Trade Costs and Regional Productivity in Indian Manufacturing

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Overview

- Motivation for spatial and firm heterogeneity in responses to trade cost changes
- Theoretical basis from the heterogeneous-firms model and new economic geography
- Empirical strategy relying on spatial econometrics and a time-variant measure of trade costs
- Results from Indian manufacturing and their implications

Modeling Heterogeneous Firms

- Melitz (*Econometrica 2003*)
  - Monopolistic competition model with an asymmetric equilibrium (Krugman's model is a special case)
  - Introduces uncertainty on productivity prior to firm entry, subject to a fixed entry cost; plus a constant fraction of firms is subject to a "death" shock every period
  - Equilibrium (price, quantity, revenue and profit) is summarized by the industry's average productivity level, which depends on cut-off productivity
  - Trade liberalization increases average productivity and changes the number of available varieties
  - Higher average productivity implies higher welfare (holding variety gains constant)

Modeling Heterogeneous Firms (continued)

- Melitz and Ottaviano (*RES 2008*)
  - Endogenous mark-up (non-CES utility function) and regional differences in market size
- Bernard et al. (*AER 2003*), Chaney (*AER 2008*), Baldwin and Okubo (*JoEG* 2006), Saito, Gopinath and Wu (*CJE 2011*)…
- Empirical applications
  - Helpman, Melitz and Yeaple (*AER 2004*) extend the model to include FDI; Helpman, Melitz and Rubinstein (*QJE 2008*) identify heterogeneity and selection biases using aggregate data; Syverson (*JPE 2004*); Saito and Gopinath (*JoEG 2009*)

Implications for Spatial/Firm Heterogeneity

- Industry: Moving from autarky to openness has asymmetric effects on firms within an industry (Melitz 2003)
  - Low-productivity firms exit (enter)
  - Market share/resources reallocated to high-productivity firms
- Spatial: Large markets additionally discipline firms via competition (Melitz and Ottaviano 2008)
  - Productivity distribution is truncated from below
  - Again, trade liberalization improves average industry productivity (mark-up/self-selection/sorting issues)

Focus on Average Industry Productivity

- We focus only on gains in average industry productivity and changes in cut-off productivity

- Abstain from quantifying the variety gains from trade
  - Feenstra (*2008 CJE*) and Broda and Weinstein (*QJE 2006*) are good examples for measuring variety-based welfare gains

Equilibrium Distribution of Productivity

- For region *r*, industry *k* and time *t*:

$$\mu_{krt}(\omega) = g_{krt}(\omega|\omega \geq \omega^*_{krt}) = \frac{g_{krt}(\omega)}{Prob(\omega \geq \omega^*_{krt})}$$

  the equilibrium productivity distribution is truncated from below.

  – The truncation point, ω^*_{krt}, is determined by the zero cut-off profit and free entry conditions

- Truncation increases with domestic and international competition (lower variable trade costs).

  – Factor market explanation, e.g. increases in wages forces least productive firms to exit since mark-up is constant (Melitz 2003)

  – Product and factor market reasons (Melitz and Ottaviano 2008)

Specifying Cut-off and Average Productivity

- Cut-off Productivity (left-tail of the distribution)

$$\omega^*_{krt} = \omega^*(\text{trade costs}, \text{market size}, \text{controls})$$

  - Inverse of equation (23) in Melitz and Ottaviano (*RES 2008*)
  - International and domestic (variable) trade costs

- Average Productivity

$$\bar{\omega} = \bar{\omega}(\omega^*(\text{trade costs}, \text{market size}, \text{controls}), \text{controls})$$

- How about high-productivity firms (right-tail of the distribution)?

Empirical Strategy

- Objective here is to first identify regional productivity and attribute it to pure technical change (raw productivity) and agglomeration effects.
- Then, investigate the role of international competition and domestic infrastructure, i.e. changes in variable trade costs, on regional raw productivity distribution (mean, median, left- and right-tail).
- Resource reallocation following changes in trade costs (future work).

Indian Manufacturing

- Significant trade reforms in 1991. Selected industries.
- Traditional (comparative) advantage in low-tech, e.g. textiles
- Emerging advantages in electronics, pharmaceutical and transport industries
- Significant investments in infrastructure, especially since 2000.
- Significant spatial variations in income (per capita net domestic product ranges between $217 and $1932 among Indian states in 2006)

Industry Productivity Estimation

- Firm-level production function:

$$y_{it} = \beta_0 + \beta_u U_{it} + \beta_s W'_{it} y + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_e e_{it} + \omega_{it} + \varepsilon_{it}$$

- Two important differences from Levinsohn and Petrin's (2003) approach:
  - U_{it} and W_{it} respectively denote urbanization economies and spatial spillovers (firm-specific)
  - W is a spatial weighting matrix commonly used in a spatial lag model

Estimation Issues

- Covariance between the spatial lag and error term
  - In a spatial lag model, $\beta_s \neq 0$ implies that shocks to one region's output spills over to other regions and hence, are correlated with the spatial lag of output
- Covariance between productivity and conventional input levels (labor, capital) is non-zero – the usual suspect
- Covariance between agglomeration variables and productivity (self-selection)

Production Function Data

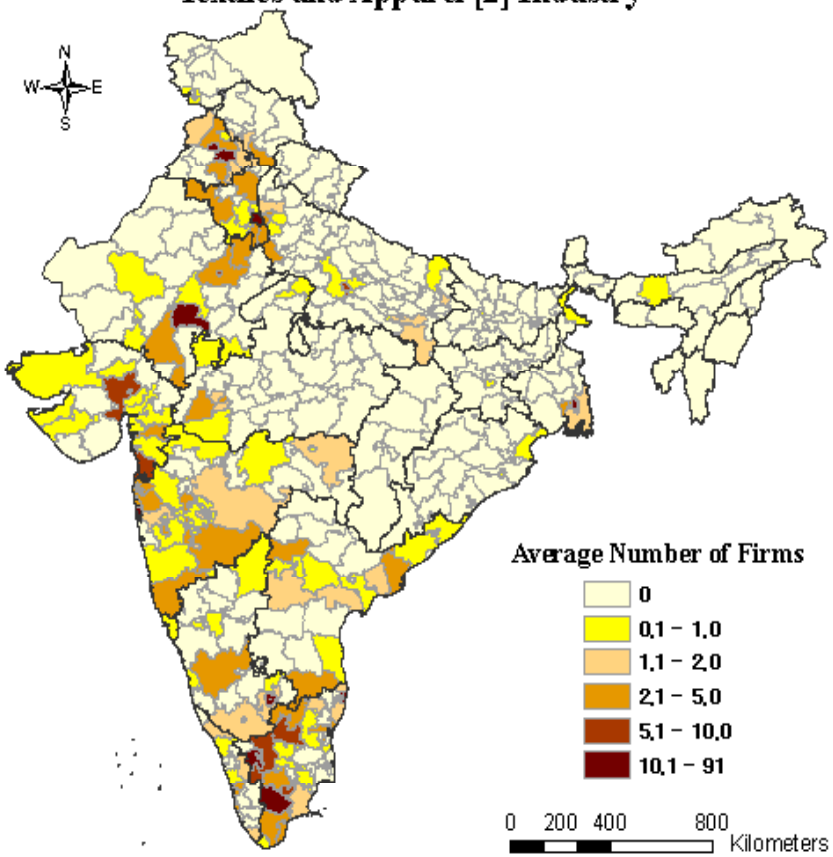
- Centre for Monitoring Indian Economy (CMIE)
  - Sample period: 1994-2007; 8,472 firms
  - Value of output and inputs available; appropriate deflators (in related literature) are used to identify quantities or constant rupee estimates: IV estimates for U_{it} and W_{it}y
  - Location information has recently been included (2007-2008)
  - Urbanization economies is represented by output of all firms (manufacturing and services) within a three-digit postal code area of a firm's location
  - Spatial lag is given by output of firms in the same industry within a 50 km radius

Industry Definitions

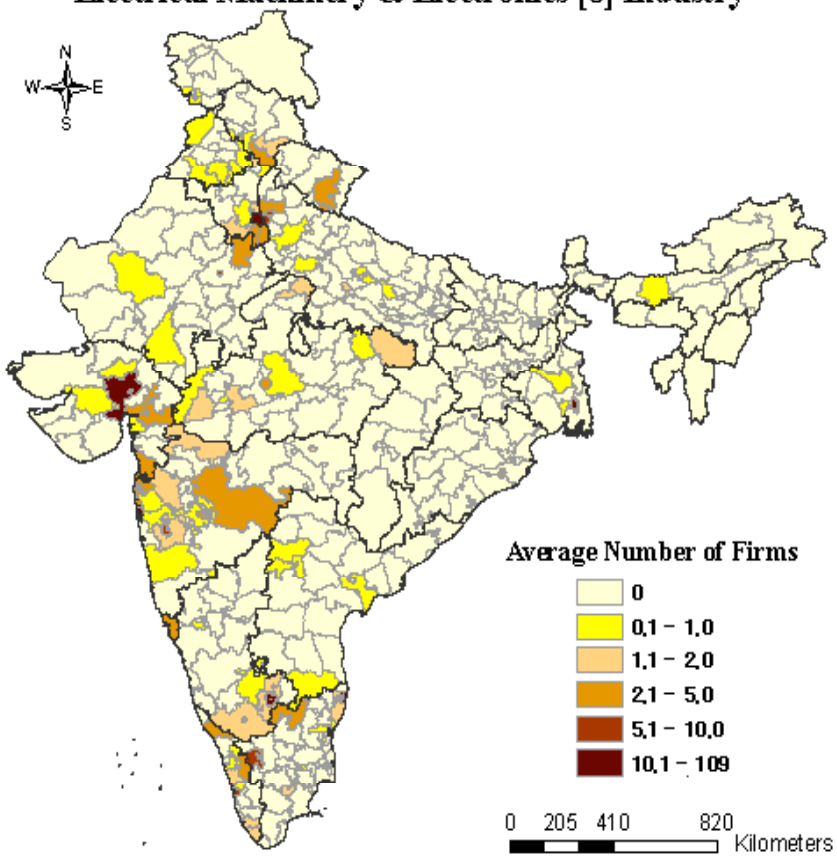
- 1 Food
- 2 Textiles & Apparel
- 3 Wood, Paper & Printing
- 4 Chemicals & Rubber
- 5 Fuels & Mineral
- 6 Metals
- 7 Machinery
- 8 Electricals & Electronics
- 9 Transport Vehicles & Equipment

(22 two-digit NIC industries regrouped into the above 9 industries)

Average Number of Firms (1994-2007)
Textiles and Apparel [2] Industry



Average Number of Firms (1994-2007)
Electrical Machinery & Electronics [8] Industry



Firm-Level Production Function Estimation Results: Dependent Variable is *ln(y)*

Industry	*Wln(y)*	*ue*	*ln(k)*	*ln(m)*	*ln(l)*	*ln(e)*	RTS	Obs.
1	0.077	0.0003[a]	0.157	0.687	0.195	0.065	1.104	8,180
	(0.020)	(0.003)	(0.041)	(0.008)	(0.005)	(0.004)	(0.013)	
2	0.060	0.002	0.138	0.717	0.122	0.068	1.045	8,559
	(0.008)	(0.001)	(0.009)	(0.010)	(0.004)	(0.004)	(0.009)	
3	0.037	0.003	0.061	0.728	0.169	0.073	1.031[c]	2,997
	(0.013)	(0.001)	(0.015)	(0.026)	(0.009)	(0.006)	(0.022)	
4	0.056	0.001[a]	0.129	0.703	0.168	0.077	1.077	16,672
	(0.018)	(0.001)	(0.020)	(0.009)	(0.003)	(0.003)	(0.010)	
5	0.034	0.002[a]	0.122	0.711	0.151	0.120	1.105	3,165
	(0.010)	(0.003)	(0.026)	(0.019)	(0.009)	(0.008)	(0.019)	
6	0.045	0.002[b]	0.082	0.759	0.124	0.086	1.051	7,799
	(0.008)	(0.001)	(0.008)	(0.007)	(0.007)	(0.005)	(0.009)	
7	0.021[b]	0.004	0.103	0.725	0.173	0.050	1.051	4,320
	(0.009)	(0.001)	(0.012)	(0.009)	(0.015)	(0.006)	(0.019)	
8	0.036	0.001[a]	0.100	0.779	0.127	0.055	1.062	6,403
	(0.020)	(0.001)	(0.021)	(0.016)	(0.009)	(0.006)	(0.016)	
9	0.051	0.0004[a]	0.153	0.699	0.152	0.074	1.078	3,858
	(0.010)	(0.001)	(0.027)	(0.014)	(0.008)	(0.005)	(0.015)	

Note: Value in parenthesis is the bootstrapped standard error based on 200 iterations. All estimates are statistically significant at 1% level except (a) and (b) indicating statistically insignificance at 10% level, and significance at 5% level, respectively.

Estimated Raw TFP and Agglomeration Effects (AE), 1994-2007 average

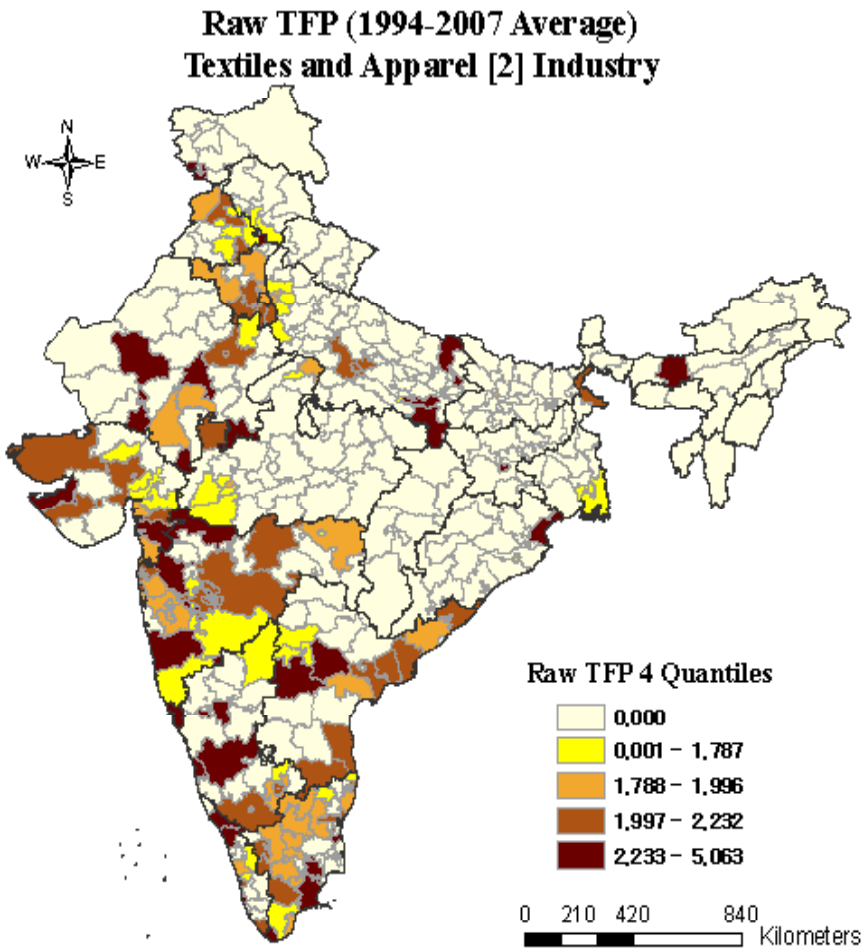
	Raw TFP		AE		Overall TFP		Annual Growth Rate		
Industry	Mean	S.D.	Mean	S.D.	Mean	S.D.	RTFP	AE	OTFP
1	2.198	1.069	1.270	0.122	3.469	1.041	0.58	0.10	0.40
2	1.980	0.863	1.214	0.075	3.194	0.852	1.07	0.02	0.68
3	2.415	0.766	1.149	0.102	3.564	0.748	0.10	0.26	0.15
4	2.127	0.866	1.212	0.075	3.338	0.852	-0.08	0.04	-0.04
5	2.257	0.925	1.129	0.081	3.386	0.918	0.36	0.23	0.32
6	2.120	0.763	1.181	0.070	3.301	0.751	0.47	0.13	0.35
7	2.279	0.712	1.124	0.090	3.403	0.698	-0.18	0.23	-0.05
8	2.136	0.836	1.136	0.055	3.273	0.828	0.09	0.16	0.12
9	2.186	0.777	1.213	0.073	3.399	0.769	0.22	0.24	0.23
Total	2.151	0.867	1.194	0.094	3.345	0.852	0.29	0.11	0.23

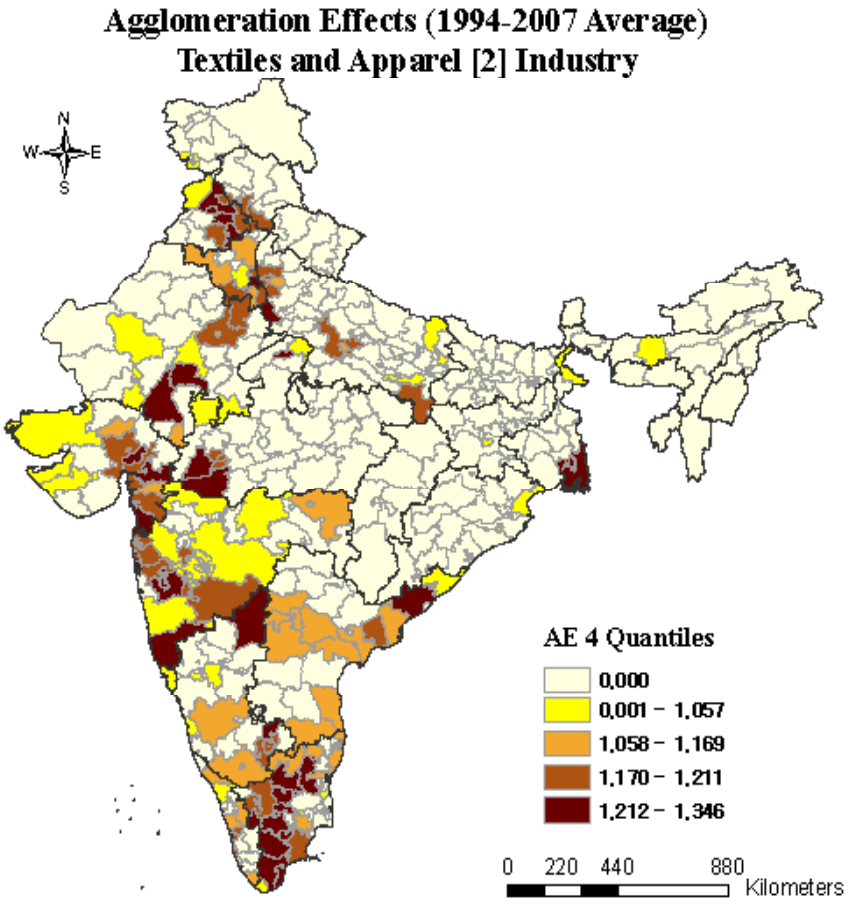
Industry Definitions: 1 Food; 2 Textiles & Apparel; 3 Wood, Paper & Printing; 4 Chemicals & Rubber; 5 Fuels & Mineral; 6 Metals; 7 Machinery; 8 Electricals & Electronics; 9 Transport Vehicles & Equipment

Now, What is a Region?

- Each state is considered to be a region:
  - District level policy making is very limited
  - Most observed policy differences are at the state level
  - Data limitations: some of the infrastructure and natural endowments/amenities are not available on a time series basis at the district (or three-digit postal code) level

Textile Industry





Regional Raw Productivity Distribution

- For a given industry (*k*), mean, median and alternative percentiles of each region's (*r*) raw productivity at time *t* is specified as:

$$\Omega_{krt}^{p} = \delta_0^p + \delta_1^p Trade_{kt} + \delta_2^p Infra_{rt} + d_k^p + d_r^p + d_t^p + v_{krt},$$

$$p = 10\%, 50\%, 90\%.$$

  - Trade: international trade costs, Infra: Infrastructure (domestic trade costs)
  - Choose 10% and 90% to avoid outliers (Syverson 2004)
  - Some regions do not have enough firms (> 5) to derive distribution measures. So, the dependent variable can take zero values: tobit model

Trade Costs

- A number of problems with tariff data (bound versus applied, time variation, non-tariff measures)
- We use a recent approach to measuring trade costs along the lines of Novy (2008), originally due to Anderson and van Wincoop (2003) and Head and Ries (2001).
  - Accounts for both trade policy and geographic barriers (international transport costs)
  - Measures trade costs as frictions in a gravity framework

Trade Costs, Continued…

$$\tau_{cI}^{k} = \left(\frac{t_{Ic}^{k} t_{cI}^{k}}{t_{II}^{k} t_{cc}^{k}}\right)^{\frac{1}{2}} - 1 = \left(\frac{X_{II}^{k} X_{cc}^{k}}{X_{Ic}^{k} X_{cI}^{k}}\right)^{\frac{1}{2(\sigma_k - 1)}} - 1$$

- X_{Ic}^{k}, X_{cI}^{k} trade flow in both directions
- X_{II}^{k}, X_{cc}^{k} intra-country trade
- t_{cI}^{k} is the trade costs factor (one plus tariff equivalent) incurred form country *c* to India
- $\sigma_k > 1$ industry-specific elasticity of substitution (estimated)

- Infrastructure is road length (surfaced and unsurfaced) divided by the total area of the state, i.e. road density (km/km-square)

Industry-Specific Trade Costs

	Industry								
Year	1	2	3	4	5	6	7	8	9
1993	15.05	1.18	4.99	3.58	14.82	3.05	1.32	1.21	7.07
1994	12.86	1.09	4.82	3.30	14.28	2.89	1.22	1.19	7.72
1995	12.13	1.12	4.47	3.34	14.32	2.88	1.21	1.09	9.21
1996	10.62	1.10	4.33	3.28	14.28	2.75	1.18	1.06	8.21
1997	12.02	1.14	4.12	3.21	13.62	2.83	1.10	1.06	8.97
1998	9.98	1.15	4.33	3.25	11.85	2.81	1.10	1.12	8.72
1999	9.15	1.15	4.46	3.24	10.85	2.76	1.17	1.13	9.74
2000	10.21	1.09	4.30	3.27	12.37	2.64	1.12	1.06	9.67
2001	10.62	1.04	4.21	3.11	13.76	2.62	1.08	1.03	7.89
2002	9.10	1.01	3.92	3.03	12.70	2.68	1.04	0.99	8.34
2003	8.58	0.96	3.76	2.95	11.29	2.70	0.99	0.97	7.10
2004	8.93	1.02	3.70	2.87	11.93	2.58	0.97	0.97	6.99
2005	9.09	0.87	3.48	2.54	10.66	2.55	0.90	0.80	6.42
2006	9.29	0.87	3.60	2.43	8.46	2.44	0.85	0.77	5.92
AG(TC)	-3.64	-2.32	-2.48	-2.93	-4.22	-1.69	-3.33	-3.45	-1.36
AG(FT)	3.78	2.38	2.55	3.02	4.40	1.71	3.45	3.57	1.38
ES	3.57	7.42	4.85	4.58	2.99	5.45	8.06	8.69	3.94

Notes: AG (TC) and AG (FT) are average annual growth rate of trade costs and freeness of trade, respectively. ES is the estimate of elasticity of substitution for each industry.

Industry Definitions: 1 Food; 2 Textiles & Apparel; 3 Wood, Paper & Printing; 4 Chemicals & Rubber; 5 Fuels & Mineral; 6 Metals; 7 Machinery; 8 Electricals & Electronics; 9 Transport Vehicles & Equipment.

Estimation Results of Tobit
(Dependent Variable: Mean and Alternative Percentiles of Productivity Distribution)

	Percentiles		
	10th	50th	90th
FT	0.281 *	-0.232	1.312 ***
	(0.151)	(0.233)	(0.462)
IN	0.201 ***	0.193 ***	0.772 ***
	(0.030)	(0.036)	(0.072)
SIN	0.167 *	0.124	1.229 ***
	(0.096)	(0.115)	(0.233)
FTIN	-0.009	-0.017 **	0.0005
	(0.007)	(0.009)	(0.018)
FTSIN	0.135	0.726 ***	-0.564 *
	(0.150)	(0.182)	(0.364)
INSIN	-0.067 **	-0.015	-0.216 ***
	(0.027)	(0.033)	(0.066)
HHI	-1.529 **	-1.911 *	-1.042
	(0.673)	(1.261)	(2.556)
Pop. Share	0.398 *	0.902 ***	3.220 ***
	(0.249)	(0.301)	(0.603)
Pseudo R2	0.264	0.307	0.164
Log-Likelihood	-1419	-1641	-2874
Obs.	2268	2268	2268
Censored Obs.	552	652	552
L.B.	0.787	1.1	1.45
F(6, 2247)	15.56	23.21	41.69
F(8, 2247)	28.79	12.32	14.75

Standard errors are in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% level, respectively.
FT: Freeness of trade; Infra: Infrastructure; HHI: Herfindahl- Hirschman Index; Pop. Share: Population Density.

Elasticities from the Tobit Model on Regional Productivity Distribution

	Percentiles		
	10th	50th	90th
FT Elasticity	0.109 ***	0.017	0.164 ***
	(0.041)	(0.053)	(0.062)
IN Elasticity	0.177 ***	0.150 ***	0.333 ***
	(0.025)	(0.023)	(0.027)
SIN Elasticity	0.043 **	0.111 ***	0.099 ***
	(0.021)	(0.020)	(0.023)

Estimation Results and Elasticities from the CLAD Model of Regional Productivity Distribution

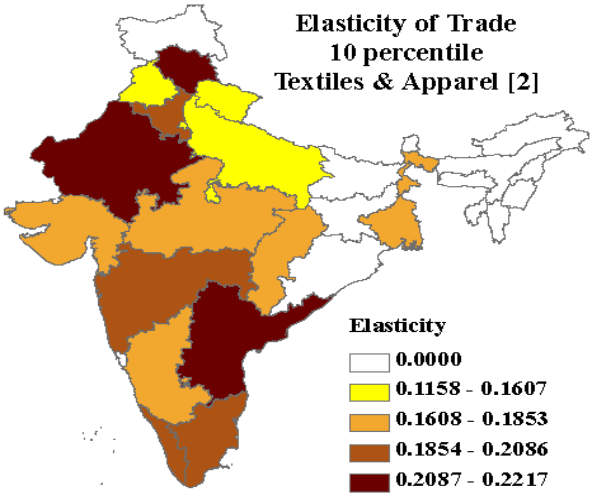
	Percentiles		
	10th	50th	90th
FT	0.160 *	-0.296 *	0.677 *
	(0.141)	(0.171)	(0.364)
IN	0.153 ***	0.171 ***	0.366 ***
	(0.032)	(0.033)	(0.101)
SIN	0.212 **	0.102	0.745 **
	(0.097)	(0.122)	(0.278)
FTIN	-0.009 *	-0.004	-0.003
	(0.006)	(0.008)	(0.017)
FTSIN	0.222 *	0.561 ***	0.048
	(0.161)	(0.153)	(0.429)
INSIN	-0.065 **	-0.002	-0.120 *
	(0.025)	(0.028)	(0.083)
HHI	-0.774 *	-0.743	-0.355
	(0.746)	(1.372)	(2.241)
Pop. Share	-0.343 *	0.289 *	1.197 **
	(0.291)	(0.277)	(0.460)
Elasticity_FT	0.088	-0.014	0.123
Elasticity_IN	0.136	0.143	0.176
Elasticity_SIN	0.076	0.092	0.102
Pseudo R2	0.157	0.150	0.122
Obs.	2268	2268	2268
Censored Obs.	552	652	552
L.B.	0.787	1.1	1.45

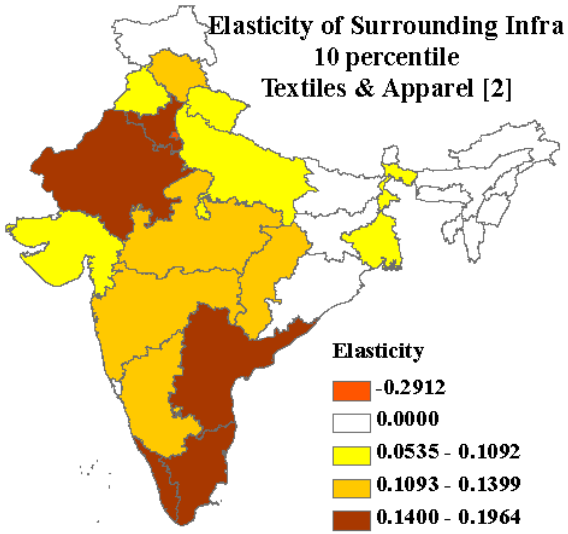
Notes: Numbers in parentheses are bootstrap standard errors with 200 draws. *, **, and * indicate significance at 1%, 5%, and 10% level, respectively.**

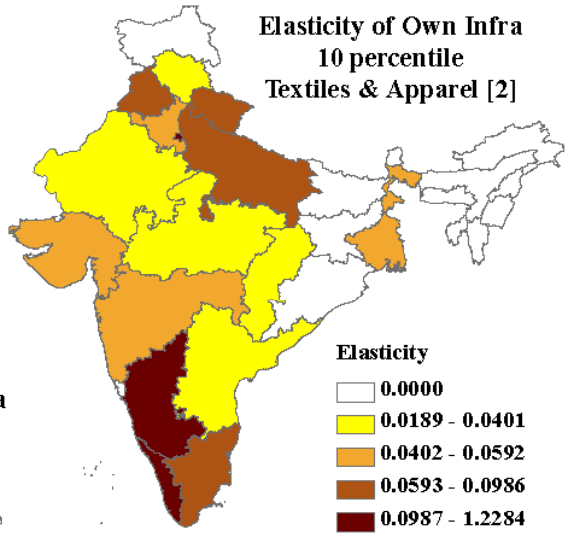
Trade Costs and Productivity Results

- Tobit versus CLAD models (homoskedastic and normally distributed disturbances)
- Freeness of trade (1/trade costs)
- CLAD model preferred
  - Own infrastructure has the highest elasticity followed by that of the trade costs.
- Economic significance
  - Own infrastructure has contributed the most to raw productivity growth followed by that of the trade costs.

Spatial Differences in Elasticities: Textile Industry







Message

- After taking out the agglomeration/spatial spillovers, falling trade costs discipline firms (regardless of where they are) and improve industry productivity
- Infrastructure independently and in concert with falling trade costs boosts productivity of firms
- It is tempting to interpret the larger effects of infrastructure on productivity as evidence of a more effective development strategy. However, knowledge on costs of each of these options is necessary in the search for efficient regional development strategies