How Productive is Public Investment? Evidence from Indian Manufacturing

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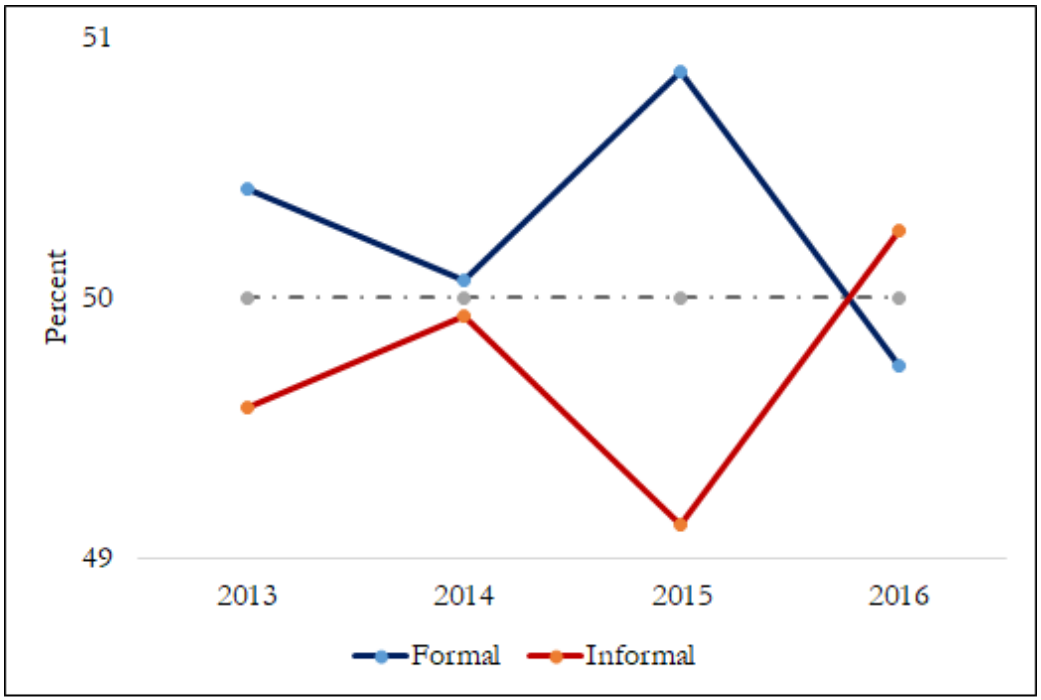
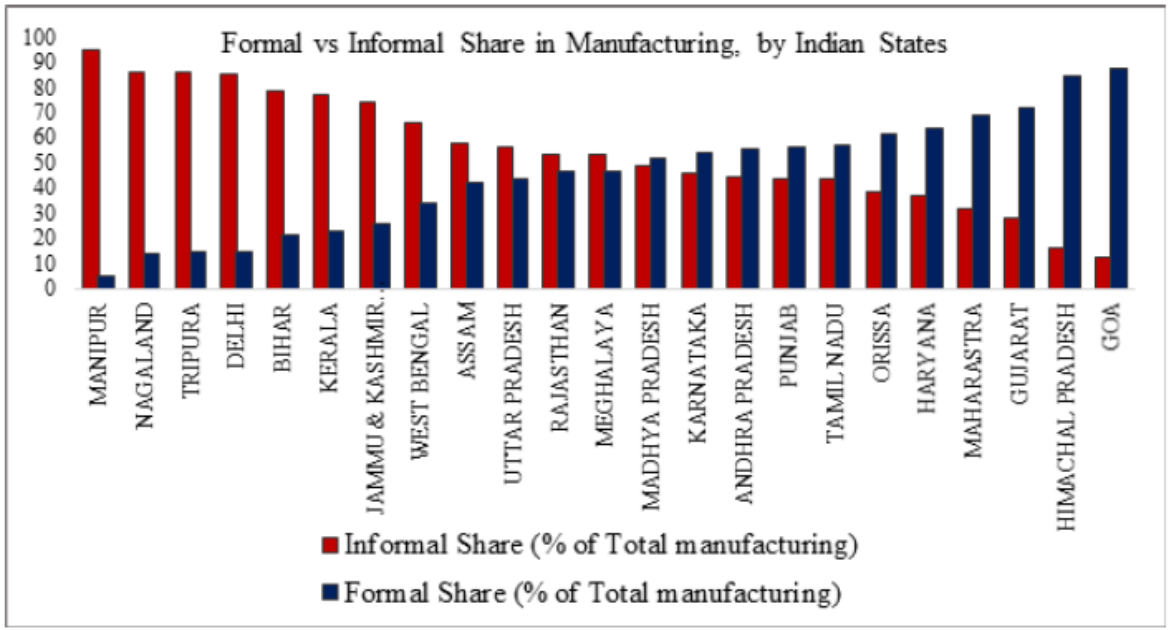
Share of Informal Sector in GDP: India

Figure 1: Share of Informal Sector in GDP (%): India



Share of Formal and Informal Production in Manufacturing: Indian States

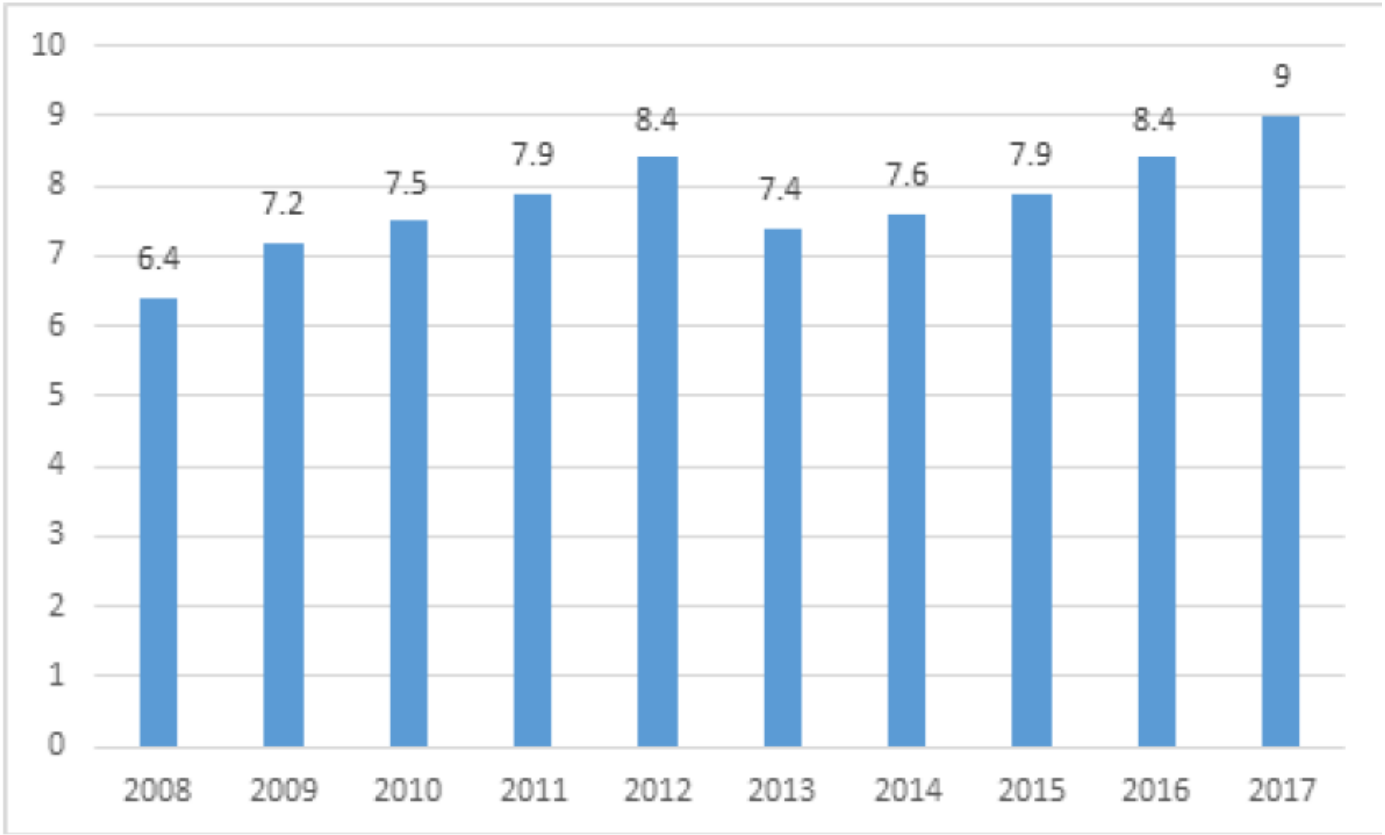
Figure 2: Share of Formal and Informal Production in Manufacturing (%): Indian States



Source: ASI, NSSO

Public Investment in India

Figure 3: Share of infrastructure spending in GDP (%), 2008-2017



Research Question

- Importance of public investment for firm-level productivity in an emerging market

$$Y_t = A_t L_t^{\alpha} K_t^{\beta} G_t^{\gamma}$$

  - Need to account for both formal and informal production
- Two large firm-level datasets on formal and informal production in India's manufacturing sector
  - **Output elasticity** of public investment for formal and informal sector firms
  - **Natural experiment:** The National Highway Development Program (NHDP) in India
    - ★ Access to public goods and sectoral differences in firm-level productivity
    - ★ Sectoral variation in effects of public investment across size and age distribution of firms

Data: Firms

- **Formal Sector:** The 2009 Annual Survey of Industries (ASI)
  - nationally representative sample of firms registered under the 1948 Factories Act
  - repeated cross section
  - firm-level information on location, inputs, outputs, ownership structure, etc.
  - 57, 114 firms, with 93.7% in manufacturing.

Data: Firms

- **Informal Sector:** The 2009 Survey of Unincorporated Non-agricultural enterprises (NSSO)
  - conducted every 10 years
  - similar firm-level information as the formal sector (ASI)
  - 334,474 firms with 36% in manufacturing
- We restrict coverage to only **manufacturing** firms in both sectors
  - This gives us a sample of 30, 533 formal-sector firms and 82, 748 informal-sector firms in 2009

Data: Public Investment

- **Public Investment:** State Finances Database of the Reserve Bank of India
  - Economic Services: transport, communications, energy (state-level)
  - Social Services: health, education, water and sanitation, welfare programs (state-level)
  - Total Development Expenditures = Economic Services + Social Services
  - We use the average investment between 2006 - 2010 as our flow measure
  - Additionally we construct a stock measure using the perpetual inventory method

Data: Public Investment

- **The National Highway Development Program (NHDP)**
  - The Golden Quadrilateral (GQ) and the North-South East-West (NS-EW) corridor projects
- National Highway Authority of India
  - Start and Stop location of a completed section, highway number, length, cost and start/completion date
- World Bank Urban Development Unit
  - Geospatial data to identify coordinates of the highways
- DIVA-GIS
  - Geospatial data to identify Indian district boundaries

Benchmark Specification

- We estimate a Cobb-Douglas Production function

$$Y_t = A_{is} L_{is}^{\alpha} K_{is}^{\beta}, \;\; A_{is} = \varepsilon_{is} G_s^{\gamma}$$

- Empirical specification

$$ln\, GV\, A_{is} = \alpha\, ln\, L_{is} + \beta\, ln\, K_{is} + \boldsymbol{\gamma}\, ln\, G_s + \theta X_{is} + \rho Z_s + \varepsilon_{is}$$

- X: vector of firm-level characteristics
- Z :vector of state-level variables other than public investment
- Estimated with both flow and stock measures of public investment
- Parameter of interest is γ : output elasticity of public investment/capital

Econometric Issues

- Capital and labor may be endogenous to the firm's choices
  - Levinsohn and Petrin (2003) and Sivadasan (2009) propose methods to control for endogeneity of **capital**
  - Ackerberg, Caves, and Frazer (2015) controls for endogeneity of both **labor and capital (ACF)**
- Reverse causality between firm-level output and public investment
  - Natural experiment: GQ/NS-EW corridor project between 2001-2009

Benchmark Specification: Formal Sector

Table 1: Benchmark Specification: Forrmal Sector

Sector: **Formal**	Public Investment (Flow)		Public Investment (Stock)	
Dep variable: *ln*GVA	OLS	ACF	OLS	ACF
ln *L*	0.791***	0.796***	0.790***	0.796***
	(0.021)	(0.017)	(0.022)	(0.016)
ln *K*	0.334***	0.331***	0.334***	0.332***
	(0.016)	(0.012)	(0.016)	(0.012)
lnPub Exp. per capita	0.023	0.079**	0.12**	0.171**
	(0.037)	(0.031)	(0.048)	(0.038)
lnSocial serv exp per capita	−0.006	0.032	0.005	0.031
	(0.036)	(0.028)	(0.034)	(0.026)
lnEcon serv exp per capita	0.019	0.068**	0.115**	0.156**
	(0.032)	(0.028)	(0.044)	(0.037)
N	30.533	30, 533	30, 533	30, 533

*$p < 0.05$,**$p < 0.01$,***$p < 0.001$. Bootstrap (1000 replications) standard errors (in parentheses) are clustered at the state NIC-3 digit level. Regressions include firm and state controls, and industry dummies.

Benchmark Specification: Informal Sector

Table 2: Benchmark Specification: Informal Sector

Sector: **Informal**	Public Investment (Flow)		Public Investment (Stock)	
Dep variable: *ln*GVA	OLS	ACF	OLS	ACF
ln *L*	0.820^{***}	0.866^{***}	0.820^{***}	0.866^{***}
	(0.017)	(0.025)	(0.018)	(0.025)
ln *K*	0.252^{***}	0.281^{***}	0.252^{***}	0.282^{***}
	(0.007)	(0.008)	(0.008)	(0.008)
lnPub Exp. per capita	−0.002	0.028	−0.020	0.024
	(0.027)	(0.031)	(0.052)	(0.044)
lnSocial serv exp per capita	−0.048	−0.022	−0.033	−0.011
	(0.028)	(0.030)	(0.030)	(0.030)
lnEcon serv exp per capita	0.009	0.039	−0.012	0.035
	(0.027)	(0.031)	(0.042)	(0.046)
N	82,748	82,748	82,748	82,748

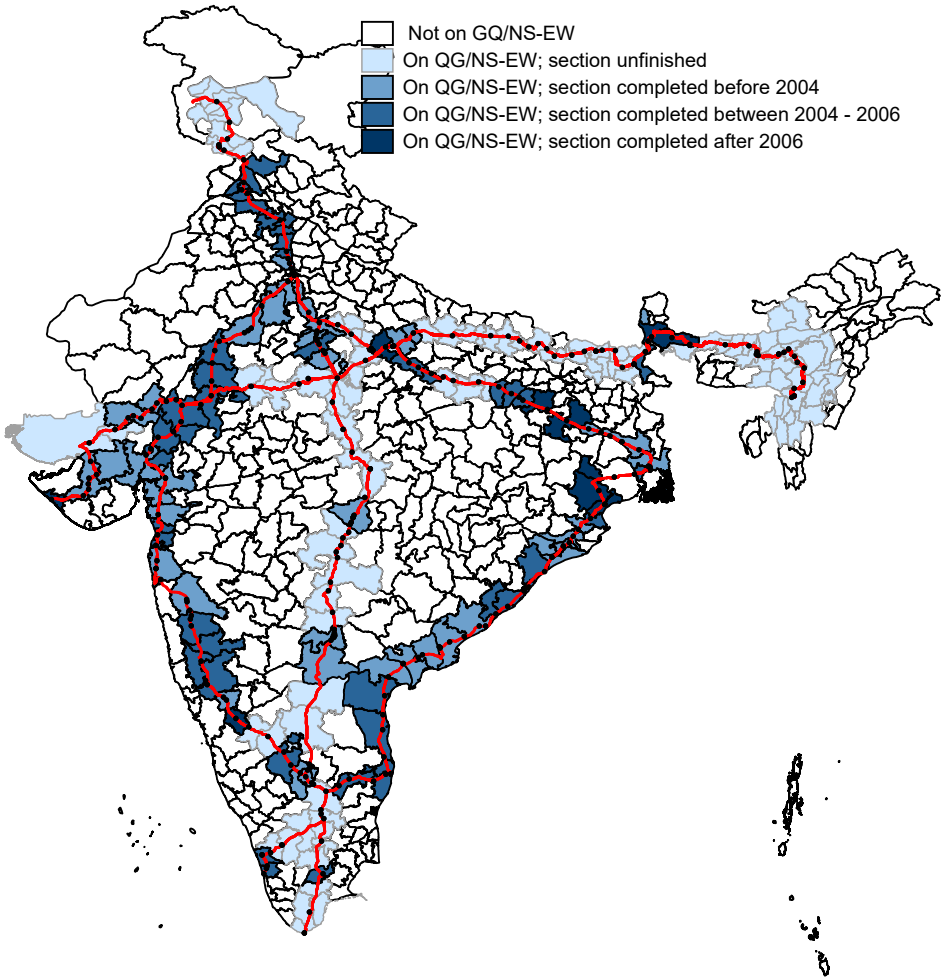
$^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$. Bootstrap (1000 replications) standard errors (in parentheses) are clustered at the state NIC-3 digit level. Regressions include firm and state controls, and industry dummies.

Public Investment as an Input: Limitations

- Endogeneity of public investment
- Time-to-build aspect of infrastructure spending
- Use of state-level government spending data may not be appropriate for firm-level analysis

The National Highway Development Program (NHDP)

Figure 4: Map of GQ and NS-EW Corridor



Empirical Specification

$$ln\left(GVA_{id}\right) = \alpha\, ln\left(L_{id}\right) + \beta\, ln\left(K_{id}\right) + \gamma_1 GQ_{id} + \boldsymbol{\gamma_2} GQ_{id} * Compl_{id} + \theta\, X_{id} + \rho Z_d + \delta_s + \varepsilon_{id}$$

- $GQ = 1$ if firm is located in a GQ/NS-EW district
- $Compl$: number of years a section of GQ/NS-EW has been completed prior to 2009
  - $max[0, 2009 completion\ year]$
- Specifications distinguish between firms (i) on the GQ/NS-EW, (ii) within 30 miles of GQ/NS-EW, and (iii) between 30-50 miles of GQ/NS-E

Results: Formal Sector

Table 3: Formal Sector

	Formal Sector			
Dep variable: lnGVA	Benchmark		No Nodal	
I(onGQ)	0.10***	0.13***	0.09**	0.12***
	(0.04)	(0.05)	(0.04)	(0.04)
I(0<dist<30)		-0.06		-0.01
		(0.07)		(0.07)
I(30<dist<50)		-0.06		-0.06
		(0.08)		(0.08)
I(on GQ) X Compl	-0.01	-0.01	-0.01	-0.002
	(0.01)	(0.01)	(0.01)	(0.005)
I(0<dist<30) X Compl		0.04***		0.02***
		(0.01)		(0.01)
I(30<dist<50) X Compl		0.03**		0.03**
		(0.01)		(0.01)
N	29923	29923	28766	28766

Results: Informal Sector

Table 4: Informal Sector

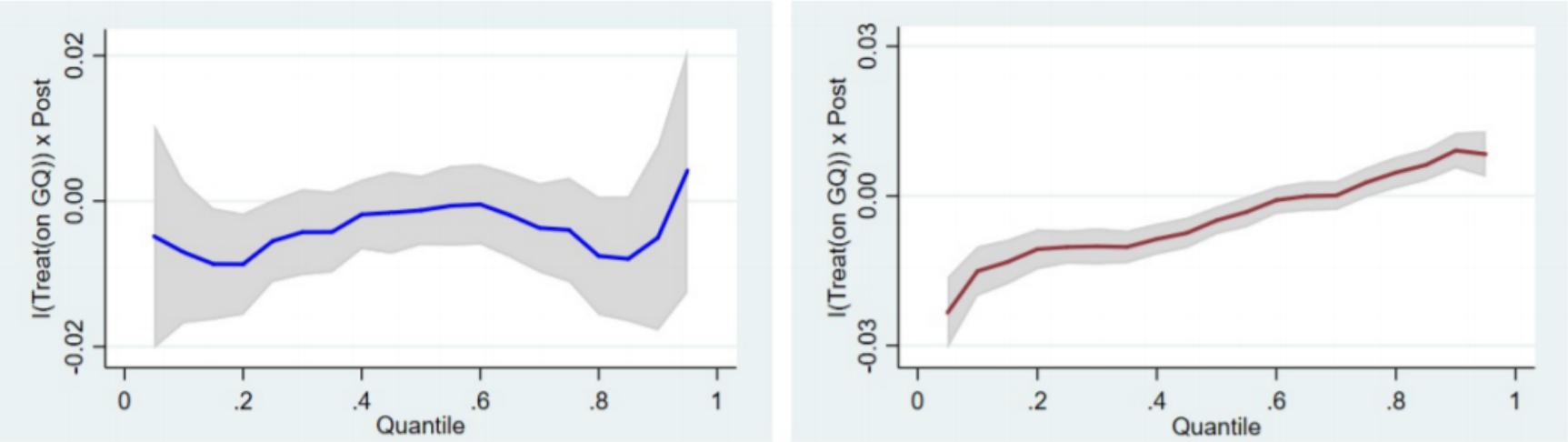
	Informal Sector			
Dep variable: lnGVA	Benchmark		No Nodal	
I(onGQ)	-0.02	-0.02	-0.003	0.002
	(0.02)	(0.03)	(0.02)	(0.03)
I(0<dist<30)		-0.05		-0.01
		(0.04)		(0.04)
I(30<dist<50)		-0.04*		-0.03
		(0.02)		(0.02)
I(on GQ) X Compl	-0.01	-0.004	-0.01*	-0.005
	(0.004)	(0.004)	(0.003)	(0.003)
I(0<dist<30) X Compl		0.014*		0.01*
		(0.008)		(0.007)
I(30<dist<50) X Compl		0.01**		0.01***
		(0.005)		(0.004)
N	85660	85660	80985	80985

Potential Problems

- Were firms along the GQ/NS-EW corridor significantly different from firms that were not on the corridor in 1999 (pre-construction)? NO
- Were the highway upgrades allocated randomly? YES
- Self-selection
  - Did firms choose to locate or move to areas close to the GQ/NS-EW, especially "younger" firms? NO
- Robustness checks suggest none of the above were issues for our results

Distributional Effects: Formal vs. Informal Firms

Figure 5: Distributional Effects: Formal vs. Informal Firms

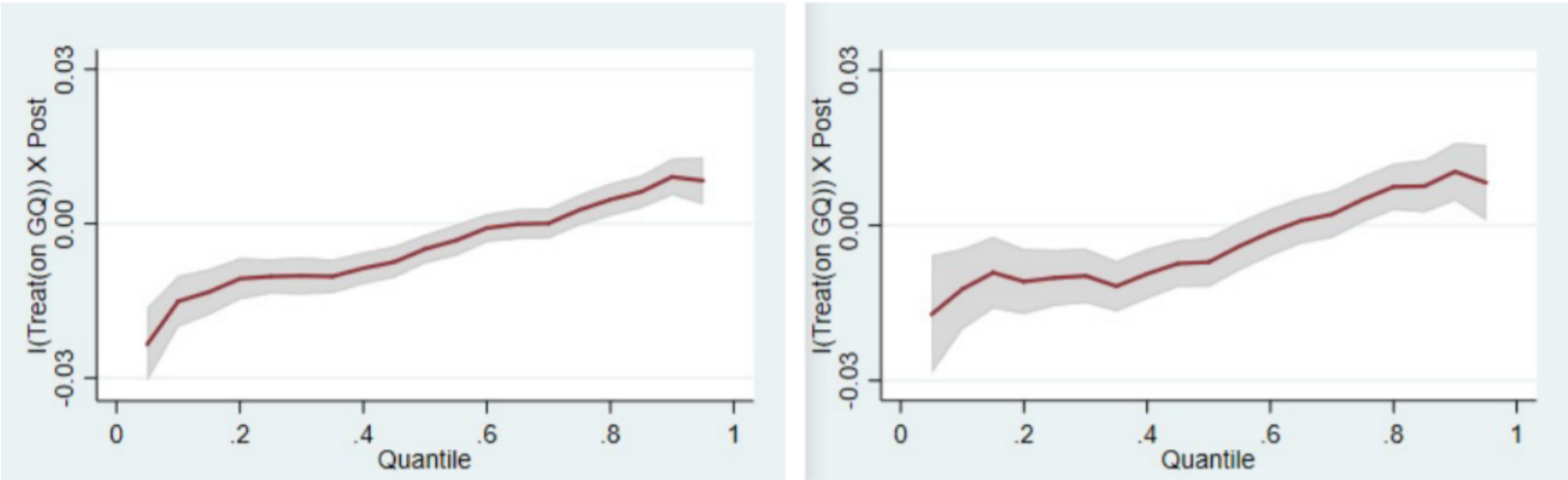


Blue: The effect on GVA of formal sector firms from being an additional year on a completed section of the GQ/NS-EW corridor

Red: The effect on GVA of informal sector firms from being an additional year on a completed section of the GQ/NS-EW corridor

Distributional Effects for Start-up Informal Firms

Figure 6: Distributional Effects for Start-up Informal Firms



Left panel: The effect on GVA of informal sector firms from being an additional year on a completed section of the GQ/NS-EW corridor

Right panel: The effect on GVA of informal sector firms with sample excluding firms founded after the announcement of NHDP in 2000

Crowding Out

- Complementarity between public investment and firm size
  - do large firms crowd out small informal sector firms?
- Intuition:
  - production of smaller informal firms more likely to be crowded out in districts that host more large, capital intensive firms
  - highway completion should have a more negative effect on small informal firms in districts with many large firms

Crowding Out

	Large Informal Firms		Large Formal Firms	
	25th p-tile	50th p-tile	25th p-tile	50th p-tile
I (on GQ)	0.00	-0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
I (# of large firms > mean)	0.25***	0.21***	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
I (on GQ) X Compl	-0.01***	-0.01***	-0.01***	-0.01***
	(0.003)	(0.002)	(0.002)	(0.002)
I (# of large firms > mean) X Compl	-0.01***	-0.02***	-0.01***	0.001
	(0.003)	(0.002)	(0.003)	(0.002)
N	85660	85660	85660	85660

Conclusions

- Relationship between public investment and firm productivity for formal and informal manufacturing firms in India
  - estimation of sectoral firm-level production functions with a public input
  - natural experiment using a major highway construction project
- **Formal Sector**
  - public investment increases firm output; elasticity measure in the range of 0.08 0.17
  - effect uniform across size distribution of firms
- **Informal Sector**
  - on average, no systematic effect of public investment on firm output
  - large firms (both formal and informal) crowd out small informal firms
- Results not driven by self-selection or age distribution of firms
- Crowding out of small informal firms: mechanism to reduce the relative size of the informal sector?
  - labor market implications

Thank You