received a new road as part of the PMGSY programme before the year in which Y_{vcd} is measured (2013 for the voting outcomes and 2011 for consumption and transportation services). pop_{vcs} is the 2001 village population, our assignment variable. T_s is the population eligibility threshold used by state s .¹⁷ β_1 captures the average effect of receiving a new road on the outcome variable. All regressions use an optimal bandwidth of 84, calculated using a triangular kernel which places more weight on observations close to the threshold (Calonico et al., 2020). In a robustness test, we demonstrate that the results are consistent across a range of bandwidths and alternative kernels.

Control variables and fixed effects are not necessary for identification in an RD design, but do improve the efficiency of the estimation (Calonico et al., 2014; Imbens and Lemieux, 2008). We therefore include a vector of baseline village covariates – X_{vcs} – as controls in our specification. Specifically we control for: amenities (primary school, medical centre, electrification, distance from the closest urban centre),

¹⁷ As described in Section 2, while the PMGSY first targeted villages with a population above 1000, states were allowed use the lower threshold of 500 immediately if they had few villages of population over 1000 with no roads. Among our sample of the six states that closely complied to the programme, the thresholds used are: Chhattisgarh – 500 and 1000, Gujarat – 500, Madhya Pradesh – 500 and 1000, Maharashtra – 500, Orissa – 500, and Rajasthan – 500. Since the optimal bandwidth is less than 100, there is no overlap between the group of villages receiving roads under the 500 or 1000 threshold. This enables us to pool villages according to the population thresholds applied in each state. The lowest population eligibility threshold stipulated by the PMGSY guidelines was that of 250. However few villages of this group had received a road by 2014, hence we do not include this threshold in our analysis.

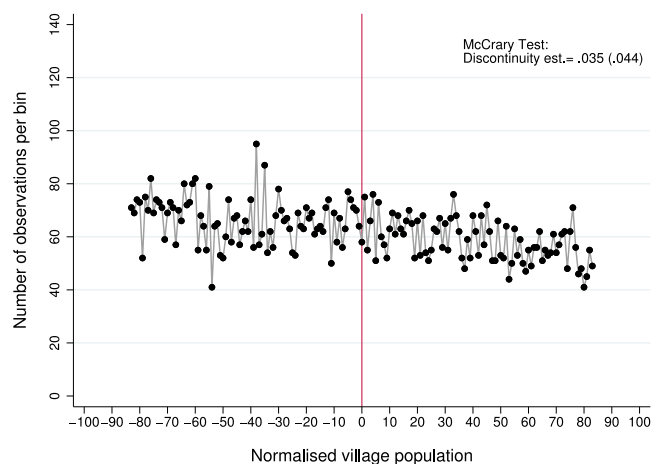


Fig. 2. Distribution of the assignment variable across the threshold.

Notes: This figure plots the number of observations in each bin of the assignment variable. The assignment variable – village population – is normalised around the PMGSY eligibility threshold (either 500 or 1000). The bin size is 0.25. A *fuzzy* RD design requires for the conditional density of the assignment variable to be continuously differentiable at the threshold. Following McCrary (2008), we report the coefficient and standard error for a discontinuity test which estimates the log change in height between bins at the threshold. Using the final sample of 10,425 villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold).

agricultural sector characteristics (total agricultural land area and share of agricultural land irrigated), and socio-economic indicators (share of the village population that are literate, belonging to a scheduled caste, own land, rely on subsistence farming, and with a HH income above Rs.250/month). Furthermore, we also include parliamentary constituency threshold fixed effects – μ_c in Eq. (1) and η_c in Eq. (2) – which are an interaction of constituency dummies with an indicator variable for whether the village is in the highest population threshold (1000).¹⁸ In a robustness test, we show that the results are consistent when excluding these controls.

4.2. Impact of the PMGSY on rural roads

Causal inference in a *fuzzy* RD design is conditional on meeting three key assumptions. First, the conditional density of the assignment variable is continuously differentiable at the threshold. Second, baseline covariates are also balanced with conditional density continuously differentiable at the threshold. Third, there is a jump in the direct marginal effect of the treatment on the assignment variable at the threshold.

The first assumption is concerned with ruling out the possibility that villages could somehow manipulate their position at the threshold so as to be eligible for the programme. By plotting the density distribution of the village population in 2001 normalised at the eligibility threshold, Fig. 2 demonstrates that there is no discontinuity in our assignment variable. This is formally corroborated by the McCrary test which estimates the log change in height between bins at the threshold and confirms that we cannot detect a significant discontinuity at that point (statistic of 0.04 with s.e. 0.044).

The second assumption attempts to address the concern that there may be village characteristics which are correlated to the treatment status. Table 1 presents summary statistics on village characteristics at baseline for our full sample (Column 1), as well as disaggregated for villages just below (Column 2) and those just above (Column 3) the

¹⁸ Using district identifiers instead of parliamentary constituencies do not change our main results.

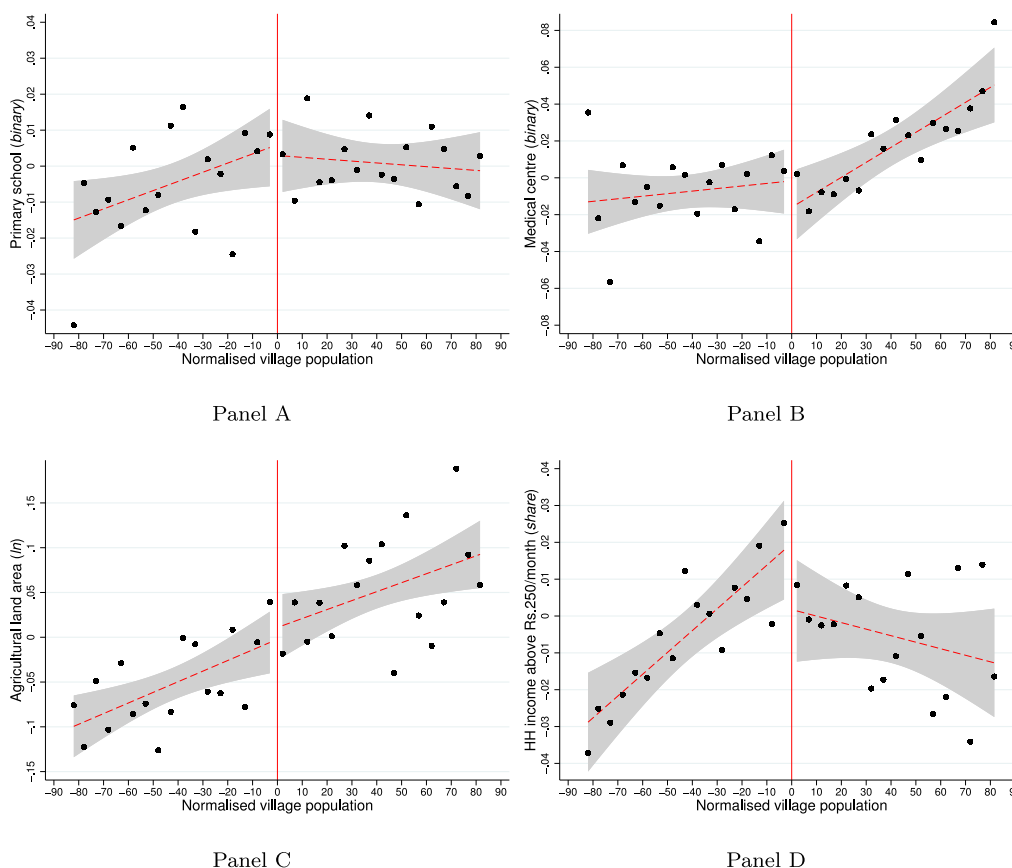


Fig. 3. Balance of village characteristics at baseline.

Notes: This figure plots the residualised village characteristics at baseline (after controlling for all variables in the main specification excluding the covariate of interest) against the assignment variable. The assignment variable – village population – is normalised around the PMGSY eligibility threshold (either 500 or 1000). Points to the right of zero are above the treatment thresholds, while points to the left are below. We present graphical evidence on four of our baseline control variables. Each panel shows the mean values of the control variable in each bin of the assignment variable. The bin size is 5. The red dashed lines display predicted values of the regressions in the linear case allowing for a discontinuity at the threshold, with 95% confidence intervals displayed. Formal estimates of a discontinuity for these variables using a *fuzzy RD* design specification are reported in [Table 1](#). Using the final sample of 10,425 villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold).

threshold. We report the sample means for all our control variables which capture information on village amenities, the agricultural sector, and demographics (including socio-economic indicators). While there are average differences between villages below and above the threshold (Columns 4 and 5), we find no statistically significant discontinuity at that point when using the *fuzzy RD* specification (Columns 6 and 7). By plotting the relationship between the baseline control variables and the village population in 2001 normalised at the eligibility threshold, [Fig. 3](#) provides graphical evidence demonstrating no discontinuous changes across the treatment cut-off.

Finally the third assumption validates the treatment effect at the arbitrarily stipulated threshold. In [Fig. 4](#) we plot the share of villages that received a new road between 2004 and 2014 in each population bin normalised at the eligibility threshold. There is a clear substantial jump in the probability of being treated – receiving a new road – for villages with a population just above the threshold. This graphical evidence is further substantiated in Panel A of [Table 2](#) which presents our first stage results from Eq. (1) under a range of bandwidths from the programme population threshold. Our results suggest that crossing the stipulated PMGSY eligibility rule increases the probability of a village receiving a new road by on average 22%, with a large amount of consistency between bandwidths. This result also holds among villages treated between 2009–2014 as well as those treated between 2004–2009, reported in Panel B and C respectively.

5. Results

5.1. Transport and the village economy

We begin by investigating whether India’s national rural road construction programme changed provision of transportation services to the village — the most immediate benefit of being connected to the national road network. [Table 3](#) presents regression discontinuity estimates on the impact of a new road on the availability of five major motorised transportation services, as recorded in the 2011 Population Census. For our full sample, reported in Panel A, we find that a new road causes a statistically significant 13.5 percentage points increase in the availability of public bus services; more than double that of the control group mean (11.7%) (Column 1). However, when we consider the timing of new road construction in Panel B and C, we see that increases in public bus services only manifests itself more than three years after the new roads are built. That is, we only estimate a statistically significant increase in public bus services in villages where the new road was built between 2004 and 2009. In contrast, there is no effect on provision of private bus services for the full sample (Column 2), however there is some marginal evidence that they do increase in the long run. We estimate a 18.5 percentage points increase in private bus services for roads built between 2004 and 2009, which is only significant at the 10% level. In terms of the other private transport services, while we do not find any significant shifts in the availability of taxis (Columns 3), there is evidence of an immediate substitution away from vans that

Table 2
First stage – Effect of PMGSY eligibility rules on road construction.

	Bandwidth of the population threshold					
	± 60 (1)	± 70 (2)	± 80 (3)	± 90 (4)	± 100 (5)	± 110 (6)
Panel A: New roads completed between 2004 and 2014						
New road	0.233*** (0.022)	0.229*** (0.020)	0.226*** (0.019)	0.222*** (0.018)	0.221*** (0.017)	0.221*** (0.016)
F-Statistic	115.80	130.18	143.56	154.92	170.15	187.82
N	7736	9023	10299	11567	12895	14170
R ²	0.19	0.19	0.18	0.18	0.18	0.18
Panel B: New roads completed between 2009 and 2014						
New road	0.162*** (0.022)	0.159*** (0.020)	0.155*** (0.019)	0.151*** (0.018)	0.150*** (0.017)	0.150*** (0.016)
F-Statistic	53.87	60.57	65.52	69.67	76.22	82.98
N	6039	7075	8087	9090	10097	11100
R ²	0.16	0.16	0.16	0.15	0.15	0.15
Panel C: New roads completed between 2004 and 2009						
New road	0.194*** (0.022)	0.192*** (0.020)	0.190*** (0.019)	0.188*** (0.018)	0.187*** (0.017)	0.188*** (0.016)
F-Statistic	79.10	90.10	101.12	110.49	121.81	135.17
N	6370	7429	8472	9543	10658	11724
R ²	0.22	0.21	0.21	0.21	0.21	0.21

Notes: This table presents first stage estimates on the effect of being above the PMGSY eligibility threshold on the probability of a village being treated – receiving a new road. Panel A presents result where the dependent variable is an indicator variable that takes the value one if the village has received a PMGSY road between 2004 and 2014. Panel B presents results for villages treated between the 2009 and 2014 general elections, while Panel C presents results for villages treated between the 2004 and 2019 general elections. Results for villages within 60 of the population threshold (440–560 for the low threshold and 940–1060 for the high threshold) are presented in Column 1. Columns 2–6 expand the sample to include villages within 70, 80, 90, 100, and 110 of the population threshold. We restrict our sample to the six compliant States, including villages with no paved road at baseline. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). Heteroskedasticity robust standard errors are reported in parenthesis below the point estimates. * significant at 10% ** significant at 5% *** significant at 1%.

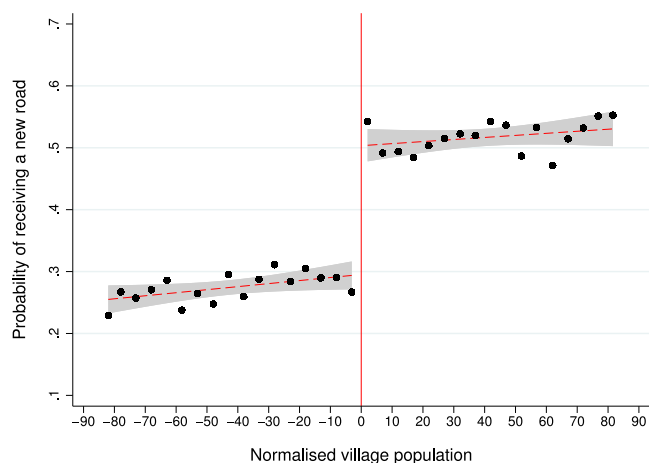


Fig. 4. First stage – Effect of PMGSY eligibility rules on road construction.
Notes: The figure plots the probability of getting a new road under the PMGSY by 2014 against the assignment variable. The assignment variable – village population – is normalised around the PMGSY eligibility threshold (either 500 or 1000). Points to the right of zero are above the treatment thresholds, while points to the left are below. The figure shows the mean values of the variable of interest in each bin of the assignment variable. The bin size is 5. The red dashed lines display predicted values of the regressions in the linear case allowing for a discontinuity at the threshold, with 95% confidence intervals displayed. Formal estimates of a discontinuity for this variable using a fuzzy RD design specification are reported in Table 2. Using the final sample of 10,425 villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold).

may be better suited to unpaved roads (Column 4). Specifically, we estimate a large 43.3 percentage points drop in private vans in villages where a new road is less than 3 years old. Furthermore, we estimate a significant increase of 12.7 percentage points in the availability of

autorickshaws – the least expensive form of private transport (Column 5). This effect is largest immediately after new roads are completed and before we see the increase in availability of more affordable public bus services. These results provide evidence that villages treated by the PMGSY initiative witnessed a consequential improvement in their integration to the wider economy.

Next, we examine whether access to a new road made people in these villages economically better off. Table 4 reports regression discontinuity estimates on four indicators of consumption. Our results consistently suggest that there are no improvements in predicted consumption at the village-level. We estimate a statistically insignificant 1.9% increase in predicted consumption per capita; and can rule out a greater than 10% increase with 95% confidence (Column 1). Similarly, we find a statistically insignificant 1.9 percentage points drop in the village poverty rate; and can rule out a 9% decline with 95% confidence (Column 2). Evidence on asset ownership and night light are also not statistically significant and indicate well estimated null effects (Columns 3 and 4 respectively).¹⁹ It would appear that a new road, despite providing a link to increased market opportunities, does not on average substantially improve the economic status of the population. Our results replicate those of Asher and Novosad (2020). Evaluating the impact of the PMGSY programme on the economic development of the village, the authors find that a new road does not appear to translate into any substantial improvements either on the aggregate economy or predicted consumption in the short to medium term. This however does not rule out shifts on other dimensions of welfare. Indeed, evidence suggests that this scheme significantly improved educational outcomes (Adukia et al., 2020) as well as access and use of finance (Agarwal et al., 2023).

¹⁹ In Table A1 we present regression discontinuity estimates on individual components of the asset index and find no statistically significant effects on the share of households owning these assets.

Table 3
Impact of new road on transportation.

	Public bus (binary) (1)	Private bus (binary) (2)	Taxi (binary) (3)	Van (binary) (4)	Autorickshaw (binary) (5)
Panel A: New roads completed between 2004 and 2011					
New road	0.135** (0.064)	0.080 (0.079)	0.000 (0.052)	-0.071 (0.072)	0.127** (0.051)
F-statistic	138.191	138.191	138.191	138.191	138.191
N	10 425	10 425	10 425	10 425	10 425
Panel B: New roads completed between 2009 and 2011					
New road	0.081 (0.116)	0.171 (0.144)	-0.055 (0.090)	-0.433*** (0.122)	0.265** (0.103)
F-statistic	61.358	61.358	61.358	61.358	61.358
N	8214	8214	8214	8214	8214
Panel C: New roads completed between 2004 and 2009					
New road	0.184** (0.086)	0.185* (0.104)	0.035 (0.067)	0.001 (0.094)	0.166** (0.069)
F-statistic	95.992	95.992	95.992	95.992	95.992
N	9071	9071	9071	9071	9071
Control mean	0.117	0.204	0.070	0.157	0.052
Control SD	0.322	0.403	0.255	0.363	0.223

Notes: This table presents fuzzy RD estimates on the effect of a new road on transportation facilities to the village by 2011. We consider five categories of transport services – public buses, private buses, taxis, vans, and autorickshaws, reported in Columns 1 to 5 respectively – measured by an indicator variable which takes the value one if the service is present within the village and zero otherwise. Panel A includes all new PMGSY roads built between 2004 and 2011. Panel B refers to villages which received a new road between 2009 and 2011, while Panel C only includes villages with a new road built between the 2004 and 2009 general elections. We restrict our sample to the six compliant States, including villages with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold) is reported. Heteroskedasticity robust standard errors are presented in parenthesis. * significant at 10% ** significant at 5% *** significant at 1%.

Table 4
Impact of new road on consumption.

	Consumption per capita (ln) (1)	Poverty rate (share) (2)	Household assets (index) (3)	Night light (ln) (4)
Panel A: New roads completed between 2004 and 2012 (2014 for night light)				
New road	0.019 (0.047)	-0.019 (0.037)	-0.019 (0.171)	0.064 (0.176)
F-statistic	71.10	70.81	138.191	144.580
N	10 425	10 425	10 425	10 425
Panel B: New roads completed between 2009 and 2012 (2014 for night light)				
New road	-0.075 (0.084)	0.080 (0.067)	-0.067 (0.311)	-0.280 (0.290)
F-statistic	32.06	31.82	61.358	67.380
N	8215	8212	8214	8214
Panel C: New roads completed between 2004 and 2009				
New road	0.028 (0.057)	-0.028 (0.047)	-0.038 (0.225)	0.186 (0.234)
F-statistic	49.23	49.80	95.992	100.445
N	9072	9070	9071	8585
Control mean	2.656	0.478	-0.009	12.145
Control SD	0.283	0.219	1.008	22.068

Notes: This table presents fuzzy RD estimates on the effect of a new road on consumption by 2012 (2014 for night light). We consider three direct measures of consumption: imputed log consumption per capita (Column 1), share of the population living below the poverty line (Column 2; poverty line is set at Rs.31/day), and a household asset ownership index (Column 3; calculated as the village-level average of the primary component of indicator variables for all household assets captured in the Socio Economic Caste Census of 2012). Additionally, we rely on measures of night light luminosity from satellite images as a proxy for consumption. We calculate the average of total night light over a three year period (Column 4). Panel A includes all new PMGSY roads built between 2004 and 2012 (in the case of night light this is measured until 2014). Panel B refers to villages which received a new road between 2009 and 2012 (2014 in the case of night light), while Panel C only includes villages with a new road built between the 2004 and 2009 general elections. We restrict our sample to the six compliant States, including villages with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold) is reported. Summary statistics for consumption per capita and night light are reported on the level form of the variable. Heteroskedasticity robust standard errors are presented in parenthesis, except for consumption and poverty which report bootstrapped standard errors. * significant at 10% ** significant at 5% *** significant at 1%.

Table 5
Impact of new road on share of votes to political parties.

	United Progressive Alliance		National Democratic Alliance		Small parties & independents (5)
	INC (1)	All parties (2)	BJP (3)	All parties (4)	
Panel A: New roads completed between 2004 and 2014					
New road	0.062* (0.034)	0.070** (0.034)	-0.048 (0.036)	-0.048 (0.036)	-0.030 (0.027)
F-statistic	142.590	144.070	147.442	143.468	142.872
N	7335	7532	7326	7548	7558
Panel B: New roads completed between 2009 and 2014					
New road	0.081 (0.066)	0.098 (0.064)	-0.059 (0.065)	-0.050 (0.066)	-0.058 (0.047)
F-statistic	51.614	54.672	54.917	54.761	54.672
N	5480	5648	5466	5661	5670
Panel C: New roads completed between 2004 and 2009					
New road	0.074* (0.041)	0.082** (0.042)	-0.062 (0.044)	-0.061 (0.045)	-0.032 (0.034)
F-statistic	111.067	109.010	112.328	107.408	107.391
N	6140	6321	6138	6339	6345
Control mean	0.357	0.359	0.517	0.515	0.126
Control SD	0.194	0.194	0.204	0.204	0.155

Notes: This table presents *fuzzy* RD estimates on the effect of a new road on the share of votes to political parties in the 2014 general election of India. Panel A includes all new PMGSY roads built between the 2004 and 2014 general elections. Panel B reports results for villages treated between the 2009 and 2014 general elections, while Panel C presents results for villages treated between the 2004 and 2009 general elections. We consider three political party categories: UPA (Column 1-2), NDA (Column 3-4), and small parties and independent candidates unaffiliated to any alliance (Column 5). For the two leading alliances, we report votes to both the leading party (INC for the UPA and BJP for the NDA) as well as all parties in the coalition. For each political party category, we restrict the sample to villages where a representative of that category was listed on the ballot. We restrict our sample to the six compliant States, including villages with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold) is reported. Heteroskedasticity robust standard errors are presented in parenthesis. * significant at 10% ** significant at 5% *** significant at 1%.

5.2. Voting outcomes

How exposure to the PMGSY programme and access to a new road affects voter decision at the ballot box is *a priori* ambiguous. The lack of a meaningful economic impact – if real and not a ramification of the statistical power in our estimation – may mean that voters do not perceive any benefits from the scheme and hence do not incorporate this in their accountability mechanism. Alternatively, they may believe that the lack of any improvement in their status is the result of poor implementation and hence punish the incumbent government for a failed programme. Conversely, villagers may accrue benefits on other dimensions of welfare which are not captured by broad consumption indicators. Those in treated villages may simply value being connected to the national road network. In this context, voters may decide to reward the government for this new public good. Who they decide to attribute the reward to is also unclear. They may decide to reward the party (NDA) that initiated the scheme, or the incumbent (UPA) that successfully implemented the programme.

Table 5 presents regression discontinuity estimates on the impact of a new road on votes cast to political parties contesting India's 2014 general election. While the PMGSY initiative was launched in 2000 under the guidance of the NDA government at the time, the bulk of road construction took place under the leadership of the UPA which maintained a majority rule of the *Lok Sabha* from 2004 to 2014 (see Fig. 1 for a summary of road completion alongside the timing of general elections). We find that a new road constructed under the PMGSY scheme causes a 6.2 percentage points increase in the share of votes allotted to the UPA leader – the INC – which is statistically significant at the 10% level (Panel A, Column 1). This increases marginally to a 7 percentage points advantage compared to the control group when considering all parties affiliated to the alliance, which is significant at the 5% level (Panel A, Column 2; the discontinuity is represented graphically in Panel A of Fig. 5). Finally, in the case of the NDA

opposition (Column 4), as well as small parties and independent candidates (Column 5), we estimate small and insignificant decreases in their share of votes. This suggests that voters may either not recall the party that launched the scheme, or may favour rewarding programme implementation. Politicians from the UPA may have also leveraged the successful construction of roads in their campaign for re-election, making the connection between programme and party more salient for voters.

Interestingly, these shifts in voter behaviour are seen in villages where the road was built before the 2009 general election, wherein the electorate had already had an opportunity to express their views at the ballot box (Panel C, Columns 1 and 2). While the point estimates are similar for roads built during the current electoral cycle (Panel B, Columns 1 and 2) they are less precisely estimated, consequently we cannot rule out a null effect with 90% confidence. Taken together, these results suggest that the electoral gains of public infrastructure investment are persistent over multiple elections or the electorate only express their views at the ballot box after sufficient time as elapsed for them to experience the real economic benefits of a new road. These results are consistent with recent work finding that Indian voters attribute the local effects of national policies such as demonetisation (Khanna and Mukherjee, 2023) and public-works programmes (Zimmermann, 2021) when evaluating the incumbent ruling party at the ballot box.

5.3. Spillover effects

In this section we consider the possibility that roads do not only affect the voting behaviour in the beneficiary village but could also have significant spillover effects in nearby villages that benefit from being better connected to nearby population centres. To capture this we create an outcome variable of the average vote share in villages that did not receive a road, but fall within the area of an annulus (with a one km difference between the outer and inner radii) centred

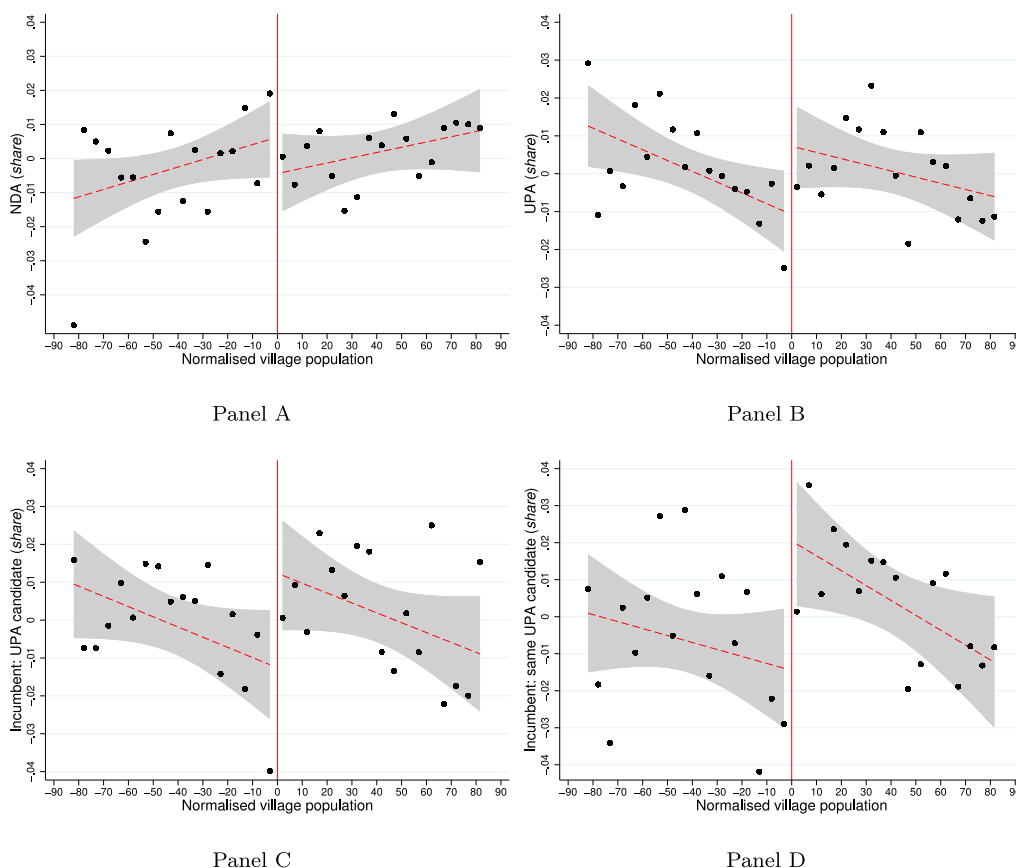


Fig. 5. Reduced form – Effect of PMGSY road construction on voting behaviour.

Notes: The figure plots residualised voting outcomes at the 2014 general election (after controlling for all variables in the main specification) against the assignment variable. The assignment variable – village population – is normalised around the PMGSY eligibility threshold (either 500 or 1000). Points to the right of zero are above the treatment thresholds, while points to the left are below. We present graphical evidence on four of our voting outcomes. Each panel shows the mean values of the outcome variable in each bin of the assignment variable. The bin size is 5. The red dashed lines display predicted values of the regressions in the linear case allowing for a discontinuity at the threshold, with 95% confidence intervals displayed. Formal estimates of a discontinuity for these variables using a *fuzzy* RD design specification are reported in Table 5 for Panels A and B, and Table 8 for Panels C and D. Using the final sample of 10,425 villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold).

around beneficiary villages. For non-beneficiary villages the outcome variable takes the value of the vote share to a party/coalition in that particular village, conditional on being outside the outer radius of the given annuli of all the beneficiary villages. Using our RD specification (Eqs. (1) & (2)) with this sample, we test for spillover effects in one kilometre incremental increases in the outer radius up to 7 km. The point estimates and confidence intervals for these spillover effects are plotted in Fig. 6. The significant vote dividend captured by the INC and UPA appears to extend to villages within 2 km. This then begins to fade away (with the exception of the 4–5 km annuli), with a zero effect by 6 km. Based on this evidence, Table 6 presents the spillover effects of the average vote share for villages within 0–2 km of a new road. For roads built in the current electoral cycle we estimate an 12.7 percentage points increase in votes to the UPA alliance, which is significant at the 5% level (Panel B, Column 2). We also find similar benefits persist for roads that were built in the previous electoral cycle (Panel C, Columns 1 and 2).

Given these large spillover effects our estimates of direct effects on beneficiary villages in Table 5 could be biased downwards relative to the total effects of new road provision. In order to explore this possibility we revisit our estimates of the direct effects on beneficiary villages when excluding villages within 2 km that did not receive a road. These results are presented in Table 7. We find that the point estimates for the share of votes to the INC and UPA were underestimated by between one and half a percentage point respectively (Panel A, Columns 1 and 2). Similar underestimates are observed for roads built between 2004 and 2009.

5.4. Incumbency effects

Under the guidelines of PMGSY programme, the award of new roads is based largely on an arbitrary population eligibility threshold and therefore should not be under the influence of individual members of parliament. Nonetheless, previous research suggests that voters have a tendency to vote for the status quo in good economic times (Bagues and Esteve-Volart, 2016). This phenomenon could create an electoral premium for incumbent candidates in locations where roads were built, despite the fact they should have had little to no influence over the decision. If this were the case, the ruling party may attempt to capitalise on this premium by fielding more incumbent candidates in locations where roads were built. To test this hypothesis we check for a discontinuity in incumbency at the population threshold. We find no evidence of targeting incumbency to capitalise on the PMGSY programme (point estimate 0.035, and standard error 0.061).

Having ruled out the possibility of political profiteering, we test to see if the electorate decide to place responsibility for the scheme to their local incumbent candidate. Table 8 presents regression discontinuity estimates on the impact of road construction on votes cast to the parliamentary constituency incumbent. Among our complete sample of villages treated between 2004 to 2014, reported in Panel A, we estimate that a new PMGSY road causes a statistically significant increase of 15 percentage points in votes for an incumbent candidate (Column 1). Interestingly, a new candidate representing the incumbent party is not rewarded for the programme (Column 2). This result is consistent when

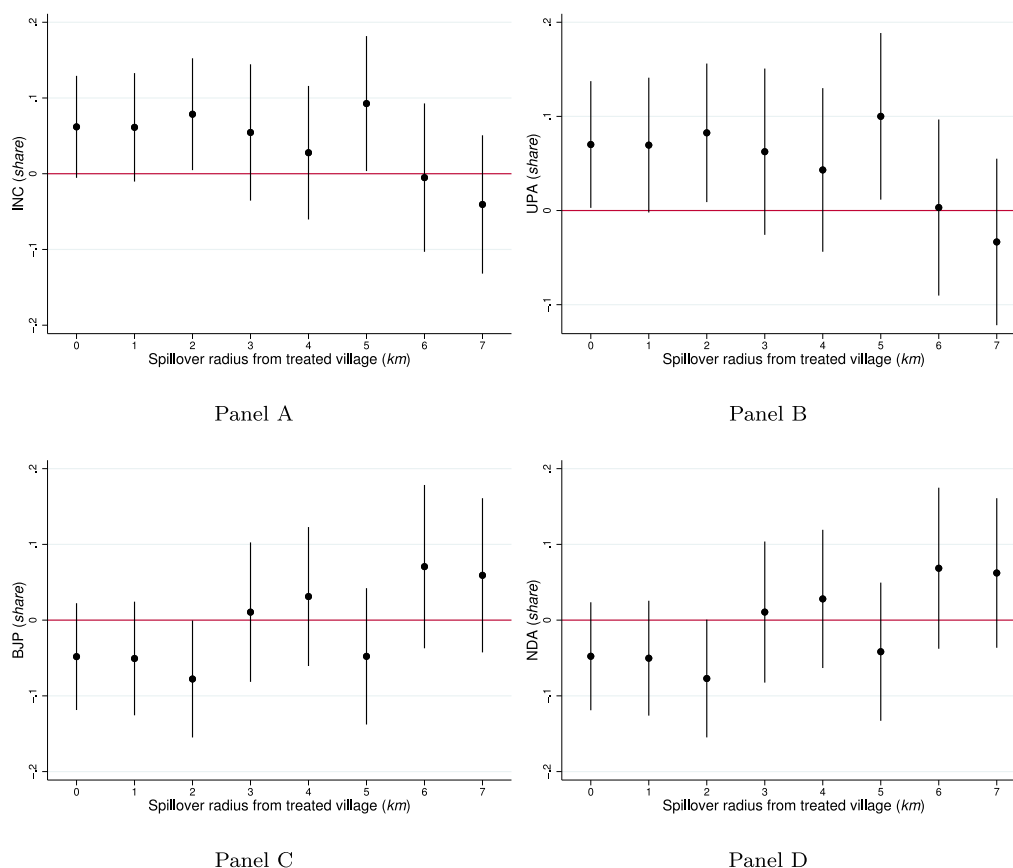


Fig. 6. Coefficient plots – Spillover effects of PMGSY road construction on voting behaviour.

Notes: The figure plots spillover estimates and 95% confidence intervals for the effect of a new road on voting outcomes at the 2014 general election in villages that did not receive a road and were within the area of an annulus of differing radii from beneficiary villages. The x axis label indicates the outer radius of the annulus (the inner radius is 1 km smaller). We present voting outcomes for the INC, UPA, BJP, and NDA in Panels A, B, C, and D respectively. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). Using the final sample of 10,425 villages (villages from the six compliant States, with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold). For each political party category, we restrict the sample to villages where a representative of that category was listed on the ballot. Confidence intervals are calculated using heteroskedasticity robust standard errors.

considering voting behaviour over the current election cycle (Panel B, Columns 1 and 2) as well as the previous election (Panel C, Columns 1 and 2).

We then disaggregate incumbency by political affiliation and find that the vote premium is targeted principally to the political alliance which delivered the programme. Having received a road between 2004 to 2014 increased the share of votes to a UPA incumbent candidate standing for re-election by 16.3 percentage points (Panel A, Column 3; the discontinuity is represented graphically in Panel D of Fig. 5). Conversely, there is no effect on the vote share to a new UPA candidate (Panel A, Column 4) or incumbents representing the opposition NDA coalition (Panel A, Columns 5 and 6).²⁰ Even if the decision to implement road construction in a village was not under the remit of the local candidate, these results indicate that voters place a significant level of responsibility for programme implementation on their local representative. Voters may perceive the provision of the public good as a signal of politician quality, likely accentuated by politicians leveraging road construction as a measure of their potential to deliver in their campaign for re-election.

²⁰ Results on Column 6 should not be interpreted to provide causal estimates due to weak instruments.

5.5. Robustness

We examine the robustness of our results to alternative regression specifications and potential confounding factors. First, we conduct a placebo test by estimating the first stage and reduced form of our key voting outcome variables for a set of states²¹ that did not adhere to the policy guidelines, as well as, villages close to the 1000 threshold in states that used only the 500-person threshold (Gujarat, Maharashtra, Orissa and Rajasthan). Importantly, all these states continued to actively build roads during the study period. As reported in Table A2, we find no evidence of either a first stage or reduced form effects on any outcomes in the placebo sample. These results suggest that our main estimates are not picking up potential confounding factors, such as the electorate expressing an opinion on another existing or proposed policy with a similar eligibility criteria. Second, in Table A3, we present the results on our main voting outcomes for a range of bandwidths (60 to 100) as well as for both triangular and rectangular kernels. The results are very consistent across all specifications. Third, Table A4 reports results on our first stage and main voting outcomes when excluding the vector of baseline covariates and fixed effects. As

²¹ These states include: Andhra Pradesh, Assam, Bihar, Jharkhand, Karnataka, Uttar Pradesh, and Uttarakhand.

Table 6
Impact of new road on share of votes to political parties in villages within 2 km of a PMGSY road.

	United Progressive Alliance		National Democratic Alliance		Small parties & independents (5)
	INC (1)	All parties (2)	BJP (3)	All parties (4)	
Panel A: New roads completed between 2004 and 2014					
New road	0.078** (0.034)	0.084** (0.034)	-0.062* (0.035)	-0.062* (0.035)	-0.031 (0.028)
F-statistic	107.869	109.186	111.075	108.362	107.983
N	5621	5775	5606	5790	5800
Panel B: New roads completed between 2009 and 2014					
New road	0.119** (0.057)	0.127** (0.056)	-0.090 (0.056)	-0.082 (0.056)	-0.055 (0.041)
F-statistic	50.150	52.854	52.395	52.741	52.704
N	3784	3909	3764	3921	3930
Panel C: New roads completed between 2004 and 2009					
New road	0.087** (0.041)	0.092** (0.042)	-0.083* (0.044)	-0.082* (0.045)	-0.020 (0.035)
F-statistic	82.953	81.064	83.690	79.520	79.567
N	4430	4568	4422	4585	4591
Control mean	0.358	0.359	0.514	0.513	0.128
Control SD	0.181	0.181	0.189	0.189	0.149

Notes: This table presents *fuzzy* RD estimates on the spillover effect of a new road on the share of votes to political parties in villages within 5 km of a PMGSY for the 2014 general election of India. Panel A includes all new PMGSY roads built between the 2004 and 2014 general elections. Panel B reports results for villages treated between the 2009 and 2014 general elections, while Panel C presents results for villages treated between the 2004 and 2009 general elections. We consider three political party categories: UPA (Column 1–2), NDA (Column 3–4), and small parties and independent candidates unaffiliated to any alliance (Column 5). For the two leading alliances, we report votes to both the leading party (INC for the UPA and BJP for the NDA) as well as all parties in the coalition. For each political party category, we restrict the sample to villages where a representative of that category was listed on the ballot. For beneficiary villages voting outcomes are aggregated across neighbouring villages within a 2 km radius, and non-beneficiary villages are limited to those further than 2 km from a new road. We restrict our sample to the six compliant States, including villages with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold) is reported. Heteroskedasticity robust standard errors are presented in parenthesis. * significant at 10% ** significant at 5% *** significant at 1%.

expected, removing the controls increases the standard errors but does not meaningfully change any of the results. Finally, in Table A5 we show consistency in our estimates when limiting our sample to villages with a polling-station within their boundary.

6. Conclusion

Evidence from the economic voting literature has predominantly painted a picture of myopic voters that place excessive weight on measures immediately prior to elections when evaluating the incumbent. Encouraging governments to leverage short-term re-election strategies can be problematic. Specifically, this phenomenon may lead governments to neglect potentially ambitious public capital investment programmes. In this paper, we seek to investigate whether voters include large-scale infrastructure development initiatives in their electoral accountability mechanism at the ballot box.

In 2000, the Government of India launched its national rural road building programme. Fourteen years later, close to 200,000 villages had received a new paved rural road connecting it to the wider economy. This cost the government a total of \$40 billion. While new road connections do not appear to transform employment opportunities and consumption of the village population in the medium-term (Asher and Novosad, 2020), there is evidence that it improves educational outcomes (Adukia et al., 2020) and increases access to finance (Agarwal et al., 2023). We find that Indian voters appear to place significant value to this local public good provision and reward the political alliance which spearheaded the investment.

Within the time period we consider in this paper – 2000 to 2014 – the PMGSY programme targeted road construction towards villages with a population above 1000 and if these already had a connection, villages above 500. Incorporating both population thresholds in our

analysis enables us to consider the impact of the programme across varying village characteristics. We do not however evaluate the impact of this programme when it targeted smaller villages (threshold of 250). Additional research on this would add value to the external validity of our results, as would analysis of similar large-scale infrastructure development schemes such as India's national electrification programme.

Importantly, this work allows us to estimate the electoral returns to investment in public infrastructure. Focusing on the direct beneficiaries of the programme the average cost of a new road was \$136,806 and the mean voting-age population in beneficiary villages was 1014.²² We estimate that a new road increased the vote share to the UPA by 7.5% when excluding spillover villages from the control group, making the cost of a single vote \$1799 on average, or 115.3% of GDP per capita in 2014. However, we also estimate a similar increase in the vote share of 8.4% in villages within a 2 km radius of a new road. When we incorporate these into our calculations by taking the average voting-age population across all villages to be 883 and the mean number of villages within a 2 km radius to be 1.5, this then reduces the average cost of a vote to \$59, or 3.8% of GDP per capita in 2014. To put this in context, evidence from vote buying through a food subsidy programme implemented immediately preceding the 2019 general election in Turkey suggests the cost of a vote to be \$22, or 5.3% of GDP per capita in 2019 (Kaba, 2022). While evidence from this study finds that voters incorporate large-scale public infrastructure investment in their electoral accountability mechanism, the cost effectiveness in comparison to short-term vote buying is largely dependent on the extent to which the benefits of the infrastructure spillover into surrounding areas.

²² The voting age in India is 18 years.

Table 7
Impact of new road on share of votes to political parties, excluding control villages within 2 km of the treatment group.

	United Progressive Alliance		National Democratic Alliance		Small parties & independents (5)
	INC (1)	All parties (2)	BJP (3)	All parties (4)	
Panel A: New roads completed between 2004 and 2014					
New road	0.070* (0.038)	0.075** (0.038)	-0.060 (0.040)	-0.060 (0.040)	-0.023 (0.030)
F-statistic	115.346	117.283	118.694	116.467	116.075
N	5999	6166	5986	6181	6191
Panel B: New roads completed between 2009 and 2014					
New road	0.090 (0.063)	0.100 (0.062)	-0.072 (0.063)	-0.064 (0.063)	-0.044 (0.045)
F-statistic	49.911	53.066	52.409	52.917	52.923
N	4144	4282	4126	4294	4303
Panel C: New roads completed between 2004 and 2009					
New road	0.085* (0.044)	0.089** (0.045)	-0.083* (0.048)	-0.083* (0.049)	-0.018 (0.037)
F-statistic	91.064	89.565	91.652	88.033	88.074
N	4804	4955	4798	4972	4978
Control mean	0.357	0.358	0.515	0.513	0.128
Control SD	0.194	0.194	0.203	0.203	0.155

Notes: This table presents *fuzzy* RD estimates on the effect of a new road on the share of votes to political parties in the 2014 general election of India where non-beneficiary villages with 2 km of PMGSY roads are excluded from the sample. Panel A includes all new PMGSY roads built between the 2004 and 2014 general elections. Panel B reports results for villages treated between the 2009 and 2014 general elections, while Panel C presents results for villages treated between the 2004 and 2009 general elections. We consider three political party categories: UPA (Column 1-2), NDA (Column 3-4), and small parties and independent candidates unaffiliated to any alliance (Column 5). For the two leading alliances, we report votes to both the leading party (INC for the UPA and BJP for the NDA) as well as all parties in the coalition. For each political party category, we restrict the sample to villages where a representative of that category was listed on the ballot. We restrict our sample to the six compliant States, including villages with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold and outside a 2 km radius of the treated group) is reported. Heteroskedasticity robust standard errors are presented in parenthesis. * significant at 10% ** significant at 5% *** significant at 1%.

Table 8
Impact of new road on votes to the constituency incumbent.

	All candidates		UPA candidate		NDA candidate	
	Same (1)	New (2)	Same (3)	New (4)	Same (5)	New (6)
Panel A: New roads completed between 2004 and 2014						
New road	0.150*** (0.048)	0.000 (0.058)	0.163*** (0.052)	0.007 (0.059)	0.070 (0.078)	0.028 (0.142)
F-statistic	100.355	51.601	71.085	56.135	34.523	8.998
N	6497	3753	3011	1338	1485	1337
Panel B: New roads completed between 2009 and 2014						
New road	0.220*** (0.082)	0.009 (0.094)	0.224** (0.095)	0.064 (0.229)	0.097 (0.140)	-0.005 (0.128)
F-statistic	43.865	22.282	25.372	3.522	14.616	14.992
N	5207	2872	2224	789	1222	1138
Panel C: New roads completed between 2004 and 2009						
New road	0.218*** (0.068)	-0.018 (0.074)	0.204*** (0.068)	0.010 (0.058)	0.137 (0.105)	-0.126 (0.405)
F-statistic	68.511	40.203	50.647	65.302	24.601	1.627
N	5468	2976	2551	1140	1263	1055
Control mean	0.420	0.420	0.366	0.402	0.542	0.515
Control SD	0.214	0.214	0.196	0.214	0.199	0.179

Notes: This table presents *fuzzy* RD estimates on the effect of a new road on the share of votes to the constituency incumbent in the 2014 general election of India. Panel A includes all new PMGSY roads built between the 2004 and 2014 general elections. Panel B reports results for villages treated between the 2009 and 2014 general elections, while Panel C presents results for villages treated between the 2004 and 2009 general elections. We disaggregate incumbency by political affiliation – whether the candidate represents the UPA (Columns 3–4) or the NDA (Column 5–6). Furthermore, we disaggregate incumbency by whether or not the incumbent is the same individual or a new individual (representing the incumbent party). The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold) is reported. We restrict our sample to the six compliant States, including villages with no paved road at baseline, and a population within the optimal bandwidth (84) of the eligibility threshold. The specification includes baseline village-level controls and constituency-cutoff fixed effects (see Section 4 for details). For each regression, the mean and SD of the control group (villages with population below the PMGSY eligibility threshold) is reported. Heteroskedasticity robust standard errors are presented in parenthesis. * significant at 10% ** significant at 5% *** significant at 1%.

Declaration of competing interest

The author declares that she has no relevant or material financial interests that relate to the research described in this paper. All data used in this study is publicly available.

Data availability

Data will be made available on request.

Appendix A. Supplementary tables and figures

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.jpube.2024.105228>.

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