The Many Costs of Remoteness

Evidence from 600,000 Villages in India

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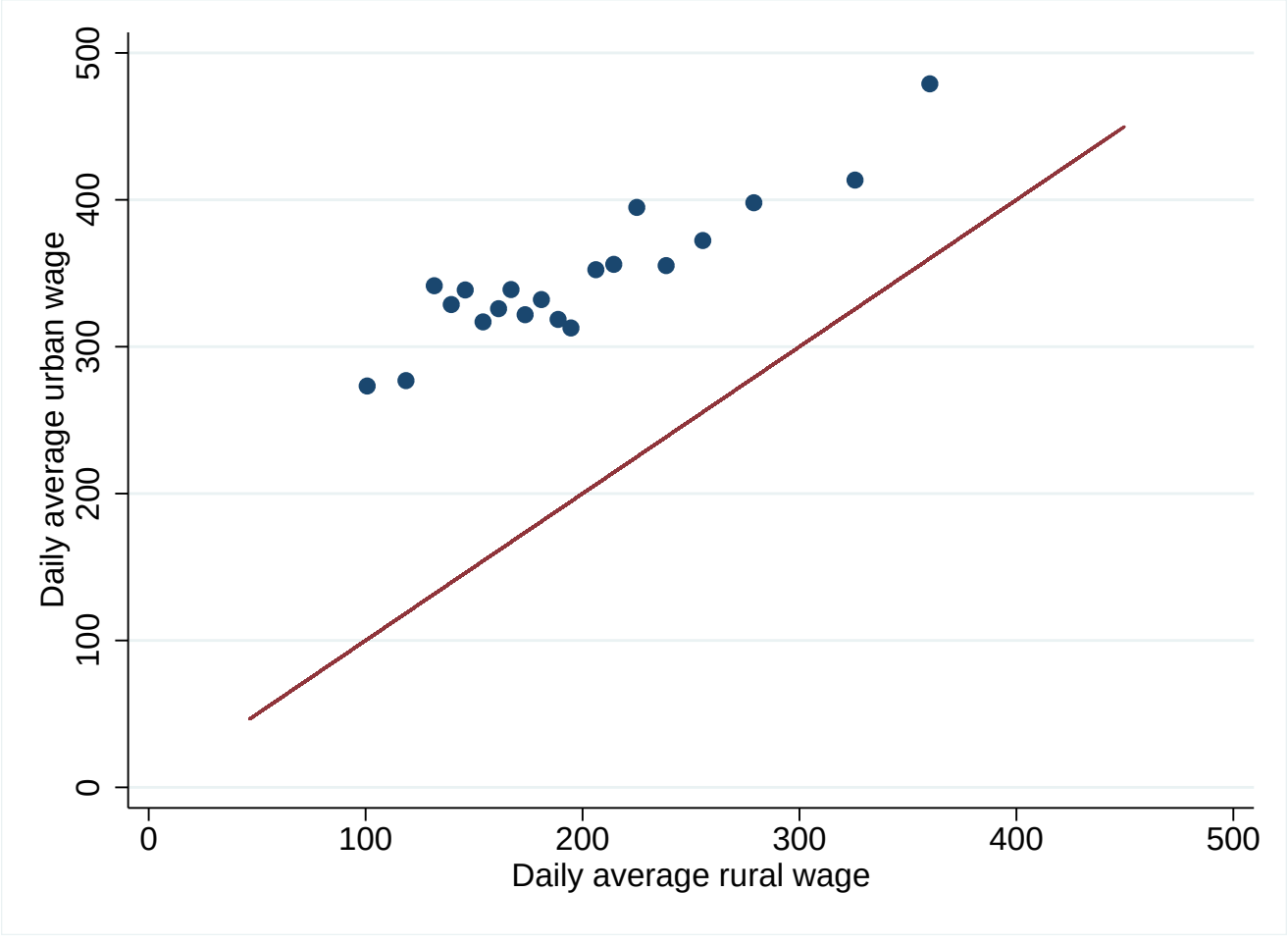
Motivation

- Developing countries urbanizing rapidly, but many differences with earlier urbanization in rich countries
  - Urbanization without industrialization (Gollin et al, 2016)
  - Urbanization outstrips growth (Glaeser, 2014)
  - Spatial equilibrium may not hold in India despite large rural-urban wage gaps (Chauvin et al, 2016)
- Much work in economics on causes of urbanization
  - Pull and push factors
- Our agenda: what role do cities play in economic development and poverty alleviation in rural areas?

Rural wages track wages in nearby cities



Cities and rural development

- Open economy cities not necessarily reliant on rural hinterland
- Little evidence on urban $\rightarrow$ rural growth channel
- Channels
  - Goods markets
    - Imports and exports, ag and non-ag
  - Labor markets
    - Only 42% of HH send no migrants (2002)
  - Public service delivery

This presentation

- Paper 1: labor market impacts of rural road construction
- Paper 2: educational impacts of roads
- Paper 3: costs of administrative remoteness

Research challenge

- Empirical requirements
  - Large number of cities and rural areas
  - Consistent data over space and time
  - Exogenous variation in linkages to urban areas
- India as ideal laboratory: lots of data, high spatial resolution, consistent across entire country
  - We've assembled various censuses that cover India's 8k towns and 600k villages
  - Begun process of geocoding within cities

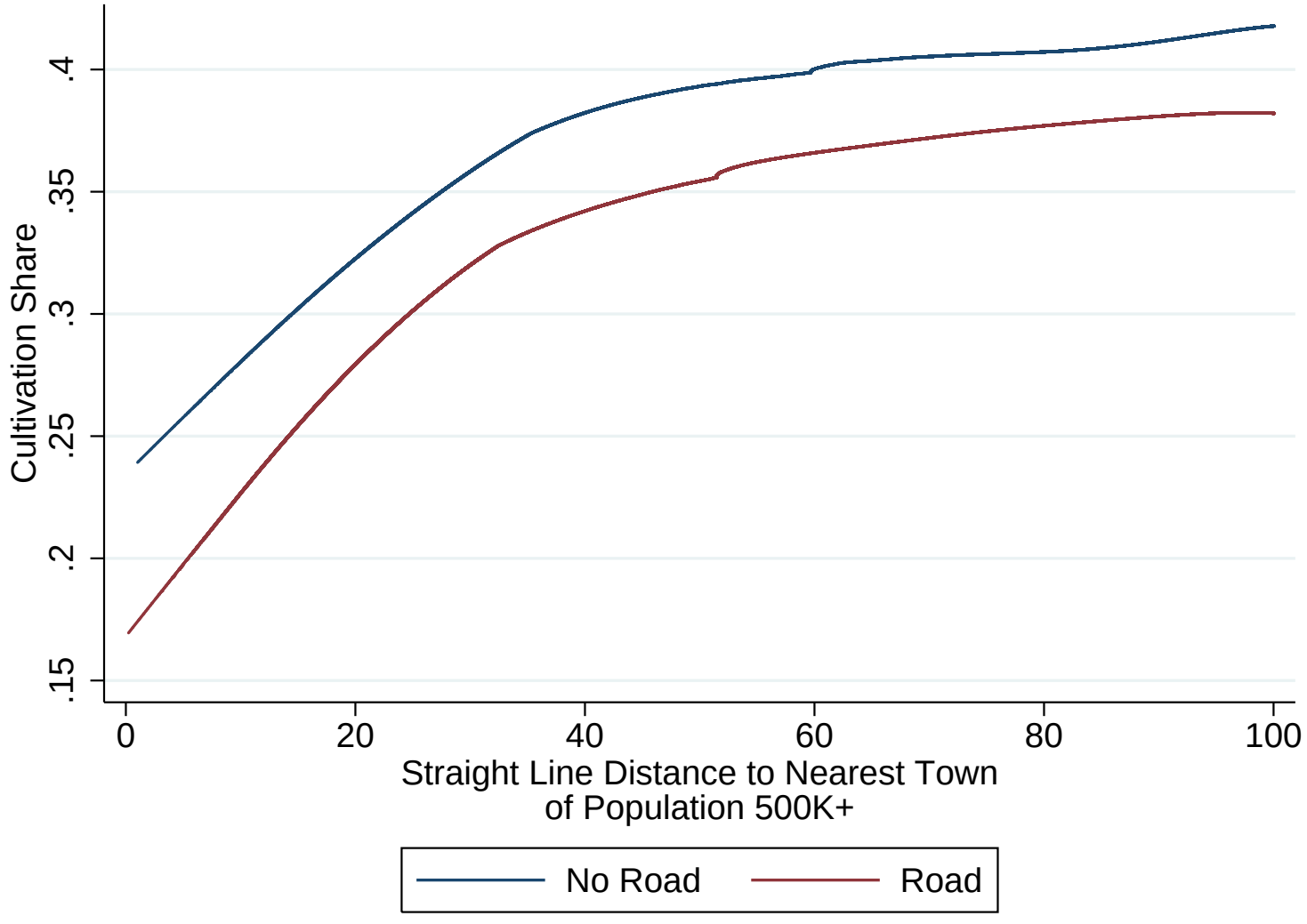
The data

- Economic Census (1990, 1998, 2005...2012)
  - Census of non-farm establishments, rural and urban, formal and informal (42m firms in 2005)
  - Employment, ownership, product code
- Village- and town-level demographic censuses (1991-2011)
  - Demographic data and amenities
- Socioeconomic censuses
  - Poverty census (2002, rural only)
  - SECC (2012, all urban and rural HH)
  - Household structure, education, parents education, occupation, durables, income and source of income
- Geocoded at town and village level

Roads and structural transformation

- Hypothesis: poor rural transport infrastructure prevents reallocation of labor
  - Over 1 billion people lack paved road access
  - India has made large gains in rural road contruction (from low baseline)
    - Villages with paved roads: 33% (1991) $\rightarrow$ 49% (2001) $\rightarrow$ 56% (2011)
    - Varies greatly by state (southern states at 80% in 2001)
- Test: estimate labor market effects of India's national rural road construction program
  - Add to growing lit on role of transport infrastructure in economic development
- Impact theoretically ambiguous
  - Road increases mobility of both goods and labor
  - Effects depend on relative changes to labor productivity across sectors
  - May be other binding constraints to labor market access

Structural transformation and access to urban markets



Empirical challenges

1. Road placement endogenous
   - Political and economic determinants of investment

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Empirical challenges

1. Road placement endogenous
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   → Exploit discontinuities in treatment probability due to program rules
2. Data availability
   - Most available data lack required spatial resolution

   → Geocoded microdata of every rural individual and household in India (N = 825m, 600k villages)

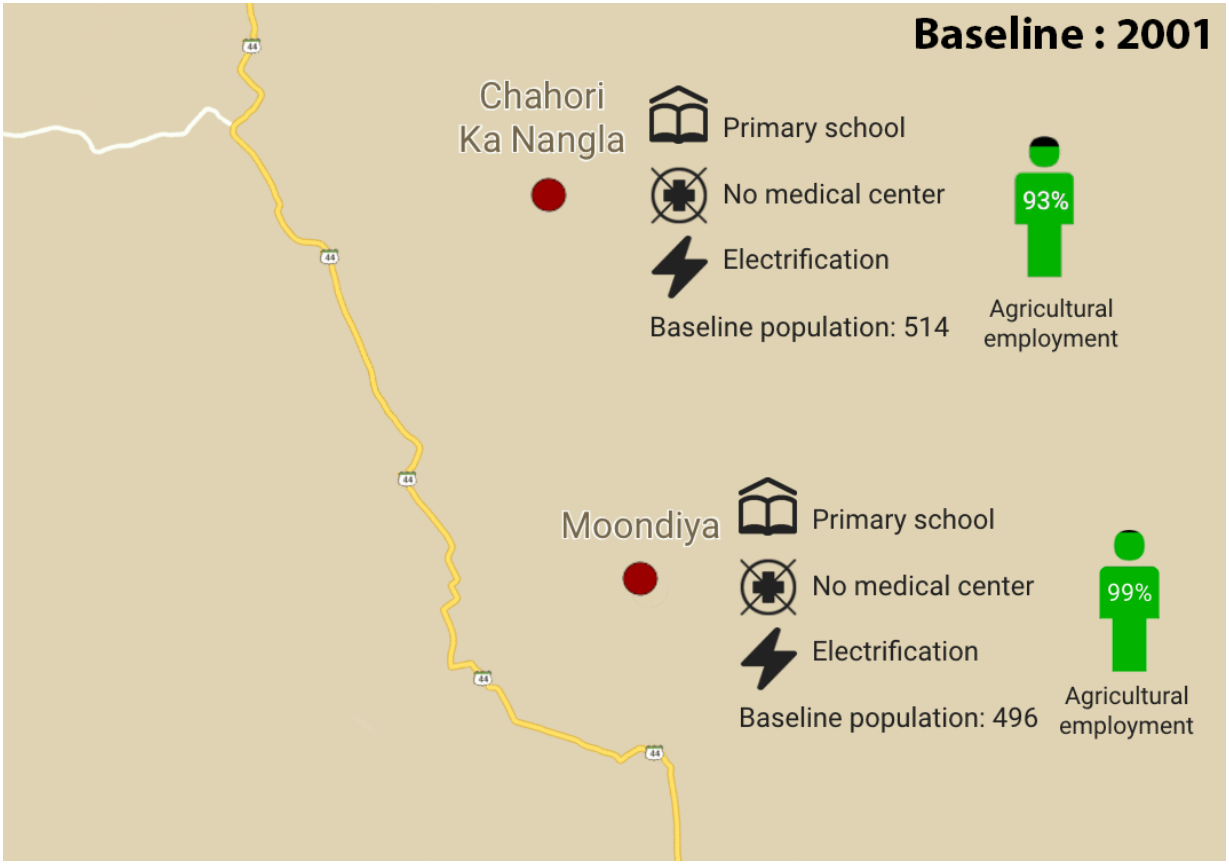
Pradhan Mantri Gram Sadak Yojana (PMGSY)

- Launched in 2000 to connect all villages to road network
- By 2015:
  - 113,000 roads constructed (400,000 km)
  - 107,000 previously unconnected villages benefited
  - $>$ \$37 billion disbursed
- Funded centrally, construction administered by states
- Transparent, systematic electronic record keeping: details of every habitation and road built
- Objective eligibility rules
  - Prioritization to villages over 1000, 500 population

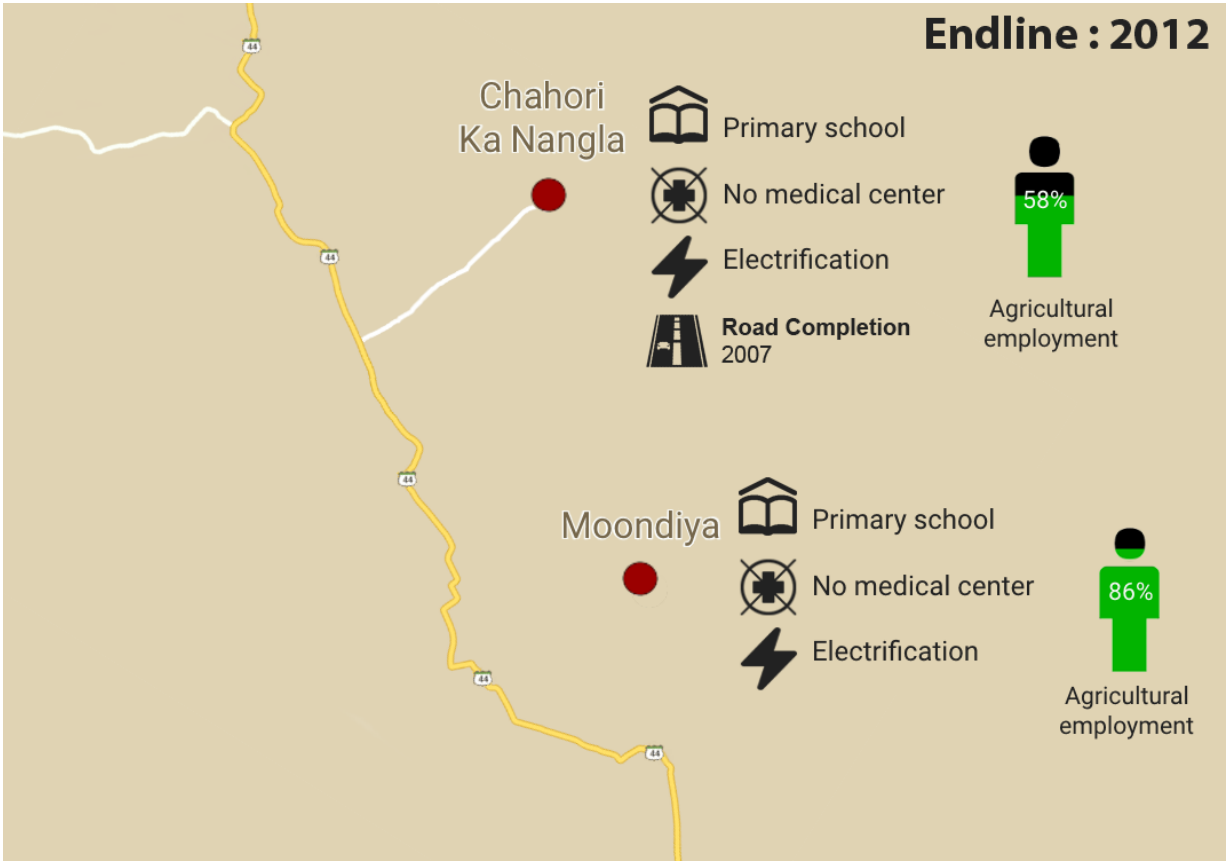
What is a rural road?

- Paved all weather road
- Median length 4 km
- Connects village to paved road network
- Village is terminus 71% of cases
- Not major artery to other regions

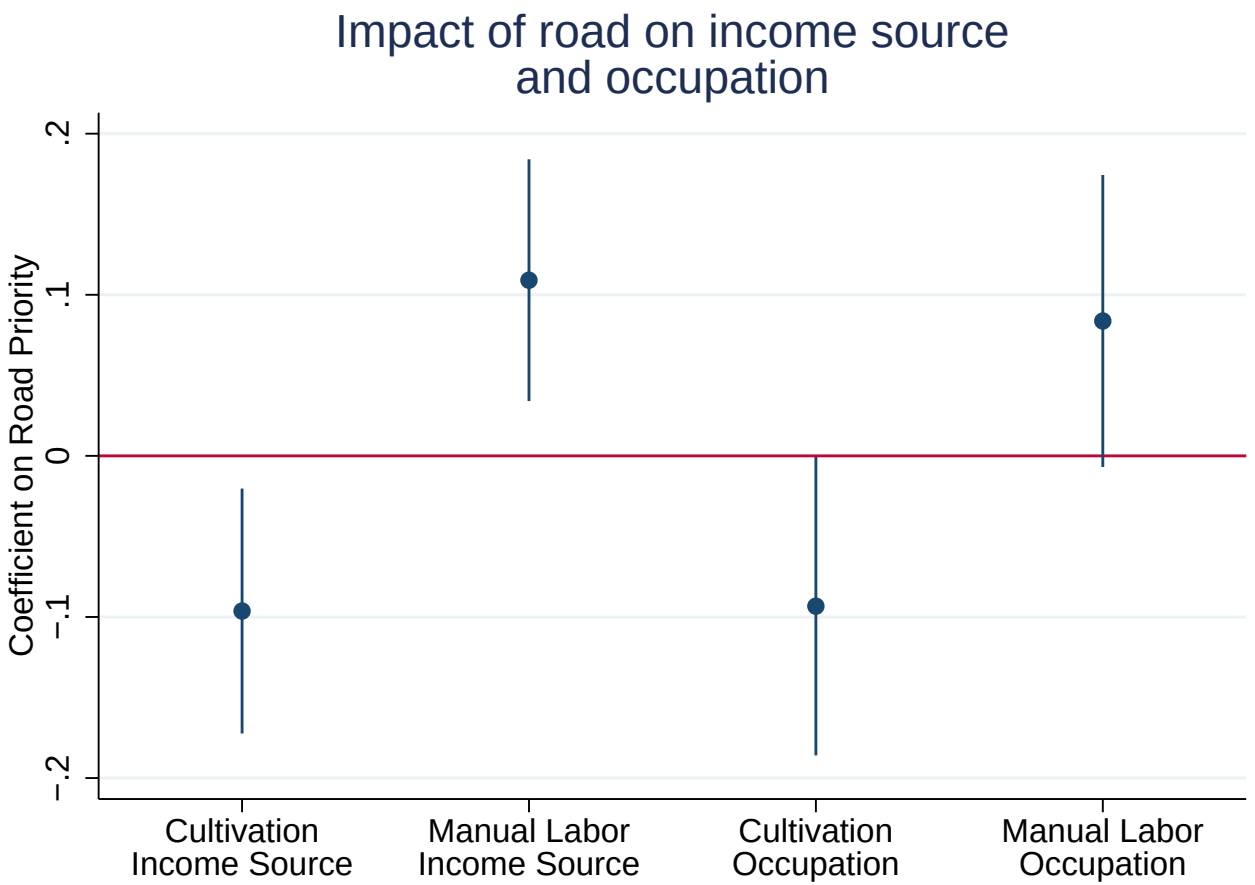
Example: before



Example: after



Agriculture down in both income source and occupational data



▸ Inc source and emp share ▸ Robustness by bandwidth and kernel ▸ Effect by cutoff

Migration and economic outcomes

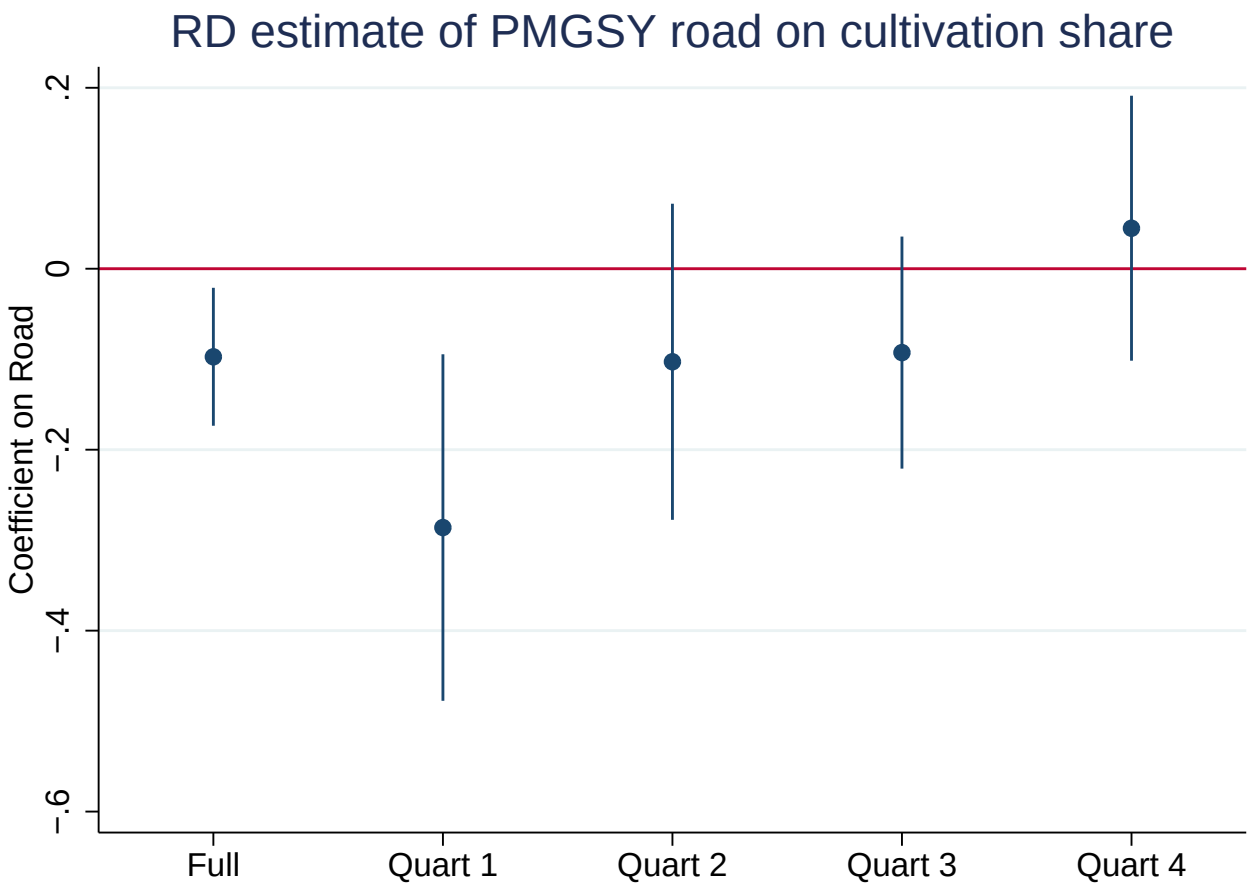
- Recent work suggests lowering transport costs can facilitate out migration
  - However increased economic opportunities may decrease net out migration
  - Our evidence suggests little effect on migration
    - No significant change in population growth, even in villages close to cities
    - Stable age distribution and male population share
- Do the roads bring visible improvements to economic outcomes? We observe:
  - Noisy gains to income and solid house materials
  - No increase in other durable assets
  - Increase in growth rate of night lights
- Within village: impacts largest for low caste, small landholders, men

▸ Pop growth ▸ Age figure ▸ Age table ▸ Income and assets

Access to urban markets

- Impact of transportation infrastructure likely to depend on market access that it facilitates
  - Redding and Sturm (2008); Donaldson and Hornbeck (2015)
- Examine results by straight-line distance to major cities (500k+ pop)
- Impacts decreasing in distance to nearest city

Reallocation decreasing in distance from cities



▸ Table: Effects by quartile

▸ Table: City proximity

Mechanism

- Road could induce movement out of agriculture through reduction in costs of moving goods, labor
- Potential channels
  1. Increase in within-village nonfarm employment
  2. Access to external labor markets
  3. Decrease in agricultural demand for labor
- Evidence suggests external labor market participation

▸ Non farm firms
▸ Wage gap
▸ Bus service
▸ Agricultural investment

Takeaways

- We estimate the labor market impact of the largest rural road scheme in history
  - Roads facilitate reallocation from agriculture to wage labor
  - Strongest effects when high access to large cities
  - Driven by groups with likely high returns to reallocation
  - Evidence suggests increased participation in external labor markets
- Argues for transport costs as significant constraint on participation in non-agricultural labor markets
- Cities as drivers of rural change
- But roads no panacea

Roads and education

- Long run impacts of infrastructure will depend on longer run investments
- Evidence on impacts of openness on education mixed
- Panel and RDD estimates find significant increase in student retention at transition from elementary school
  - Test scores increase despite likely adverse selection
- Impacts highest in poorest areas and where rural-urban wage gaps small
  - Suggests liquidity and substitution effects
  - As in labor markets, roads seem to have largest impacts for the most marginalized

Administrative remoteness

- Economists usually think of market access in terms of goods and labor
- Cities also administrative centers
- Question: what is the cost of administrative remoteness?
  - African states gets weaker with distance from capital (Bates, 1983; Herbst, 2000; Michalopoulos and Papaioannou, 2014)
  - Remote capitals have higher corruption and lower public good provision (Campante and Do, 2014)
  - Decentralization increases information and incentives (Bardhan, 2002)
- Challenge: isolate impact from other market access
  - Take advantage of administrative boundaries that generate jumps in administrative remoteness but not market access

Variation within vs across districts

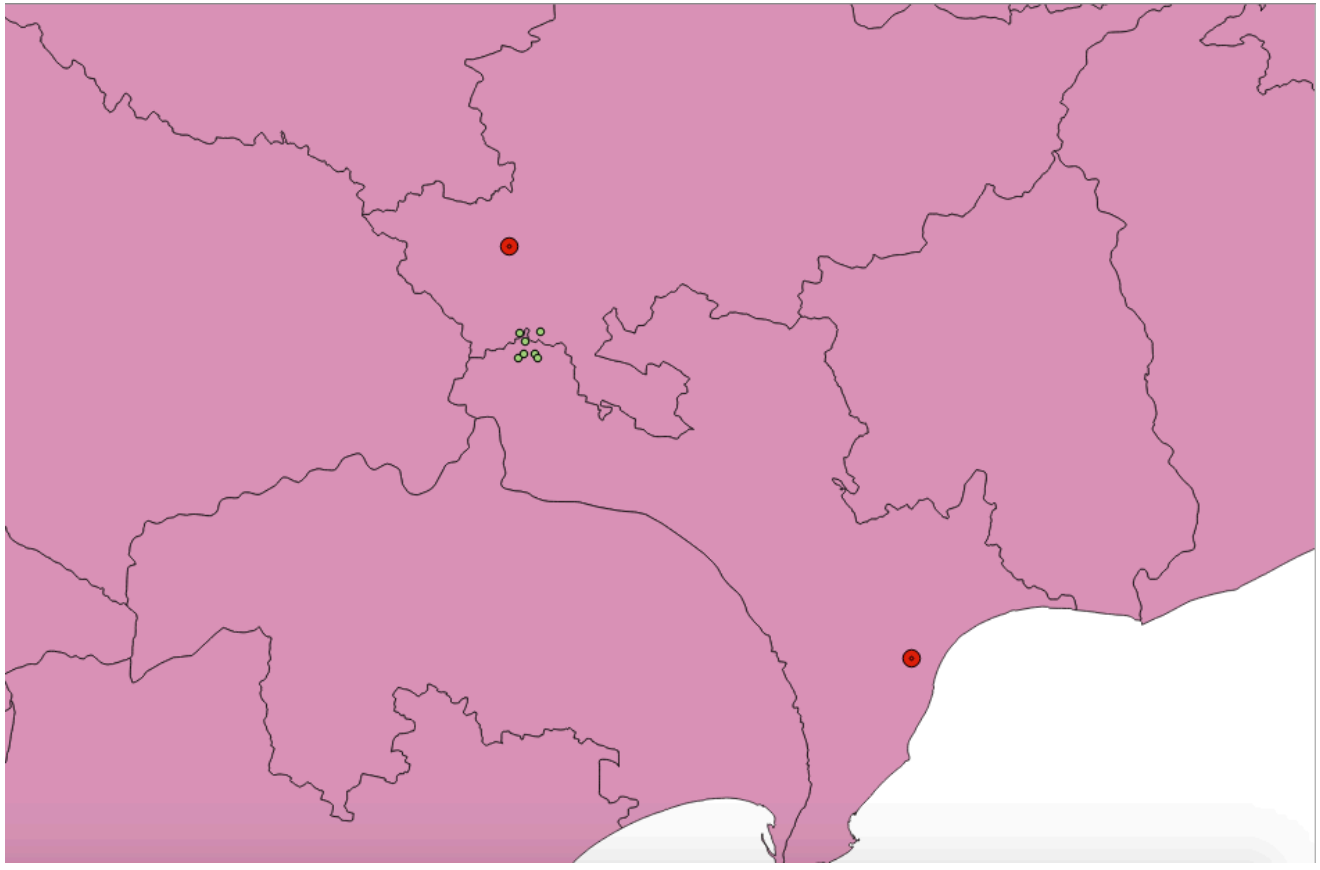
- India is a federal system with national policies implement by states through district-level administration
- Many programs in India pursue spatial equality through regional targeting, e.g. backwards districts
- We document high levels of inequality within districts
  - Only 23% of variation in mean village earnings is inter-district
- Remoteness helps to explain this pattern

Remote villages: poorer, fewer amenities, more ag

Table 1: Summary statistics by median distance to nearest town

	Full Sample	Closer Villages	Remoter Villages
Distance to District HQ (kms)	38.28	32.73	44.03
	(23.92)	(22.01)	(24.43)
Distance to nearest town (kms)	15.83	8.383	23.47
	(10.67)	(3.237)	(10.24)
Population (2011)	1484.6	1680.2	1301.3
	(2018.7)	(2182.0)	(1831.1)
Mean monthly earnings (2012 Rupees)	5113.7	5171.0	4787.0
	(2451.6)	(2110.6)	(2035.1)
Percent households with solid roof (2012)	47.75	52.47	42.46
	(34.85)	(32.67)	(36.09)
Percent population literate (2011)	57.27	59.02	55.29
	(13.94)	(12.81)	(14.70)
Percent population engaged in agriculture (2011)	72.14	69.17	75.37
	(26.78)	(26.56)	(26.44)
Percent villages electrified (2011)	61.87	67.31	56.10
	(48.57)	(46.91)	(49.63)
Percent villages with govt primary school (2011)	83.89	83.87	84.41
	(36.76)	(36.78)	(36.28)
Percent villages with health center (2011)	22.90	22.09	23.93
	(42.02)	(41.49)	(42.66)
Percent land irrigated (2011)	57.71	67.73	47.55
	(38.34)	(35.43)	(38.46)
Paved Road Access (2011)	80.50	83.84	77.13
	(39.62)	(36.80)	(42.00)
Distance to nearest highway (kms)	8.944	6.953	11.00
	(8.186)	(6.973)	(8.803)
Observations	395184	197693	193336

Example: Khammam and Krishna districts



Remoteness lowers provision of roads, schools

Table 2: Impact of remoteness on public service delivery

	Paved Roads	Electrification	Primary School	Secondary School	Medical Center
Distance to District HQ (kms)	-0.046	-0.015	0.020	-0.038	-0.010
	(0.015)***	(0.014)	(0.016)	(0.015)**	(0.016)
Distance to nearest town (kms)	-0.095	-0.060	-0.159	0.014	-0.083
	(0.075)	(0.072)	(0.079)**	(0.077)	(0.082)
Distance to nearest highway (kms)	-0.152	-0.189	-0.113	-0.166	-0.241
	(0.079)*	(0.076)**	(0.083)	(0.081)**	(0.087)***
Outcome Mean	79.22	58.9	82.71	14.58	20.42
Fixed effects	Grid-cell, District	Grid-cell, District	Grid-cell, District	Grid-cell, District	Grid-cell, District
Density controls	Yes	Yes	Yes	Yes	Yes
N	64245	64246	64245	64246	64246
R2	.4353	.6439	.2794	.215	.3063

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

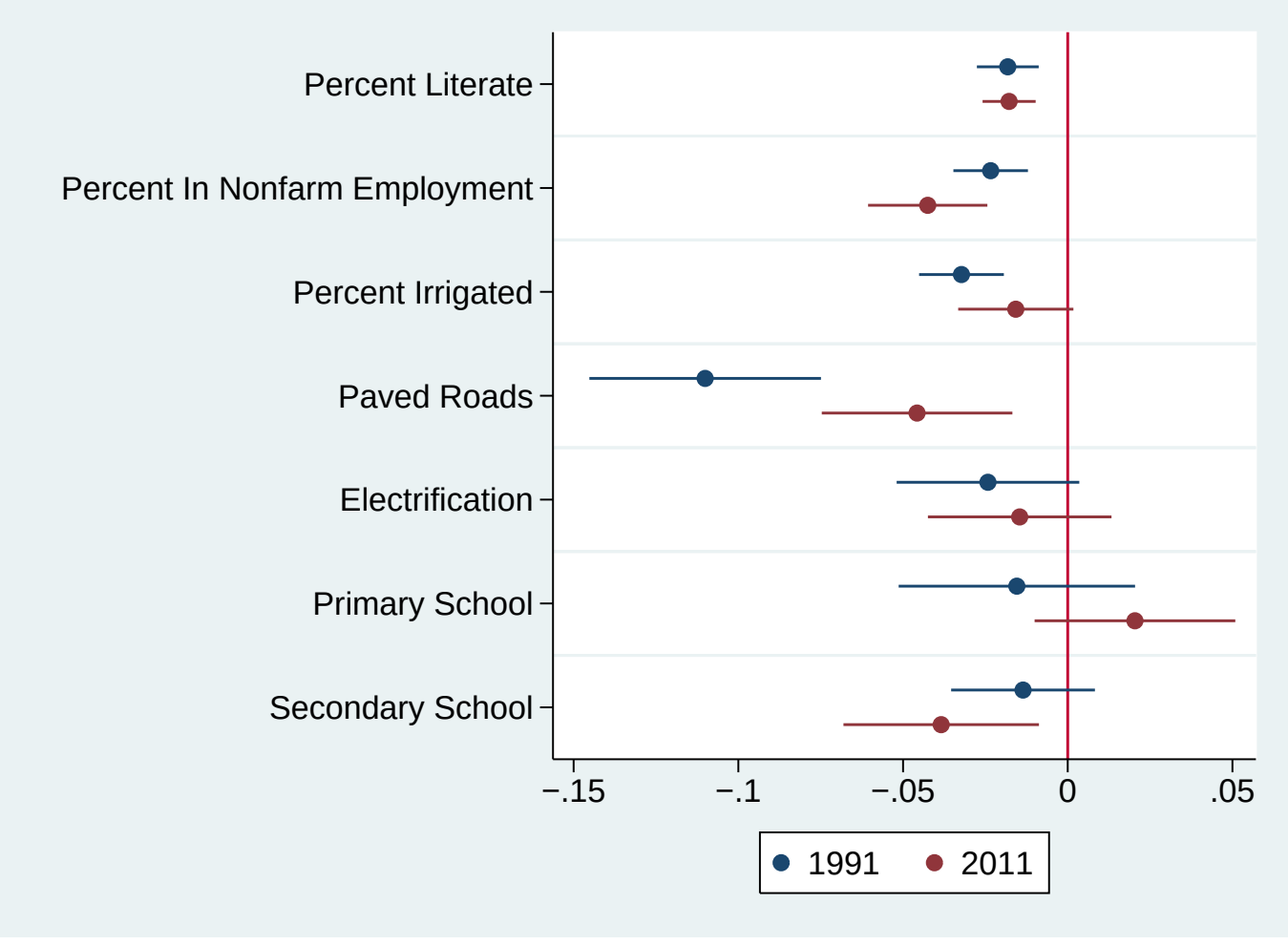
Table 3: Impact of remoteness on economic activity and outcomes

	Mean Income	Solid Roof	Percent Literate	Percent Agriculture	Percent Land Irrigated	Households with a migrant
Distance to District HQ (kms)	-2.178	-0.027	-0.018	0.043	-0.016	-0.001
	(0.761)***	(0.008)***	(0.004)***	(0.009)***	(0.009)*	(0.015)
Distance to nearest town (kms)	-0.266	0.020	-0.073	0.164	-0.128	0.250
	(3.847)	(0.040)	(0.021)***	(0.047)***	(0.045)***	(0.072)***
Distance to nearest highway (kms)	-19.912	-0.262	-0.142	0.448	-0.113	0.090
	(4.068)***	(0.042)***	(0.022)***	(0.049)***	(0.048)**	(0.076)
Outcome Mean	4943	46.47	56.59	74.08	58.66	59.57
Fixed Effects	Grid-cell, District	Grid-cell, District	Grid-cell, District	Grid-cell, District	Grid-cell, District	Grid-cell, District
Density Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	64246	64241	64171	63683	62425	43889
R2	.4516	.7876	.6693	.4796	.7752	.5579

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

Is the role of remoteness changing over time?

- Effective cost of distance should be falling over time



Rural road provision

- We measure cost of road provision
  - PMGSY: national program, identical standards
- Roads more expensive to construct when further from HQ
  - Could be either risk premium or higher costs from lower state capacity (e.g. rule of law)
- Future: time to complete, road quality

Concluding thoughts

- Transport infrastructure moves more than goods: labor, government services
- Rural-rural gap large, persistent
- Impacts of infrastructure and urbanization likely underestimated due to long lags on returns
- What we still don't understand
  - Short-term migration – with implications for policies, data collection, etc
  - Complementarity of infrastructural investments
  - Determinants of urban success
  - Intra-urban policy impacts: zoning, transport, FAR

Thank you!

Appendix

Conceptual Framework

- Many channels by which road could affect economic activity
- Transport costs decrease both for goods and people
- Imports and exports likely to increase
- Simple model of occupation choice between cultivation and wage labor
- Ambiguous effect of road construction due to potentially countervailing forces:
  - Changes in agricultural productivity (prices, inputs, etc)
  - Changes in net wages (within-village productivity, search, commuting costs)

▸ Model

First stage stable across bandwidths

Table 4: First stage effect of road priority on PMGSY road treatment

	±50	±60	±70	±80	±90	±100
Road priority	0.137	0.134	0.131	0.130	0.129	0.130
	(0.018)***	(0.016)***	(0.015)***	(0.014)***	(0.013)***	(0.013)***
F Statistic	58.38	67.2	74.81	85.03	95.1	107.3
N	8840	10484	12250	13979	15762	17469
R2	.2592	.2527	.2492	.247	.2455	.2447

$^{*}p < 0.10,^{**}\ p < 0.05,^{***}\ p < 0.01$

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Cultivation by landholdings

Table 5: RD estimate of PMGSY road on cultivation as primary source of income (share of households), by size of landholdings

	Landless	0-1 Acres	1+ Acres
Road	-0.024	-0.130	-0.047
	(0.029)	(0.058)**	(0.039)
Outcome Mean	.1218	.4867	.7213
N	19383	17203	19137
R2	.1868	.1553	.2855

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Age and gender

Table 6: RD estimate of PMGSY road on agriculture as occupation (share of individuals), by gender and age

	All		Male		Female	
	21-40	41-60	21-40	41-60	21-40	41-60
Road	-0.100	-0.097	-0.110	-0.117	-0.044	0.024
	(0.049)**	(0.050)*	(0.049)**	(0.050)**	(0.060)	(0.067)
Outcome Mean	.4088	.5403	.4258	.5693	.2673	.3154
N	19512	19438	19494	19426	18098	17041
R2	.2894	.3077	.2893	.3103	.228	.2452

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

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Caste

Table 7: RD estimate of PMGSY road on cultivation (share of households), by caste

	Scheduled Caste	Scheduled Tribe	General
Road	-0.166	0.033	-0.076
	(0.060)***	(0.053)	(0.045)*
Outcome Mean	.2624	.3362	.467
N	15424	11192	18795
R2	.2199	.4274	.3977

$^{*}p < 0.10,^{**}\ p < 0.05,^{***}\ p < 0.01$

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Proximity to large cities

Table 8: RD estimate of PMGSY road on cultivation as primary source of income (share of households), by distance to urban centers

	100k near	100k far	500k near	500k far
Road	-0.146	-0.066	-0.206	-0.023
	(0.059)**	(0.054)	(0.067)***	(0.048)
Outcome Mean	.4356	.4216	.4268	.4303
N	9806	9806	9806	9806
R2	.4412	.5159	.3988	.5108

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Comparable results in occupational data

Table 9: Impact of road on occupation in agriculture

	Household Income Source		Occupation	
	Cultivation	Manual Labor	Agriculture	Manual Labor
Road	-0.096	0.109	-0.093	0.084
	(0.039)**	(0.038)***	(0.047)**	(0.046)*
Outcome Mean	.4286	.5093	.4505	.4439
N	19612	19612	19525	19525
R2	.4743	.435	.3032	.2811

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Proximity to large cities (quartiles)

Table 10: First stage, reduced form and RD estimate of PMGSY road on cultivation as primary source of income (share of households), by distance to urban centers

Panel A. First Stage

	Full	Quart 1	Quart 2	Quart 3	Quart 4
Road Priority	0.1517	0.1372	0.1268	0.1761	0.1623
	(0.0125)***	(0.0233)***	(0.0240)***	(0.0262)***	(0.0265)***
Outcome Mean	0.3131	0.2508	0.3069	0.3175	0.3775
N	19614	4903	4903	4903	4903
R2	0.2729	0.2931	0.3538	0.2861	0.2867

Panel B. Reduced Form

	Full	Quart 1	Quart 2	Quart 3	Quart 4
Road Priority	-0.014	-0.039	-0.013	-0.016	0.0072
	(0.0058)**	(0.0118)***	(0.0113)	(0.0115)	(0.0123)
Outcome Mean	0.4285	0.4179	0.4356	0.4348	0.4257
N	19614	4903	4903	4903	4903
R2	0.4950	0.4982	0.5365	0.5184	0.5299

Panel C. Regression Discontinuity

	Full	Quart 1	Quart 2	Quart 3	Quart 4
Road	-0.097	-0.286	-0.102	-0.092	0.0447
	(0.0388)**	(0.0977)***	(0.0891)	(0.0654)	(0.0747)
Outcome Mean	0.4285	0.4179	0.4356	0.4348	0.4257
N	19614	4903	4903	4903	4903
R2	0.4733	0.3241	0.5104	0.5014	0.5255

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

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Income and assets

Table 11: Impact of road on household earnings and assets

	Income			Assets			
	Mean	< 5k	≥ 10k	Solid House	Refrigerator	Vehicle	Phone
Road	327.341	-0.027	0.015	0.054	0.016	-0.021	-0.043
	(194.806)*	(0.024)	(0.008)*	(0.032)*	(0.013)	(0.024)	(0.040)
Outcome mean	4073	.8711	.03579	.2724	.03344	.1421	.5111
Fixed effects	Dist x Cutoff	Dist x Cutoff	Dist x Cutoff	Dist x Cutoff	Dist x Cutoff	Dist x Cutoff	Dist x Cutoff
N	19792	19792	19792	19792	19792	19792	19792
R2	.2883	.2864	.2498	.7152	.1617	.3434	.6211

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

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Setup

- Continuum of villages characterized by market access $a \in [0, \bar{a}]$
- Continuum of agents within each village characterized by $\theta \sim \mathcal{U}[0, 1]$
  - θ captures relative productivity in cultivation (e.g. age, land)
- Two occupations
  - Cultivation: $\theta g(a)$
  - Wage labor: $w(a)$
- Occupation choice
  - Agent of type θ chooses cultivation if $\theta g(a) \geq w(a)$
  - Marginal farmer: $\tilde{\theta} = \frac{w(a)}{g(a)}$

$\rightarrow q = q(a) = 1 - \frac{w(a)}{g(a)}$

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Results 1

How does the share of workers in cultivation change with market access?

$$\frac{\partial q}{\partial a} \leq 0 \leftrightarrow \varepsilon_w \geq \varepsilon_g$$

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Results 2: monotonicity of q

$$q'' < 0 \leftrightarrow \frac{w''}{w} - \frac{g''}{g} > 2\frac{g'}{g}\left(\frac{w'}{w} - \frac{g'}{g}\right)$$

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Results 2: monotonicity of q

$$q'' < 0 \leftrightarrow \frac{w''}{w} - \frac{g''}{g} > 2\frac{g'}{g}\left(\frac{w'}{w} - \frac{g'}{g}\right)$$

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Potential confound: alternate program

- Total Sanitation Campaign used 1000 cutoff (Spears, 2015)

Table 12: Reduced form estimate of PMGSY road on major TSC variables

	Open Defecation	Latrine in Premises	Pit Latrine - with slab	Pit Latrine - without slab
Road priority	-0.006	0.007	0.003	0.000
	(0.009)	(0.009)	(0.005)	(0.003)
N	4540	4540	4540	4540
r2	0.38	0.38	0.38	0.10

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

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SECC Sample PDF

SECC ड्राफ्ट सूची - ग्रामीण

राज्य :RAJASTHAN	ज़िला :Ajmer	तहसील :Ajmer	शहर/ग्राम :Ajaysar	वार्ड कोड नंबर (केवल शहर के लिए) :0000	गणन ब्लॉक -उप खंड :0158_0

घरेलू संख्या : 0003	घर के प्रकार : साधारण	ग्राम पंचायत :-AJAYSAR	आदिम जनजाति वर्ग से है : नहीं	वैधानिक रुप से छुडाया गया बंधुवा मजदूर : नहीं	हाथ से मैला साफ़ करने वाले : नहीं

संख्या	नाम	मुखिया से संबंध	लिंग जन्मतिथि	पिता का नाम माता का नाम	वैवाहिक स्थिति#	व्यवसाय/ गतिविधि	अनु. जाति / जनजाति / अन्य	विकलांगता	शिक्षा
001	[redacted]	मुखिया	पुरुष 1953	[redacted]	2	मजदूर	अन्य	कोई निःशक्तता नहीं	निरक्षर
002	[redacted]	पत्नी	स्त्री 1955	[redacted]	2	मजदूर	अन्य	कोई निःशक्तता नहीं	निरक्षर
003	[redacted]	पुत्र	पुरुष 1989	[redacted]	1	मजदूर	अन्य	कोई निःशक्तता नहीं	पूर्व माध्यमिक

भाग 1 विवरण : आवासीय/निवासीय				भाग 3 रोजगार और आय विशेषताओं					भाग 4 : विवरण सम्पतियां			भाग5 अ: भूमि स्वामित्व (एकड में)				भाग 5 ब: अन्य भूमि स्वामित्व		
मकान के दीवार की प्रमुख सामग्री #	मकान की छत की प्रमुख सामग्री #	मकान का मालिकाना हक की स्थिति	निवास के कमरों की संख्या	नियमित वेतन पाने वाला कोई परिवार का सदस्य	आयकर या वृत्ति कर दाता है	स्वयं की /संचालित ऐसी संस्था जो शासन द्वारा पंजीकृत है	परिवार के सबसे अधिक कमाने वाले सदस्य का मासिक आय	परिवार की आय का मुख्य स्रोत	रेफ्रिजिरेटर	टेलीफोन / मोबाईल फोन	दो/तीन/चार पहिया या मछली पकडने की नाव पंजीकृत	स्वामित्व की भूमि (चास भूमि को छोडकर)	कुल असिंचित भूमि	2 फसलों वाली सिंचाई भूमि	अन्य सिंचित भूमि	बंधिकृत तीन/चार व्हीलर कृषि उपकरण	सिंचाई उपकरण(तलकूप , बोर , ट्रैक्टर/मिट्टी के तेल/विद्युत पंप सेट. फव्वारा/ड्रिप सिंचाई आदि समेत)	किसान क्रेडिट कार्ड की सीमा 50000 रुपए या अधिक है।
6	6	स्वय	4	नहीं	नहीं	नहीं	10,000 या अधिक	1	हां	केवल मोबाइल	दो पहिया	हां	1.0	3.0	1.0	नहीं	हां	नहीं

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Data quality

- Test whether road priority explains differences in variables measured by both 2011 Population Census and 2012 Socioeconomic and Caste Census

Table 13: Effect of road priority on differences between PC11 and SECC

	Population	Under 6 Pop.	Phone
Road	-14.233	0.003	-0.006
	(11.015)	(0.005)	(0.048)
Outcome Mean	11.45	-.03023	.09343
N	19612	19612	19606
R2	.1111	.6846	.1795

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Main results by cutoff

Table 14: RD estimate of PMGSY road on cultivation (share of households), by population threshold

	Full Sample	500 Cutoff	1000 Cutoff
Road	-0.096	-0.080	-0.126
	(0.039)**	(0.052)	(0.052)**
Outcome Mean	.4299	.4439	.3822
N	19612	15071	4541
R2	.4743	.4817	.4258

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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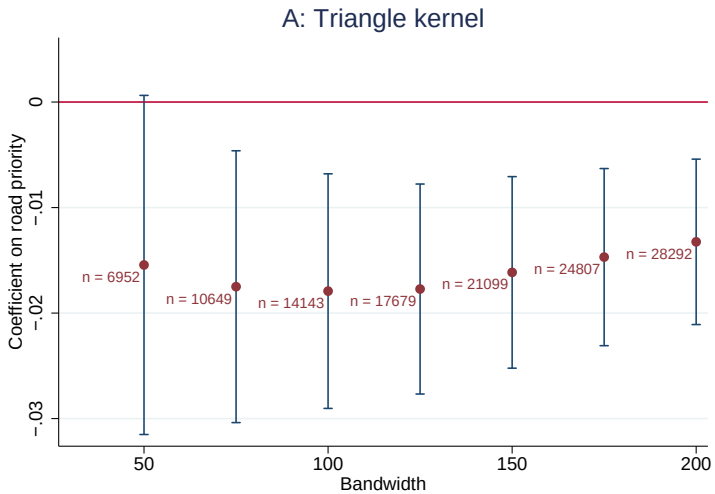
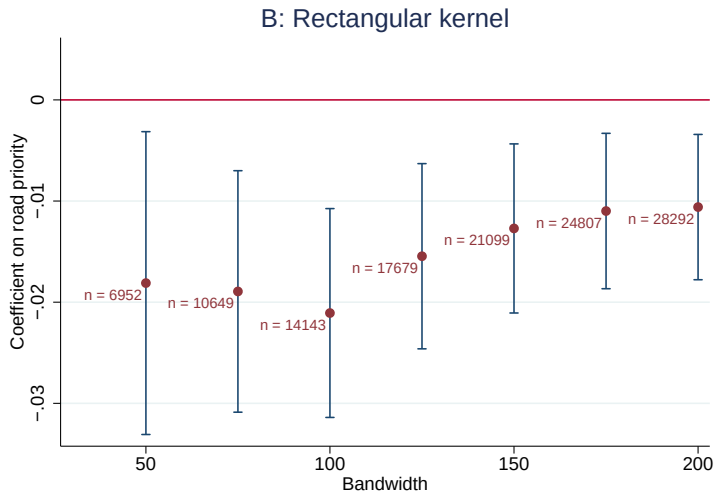
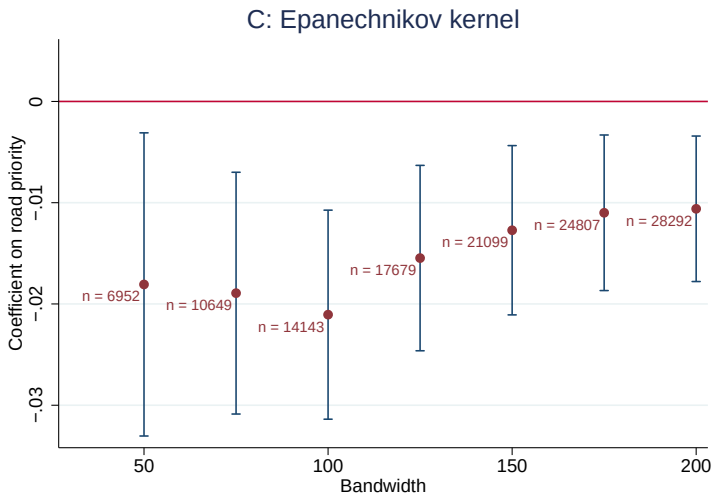
Robustness to choice of bandwidth and kernel







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Effect on distribution of landholdings

Table 15: RD estimate of PMGSY road on distribution of landholdings (share of households)

	Landless	0-1 Acres	1-2 Acres	2-4 Acres	4-10 Acres	10-25 Acres	25+ Acres
Road	-0.029	0.036	0.003	-0.012	-0.015	0.008	0.008
	(0.040)	(0.031)	(0.018)	(0.017)	(0.017)	(0.009)	(0.006)
Outcome Mean	.4194	.1991	.1248	.1162	.09667	.03354	.01023
N	19553	19553	19553	19553	19553	19553	19553
R2	.3505	.4301	.2089	.2361	.3868	.3942	.1785

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

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Farm equipment by landholdings

Table 16: RD estimate of PMGSY road on ownership of mechanized farm and irrigation equipment (share of households), by size of landholdings

Panel A. Mechanized Farm Equipment

	Landless	0-1 Acres	1-2 Acres	2-4 Acres	4-10 Acres	10-25 Acres	25+ Acres
Road Priority	0.0015	-0.011	-0.024	-0.030	-0.059	-0.181	-0.032
	(0.0043)	(0.0115)	(0.0156)	(0.0213)	(0.0323)*	(0.0528)***	(0.0817)
Outcome Mean	0.0052	0.0150	0.0293	0.0555	0.1227	0.2573	0.3768
N	19250	17094	18157	18272	17194	12602	6987
R2	0.0477	0.0863	0.1217	0.1576	0.1953	0.1968	0.3228

Panel B. Irrigation Equipment

	Landless	0-1 Acres	1-2 Acres	2-4 Acres	4-10 Acres	10-25 Acres	25+ Acres
Road Priority	-0.019	-0.067	-0.034	-0.096	-0.078	-0.104	-0.164
	(0.0098)**	(0.0299)**	(0.0356)	(0.0422)**	(0.0483)	(0.0588)*	(0.0825)**
Outcome Mean	0.0116	0.0861	0.1624	0.2531	0.3755	0.5231	0.5574
N	19250	17091	18154	18269	17193	12602	6987
R2	0.0561	0.2126	0.3397	0.3862	0.4170	0.3785	0.4077

$^{*}p < 0.10,^{**}\ p < 0.05,^{***}\ p < 0.01$

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RD: transportation services

Table 17: RD estimate of PMGSY road on bus service

	Full	Quart 1	Quart 2	Quart 3	Quart 4
Road	0.110	0.346	0.328	-0.124	-0.022
	(0.076)	(0.179)*	(0.158)**	(0.143)	(0.142)
N	27201	6985	6648	6710	6858
r2	0.30	0.23	0.25	0.30	0.35

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Electrification

Table 18: RD estimate of PMGSY road on agricultural cultivation (share of households)

	Road Priority	500K Near	Electrified	Elec & 500K Near
Road priority	-0.015	-0.003	-0.022	-0.018
	(0.006)**	(0.009)	(0.008)***	(0.011)
t_td500_near		-0.023		-0.007
		(0.012)*		(0.016)
Road Priority * Electrified			0.024	0.047
			(0.012)**	(0.017)***
Road Priority * Elec * 500K Near				-0.046
				(0.023)**
N	19612	19612	19612	19612
R2	0.50	0.51	0.51	0.52
Near				-0.03
p-value				0.02
Electrified				0.03
p-value				0.02
Elec & Near				-0.02
p-value				0.00

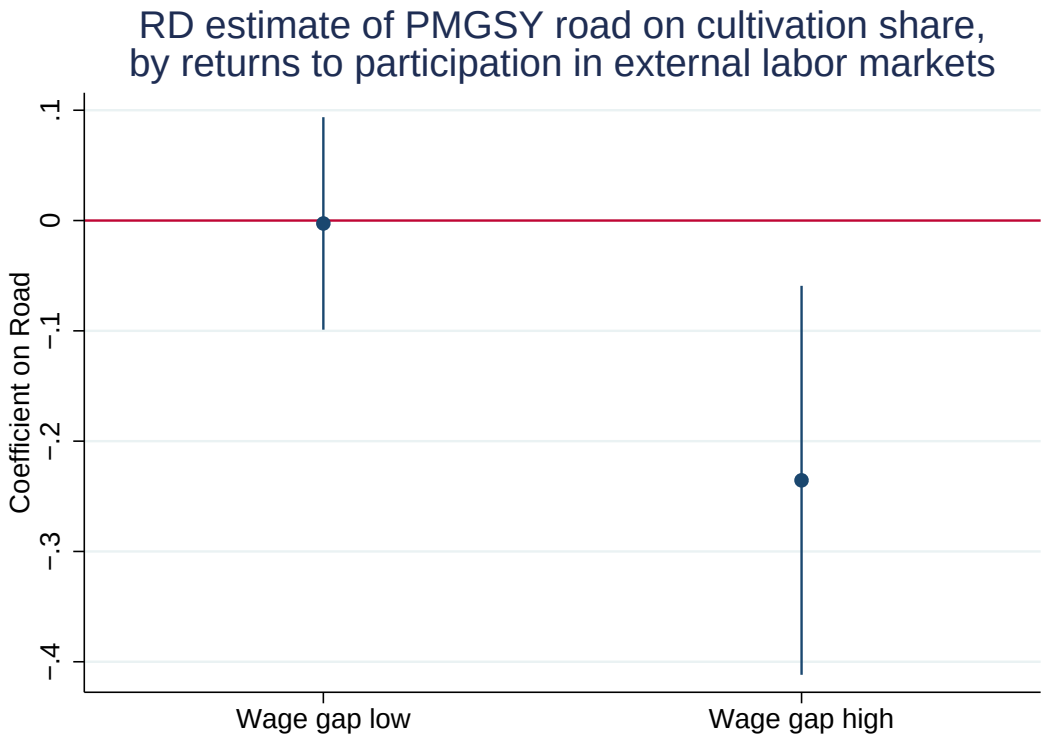
$^{*}p < 0.10,^{**}\ p < 0.05,^{***}\ p < 0.01$

Participation in urban labor markets

- Market access could be for export of goods or labor
- Ideally would observe place of work in/out of village
- If arbitraging urban-rural wage gap, should see largest effects where that gap is largest
- Compute district-level urban and rural wages
- Largest reallocation where gap high ($\geq$ \$0.65)

▸ Treatment effect by wage gap ▸ Back

Treatment effect by wage gap



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Data quality

Table 19: Effect of PMGSY road on measures of data quality

	Population	Under 6 Pop.	Phone
Road	-14.233	0.003	-0.006
	(11.015)	(0.005)	(0.048)
Outcome Mean	11.45	-.03023	.09343
N	19612	19612	19606
R2	.1111	.6846	.1795

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Potential growth of in-village nonfarm sector

- Theory predicts movement out of ag when wage effect large relative to ag productivity effect
- Roads likely to affect productivity of nonfarm sector within village
- No evidence that roads cause within village firm growth
  - RD: business ownership and primary income source in SECC
  - OLS: employment in 2005 Economic Census

▸ Figure: nonfarm firms ▸ Table: nonfarm firms ▸ Back

Nonfarm sector and agricultural investment

Table 20: Evidence on mechanism

Panel A. In-village economic activity

	Enterprise Ownership	Enterprise Income	EC05 Emp Share
Road	-0.001	-0.012	0.0004
	(0.0101)	(0.0072)*	(0.0008)
Outcome Mean	0.0101	0.0056	0.4065
N	19612	19612	13281
R2	0.0512	0.0540	0.2795

Panel B. Agricultural investments

	Mech Farm Equip	Irr Equip	Land Ownership
Road	-0.023	-0.038	0.0364
	(0.0147)	(0.0291)	(0.0393)
Outcome Mean	0.0414	0.1388	0.5831
N	19612	19612	19612
R2	0.2225	0.4190	0.3478

Panel C. Returns to participation in urban labor markets

	Wage Gap Low	Wage Gap High
Road	-0.002	-0.235
	(0.0491)	(0.0899)***
Outcome Mean	0.4359	0.4207
N	8948	7894
R2	0.5017	0.3865

$^{*}p < 0.10,^{**}p < 0.05,^{***}p < 0.01$

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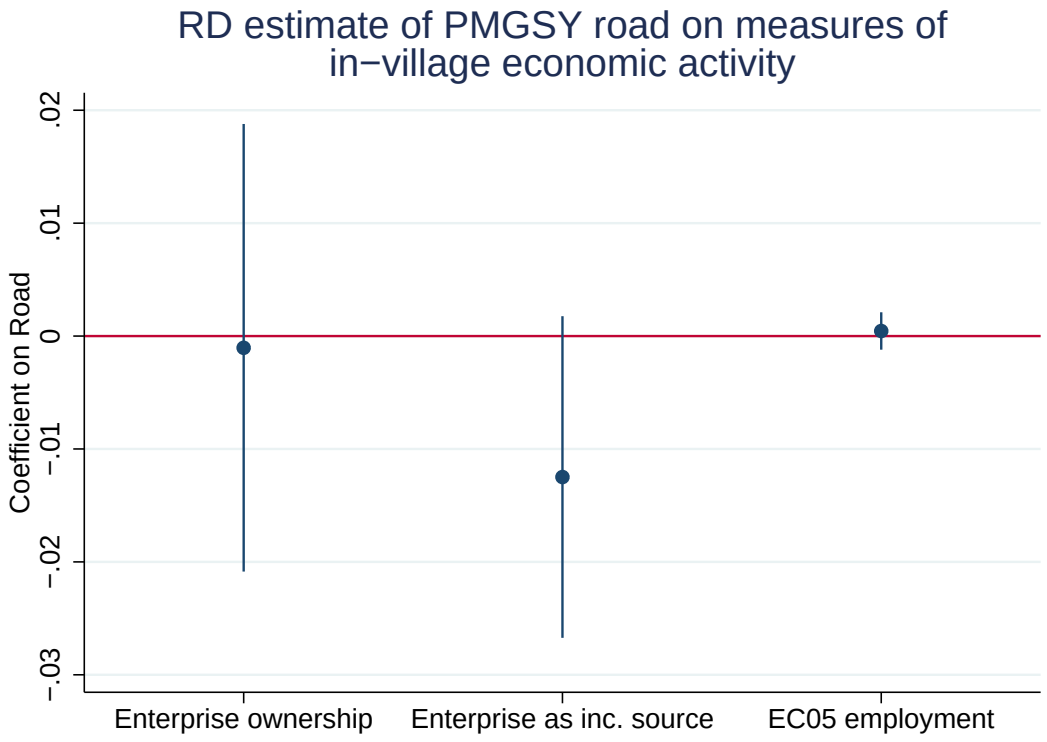
Impact on nonfarm sector



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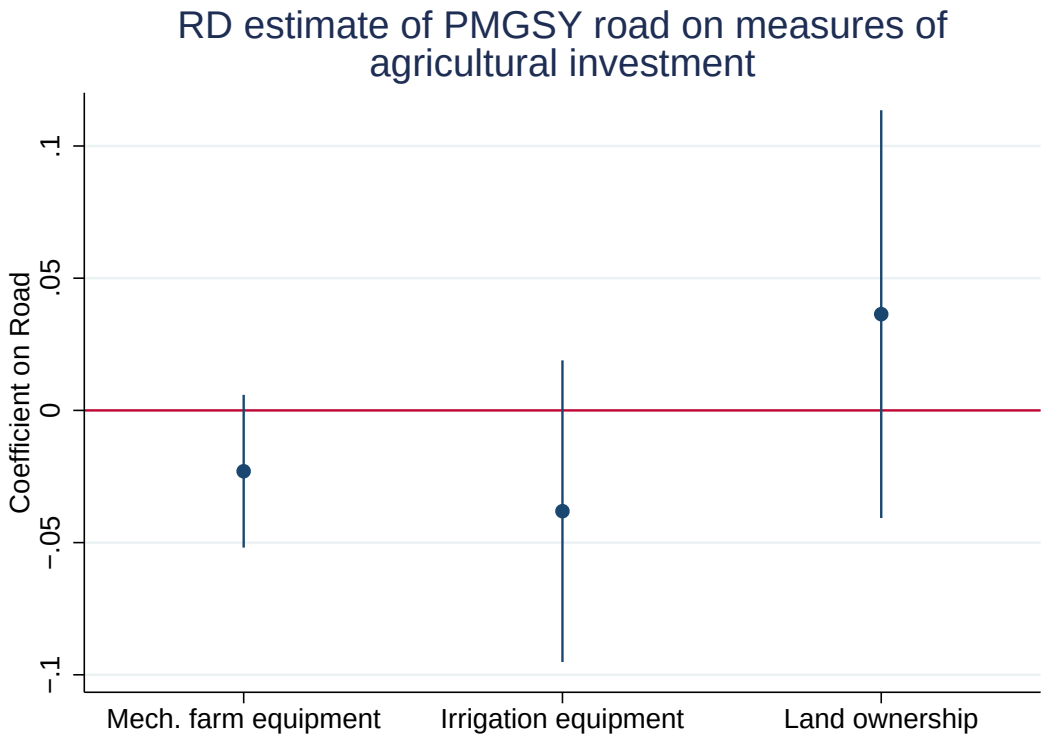
Impact on agricultural investments



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Population growth rate not affected

Table 21: Impact of road annualized population growth (2001-2011)

	Full	Quart 1	Quart 2	Quart 3	Quart 4
Road	0.001	0.004	-0.003	0.002	-0.001
	(0.002)	(0.005)	(0.004)	(0.004)	(0.005)
Outcome Mean	1.018	1.017	1.019	1.019	1.017
N	18570	4582	4644	4672	4672
R2	.2546	.2399	.2938	.3038	.3253

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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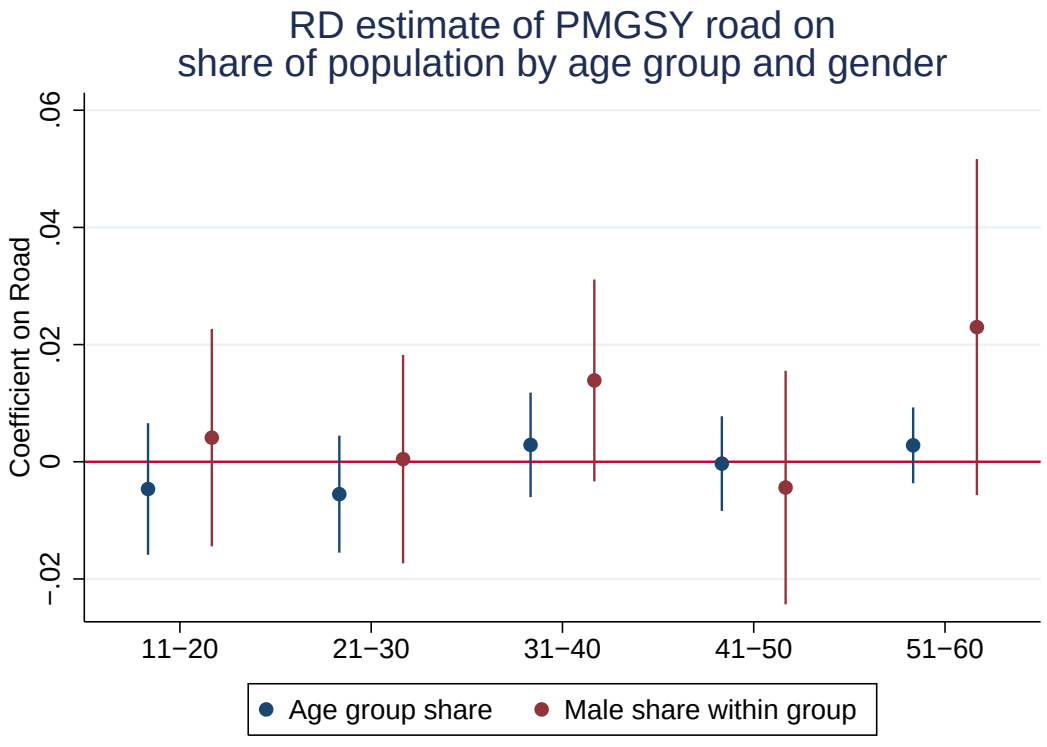
No change to age and gender distribution



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No change to age and gender distribution

Table 22: Impact of road on share of population

Panel A. Age group share

	11-20	21-30	31-40	41-50	51-60
Road	-0.004	-0.005	0.0028	-0.000	0.0028
	(0.0057)	(0.0050)	(0.0045)	(0.0041)	(0.0032)
Outcome Mean	0.2430	0.1879	0.1487	0.1136	0.0718
N	18471	18471	18471	18471	18471
R2	0.3410	0.2183	0.2504	0.3833	0.4017

Panel B. Male share by age group

	11-20	21-30	31-40	41-50	51-60
Road	0.0041	0.0004	0.0138	-0.004	0.0229
	(0.0094)	(0.0090)	(0.0087)	(0.0101)	(0.0146)
Outcome Mean	0.5231	0.5177	0.5094	0.5233	0.5141
N	18471	18471	18468	18469	18467
R2	0.1419	0.1939	0.1056	0.0912	0.0374

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Transport services: buses

- Evidence from Malawi that returns to rural infrastructure investments may be limited by demand (Raballand et al, 2011)
  - Low density and economic activity make transport services unprofitable
- We find increase in bus services to villages, but only in areas closest to cities
- Potentially both supply- and demand-driven

▸ Bus service ▸ Back

Balance of covariates

Table 23: Balance

Variable	Below threshold	Over threshold	Difference of means	t-stat on difference	RD estimate	t-stat on RD estimate
Primary school	0.89	0.84	0.06	4.49	-0.02	-0.28
Medical center	0.29	0.22	0.07	12.49	-0.03	-0.37
Electrified	0.44	0.39	0.04	3.60	-0.03	-0.39
Distance from town	22.18	23.72	-1.53	-5.15	-4.13	-1.06
Land irrigated share	0.41	0.39	0.03	3.80	-0.02	-0.48
Ln land area	4.87	4.63	0.24	6.14	0.21	1.06
Illiterate share	0.53	0.54	-0.01	-1.85	0.00	0.12
Ag emp share	0.79	0.80	-0.01	-2.27	-0.01	-0.33
SC share	0.18	0.18	0.01	3.95	0.04	1.05
N	10170	9442				

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