External Economies of Scale and Industrial Policy: A View from Trade

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  - Central (as-if) feature of trade/geography/growth models with endogenous entry
  - Only source of disagreement among workhorse gravity models of trade
  - Common rationale for industrial policy

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- **How successful could optimal industrial policy be?**
  - In our model: gains $\approx 0.2\%$ of GDP
  - (Gains from optimal trade policy: $\approx 0.8\%$ of GDP)

Related Empirical Literature

- **Using trade data to infer productivity:**
  - Eaton and Kortum (2002)
  - Costinot, Donaldson and Komunjer (2012), Hanson, Lind, and Muendler (2016), Levchenko and Zhang (2016), Redding and Weinstein (2017)
- **Empirical work on RTS and trade:**
  - Head and Ries (2001), Antweiler and Trefler (2002), Davis and Weinstein (2003)
  - Somale (2015), Lashkaripour and Lugovskyy (2017)
  - Costinot et al (2016)
- **Empirical work on RTS in other settings:**
  - Caballero and Lyons (1990), Basu and Fernald (1997)
  - Vast firm-level production/cost-function estimation literature
  - Estimation of agglomeration economies in urban economics: Rosenthal and Strange (2004), Combes et al (2012), Kline and Moretti (2014), Ahlfeldt et al (2016), Bartelme (2015)

Outline

- **Theory**
- Empirical Strategy
- Data and Results
- Optimal Policy

Basic Environment

- Countries indexed by $i, j = 1, ..., I$
- Sectors indexed by $s = 1, ..., S$, goods indexed by ω
- Technology:

$$q_{i,s}(\omega) = A_{i,s} l_{i,s}(\omega)$$

with

$$A_{i,s} = \alpha_{i,s} A_s(L_{i,s})$$

- Preferences within industry:

$$Q_{j,s} = U_{j,s}(\{B_{ij,s} q_{ij,s}(\omega)\})$$

with

$$B_{ij,s} = \beta_{ij,s} B_s(L_{i,s})$$

- Trade frictions $\tau_{ij,s} \geq 1$

Industry-level Demand System

- Perfect competition, with producers taking $L_{i,s}$ as given, leads to

$$x_{ij,s} = \chi_{ij,s}\left(c_{1j,s}, ..., c_{Ij,s}; y_i\right)$$

with

$$c_{ij,s} \equiv \eta_{ij,s} w_i / E_s(L_{i,s})$$

$$\eta_{ij,s} \equiv \tau_{ij,s} / (\alpha_{i,s}\beta_{ij,s})$$

$$E_s(L_{i,s}) \equiv A_s(L_{i,s}) B_s(L_{i,s})$$

Identification of $E_s(\cdot)$—Rough Idea

- If $\chi_{ij,s}$ is invertible (e.g. $U_{j,s}(\cdot)$ satisfies the *connected substitutes property*) then exogenous (and "complete") shifters of $\tau_{ij,s}$ non-parametrically identify $\chi_{ij,s}$
- So "trade-revealed (inverse) productivity" $c_{ij,s}$ identified from
$$c_{ij,s} = \chi_{ij,s}^{-1}\left(x_{1j,s}, ..., x_{Ij,s}; y_i\right)$$
- Then difference across two sectors and exporters:

$$\ln \frac{c_{i_1 j,s_1}}{c_{i_2 j,s_1}} - \ln \frac{c_{i_1 j,s_2}}{c_{i_2 j,s_2}} = \ln \frac{E_{s_1}(L_{i_2,s_1})}{E_{s_1}(L_{i_1,s_1})} - \ln \frac{E_{s_2}(L_{i_2,s_2})}{E_{s_2}(L_{i_1,s_2})} + \ln \frac{\eta_{i_1 j,s_1}}{\eta_{i_2 j,s_1}} - \ln \frac{\eta_{i_1 j,s_2}}{\eta_{i_2 j,s_2}}$$

- So exogenous and complete IVs for $L_{i,s}$ non-parametrically identify $E_s(\cdot)$

Alternative Approaches to Estimating EES

1. With micro-data on $p_{i,s}(\omega)$, $q_{i,s}(\omega)$, $l_{i,s}(\omega)$, could:
   - Estimate each firm's production function, then see how residuals vary with $L_{i,s}$ to estimate $A_s(\cdot)$
   - Estimate *within-industry* demand function, then see how residual varies with $L_{i,s}$ to estimate $B_s(\cdot)$
   - Pro: can speak to micro aspects of counterfactuals
   - Con: within-industry heterogeneity and demand-system can be extremely high-dimensional

2. With industry-level, quality- and variety-adjusted, internationally comparable price indices $P_{i,s}$, could:
   - Estimate how $R_{i,s}/P_{i,s}$ varies with $L_{i,s}$ to estimate $E_s(\cdot)$
   - Pro: don't need to estimate $\chi(\cdot)$ to get EES. (Though $\chi(\cdot)$ is needed for any policy simulation anyway.)
   - Con: constructing these sorts of price indices is really hard

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Empirical Strategy

- In practice, data/variation is limited (e.g. 4 time periods and 61 countries), so estimation needs to proceed parametrically

- Functional form assumptions:

$$\chi_{ij,s}\left(c_{1j,s},...,c_{Ij,s}\right) = \frac{\left(c_{ij,s}\right)^{-\theta}}{\sum_{i'}\left(c_{i'j,s}\right)^{-\theta}}$$

$$E_s(L_{i,s}) = (L_{i,s})^{\gamma_s}$$

- Bonus: for these cases, span generalized version of workhorse monopolistic competition models (Krugman, Melitz-with-Pareto)

Empirical Strategy

- The previous functional form assumptions imply that

$$\frac{1}{\theta}\left[\ln\left(\frac{x_{i_1j,s_2}}{x_{i_2j,s_2}}\right)-\ln\left(\frac{x_{i_1j,s_1}}{x_{i_2j,s_1}}\right)\right]=$$
$$\gamma_{s_1}\ln\left(\frac{L_{i_2,s_1}}{L_{i_1,s_1}}\right)-\gamma_{s_2}\ln\left(\frac{L_{i_2,s_2}}{L_{i_1,s_2}}\right)+\ln\left(\frac{\eta_{i_1j,s_1}}{\eta_{i_2j,s_1}}\right)-\ln\left(\frac{\eta_{i_1j,s_2}}{\eta_{i_2j,s_2}}\right)$$

- Using fixed effects, this is equivalent to

$$\frac{1}{\theta}\ln x_{ij,s}=\delta_{ij}+\delta_{j,s}+\gamma_s\ln L_{i,s}+\ln\mu_{ij,s}$$

- Set $\theta = 5$ (Head and Mayer, 2014) — otherwise, estimate $\theta\gamma_s$

Instrumental Variable Approach—Two Steps

- **Step 1:**
  - Estimate flexible Engel-like function $g_s(\cdot)$:

$$\ln\left(X_{j,s}/\overline{L}_j\right) = g_s(Y_j/L_j) + \xi^t_{j,s}$$

  - But in place of Y_j/L_j use prediction $\sum_l \bar{L}_j d_{jl}^{-1}$

- **Step 2:**
  - Construct IV as:

$$Z_{i,s} \equiv \ln\left(\sum_j \widehat{\beta}_{j,s}\overline{L}_j d_{ij}^{-1}\right)$$

  - With

$$\widehat{\beta}_{j,s} \equiv \frac{\exp\widehat{g}_s(\sum_l(\overline{L}_l/d_{jl}))}{\sum_{s'}\exp\widehat{g}_{s'}(\sum_l(\overline{L}_l/d_{jl}))}$$

Summarizing

- 2SLS system with S endogenous variables and S instrumental variables (pooling over various cross-sections indexed by t):

$$\frac{1}{\theta}\ln x_{ij,s}^{t} = \delta_{ij}^{t} + \delta_{j,s}^{t} + \gamma_s \ln(L_{i,s}^{t}) + \ln \mu_{ij,s}^{t}$$

$$Z_{i,s}^{t} \equiv \ln\left(\sum_j \widehat{\beta}_{j,s}^{t} \overline{L}_j^{t} d_{ij}^{-1}\right)$$

$$\widehat{\beta}_{j,s}^{t} \equiv \frac{\exp \widehat{g}_s(\sum_l (\overline{L}_l^{t}/d_{jl}))}{\sum_{s'} \exp \widehat{g}_{s'}(\sum_l (\overline{L}_l^{t}/d_{jl}))}$$

$$\ln\left(X_{j,s}^{t}/\overline{L}_j^{t}\right) = g_s(\sum_l \overline{L}_l^{t} d_{jl}^{-1}) + \xi_{j,s}^{t}$$

Exclusion Restriction

- Primitive assumptions:

$$E[\mu_{ij,s}^t|\bar{L}_j^t] = 0, \quad E[\mu_{ij,s}^t|d_{ij}] = 0$$

- One concern is misspecification of cost function (might not be a w_{it} that differences out as above)
  - Add controls for the interaction between per-capita GDP and a full set of sector dummies
  - Future: explicitly model IO linkages

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Data

- OECD Inter-Country Input-Output tables
  - 61 countries
  - 34 sectors (27 traded, 15 manufacturing)
  - Focus on manufacturing
  - Years 1995, 2000, 2005, 2010

- Population and per-capita GDP from PWT v8.1

- Bilateral distance from CEPII Gravity Database
  - Set $d_{ii} = d$ slighty below $\min_{i,j} d_{ij}$

Results: Pooled Across Sectors

Table 2: Pooled (All Sectors) Estimates of External Economies of Scale

	log (employment)	log (bilateral sales)	
	OLS	OLS	IV
	(1)	(2)	(3)
log (predicted demand)	1.48		
	(0.35)		
log (employment)		0.18	0.13
		(0.01)	(0.05)
Within R^2	0.0191	0.209	0.196
Observations	207,557	207,557	207,557
First-stage F-statistic			18.07

Notes: Column (2) reports the OLS estimate, and column (3) the IV estimate, of equation (5) subject to the constraint that all sectors have the same economies of scale elasticity (i.e. $\gamma_s = \gamma$, for all sectors s). Column (1) reports the corresponding pooled first-stage specification. The instrument ("log predicted demand") is $Z_{i,s}^t$ defined in equation (7). All regressions control for exporter-year, exporter-importer-year and importer-sector-year fixed-effects, as well as interactions between exporter-year per-capita GDP and a set of sector indicators. Standard errors in parentheses are clustered at the exporter-sector level.

Results: Separate γ_s for Each Sector

Table 3: Sector-specific Estimates of External Economies of Scale (Part I)

	γ_s (OLS)	γ_s (2SLS)	First-stage SW F-statistic
Sector	(1)	(2)	(3)
Food, Beverages and Tobacco	0.17 (0.01)	0.02 (0.08)	13
Textiles	0.18 (0.01)	0.16 (0.06)	15
Wood Products	0.17 (0.02)	0.13 (0.08)	12
Paper Products	0.20 (0.01)	0.17 (0.07)	15
Coke/Petroleum Products	0.16 (0.01)	0.13 (0.06)	13
Chemicals	0.17 (0.01)	0.14 (0.05)	19
Rubber and Plastics	0.19 (0.01)	0.20 (0.06)	20

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Results: Separate γ_s for Each Sector

Table 3: Sector-specific Estimates of External Economies of Scale (Part II)

	γ_s (OLS)	γ_s (2SLS)	First-stage SW F-statistic
Sector	(1)	(2)	(3)
Continued from previous slide...			
Mineral Products	0.20 (0.01)	0.20 (0.07)	20
Basic Metals	0.18 (0.01)	0.10 (0.06)	12
Fabricated Metals	0.19 (0.01)	0.18 (0.06)	18
Machinery and Equipment	0.18 (0.01)	0.15 (0.05)	27
Computers and Electronics	0.18 (0.01)	0.13 (0.04)	12
Electrical Machinery, NEC	0.19 (0.01)	0.16 (0.05)	15
Motor Vehicles	0.20 (0.01)	0.18 (0.05)	15
Other Transport Equipment	0.20 (0.01)	0.18 (0.05)	15
Observations	207,557	207,557	
Within R^2	0.22	0.16	

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Optimal Policy Calculations—Details

- Solve 3 planner's problems (for country i, holding others' policy constant):
  1. *Optimal Industrial Policy* to internalize externalities
  2. *Optimal Trade Policy* to improve ToT
  3. Optimal combination of OIP and OTP

- Closing the model:
  - Labor market clearing: $\sum_s L_{i,s} = \bar{L}_i$
  - Upper-tier preferences: $U_i(Q_{i,1}, ..., Q_{i,S})$—Cobb-Douglas for country i
  - γ_s in non-manufacturing = mean γ_s among manufacturing sectors

- Simplify by assuming i is a "small economy"
  - $L_i \to 0$, but maintain home bias so not small in own market

- Everything done in terms of proportional departures from current data (as in Dekle, Eaton and Kortum, 2008)

Gains from Optimal Policy

Table 4: Gains from Optimal Policies, Selected Countries

Country	Gains from Optimal Industrial Policy (1)	Gains from Optimal Trade Policy (2)	Gains from Optimal Combination of Trade and Industrial Policy (3)
United States	0.1%	0.1%	0.5%
China	0.1%	0.3%	0.5%
Ireland	0.4%	1.6%	2.1%
Brazil	0.2%	0.3%	0.4%
Vietnam	0.3%	0.06%	1.0%
World Average	**0.2%**	**0.8%**	**1.1%**

Notes: Column (1) reports the gains, expressed as a share of initial real national income, that could be achieved by each selected country were it to pursue its optimal industrial policy (under a small open economy assumption), as given by equation (25). Columns (2) and (3) contain the results of the analogous calculation for optimal trade policy, and for an optimal combination of industrial and policy, respectively. Reported world averages are computed as the unweighted average across all 61 countries in our sample.

Gains from Optimal Policy

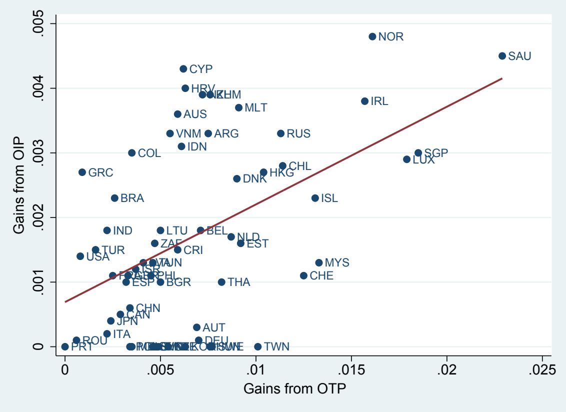

Figure 1: Gains from optimal industrial and trade policy

Notes: The y-axis displays the gains to each country from its own optimal industrial policy, and the x-axis the gains from its own optimal trade policy (both computed under a small open economy assumption, according to equation 25).

Why Are the Gains from Industrial Policy Small?

1. Gains come from *heterogeneity* in γ_s
   - Baseline assumes $\gamma_s = \bar{\gamma}_M$ for non-manufacturing
   - But even if assume $\gamma_s = 0$ in non-manufacturing $\rightarrow$ mean gains $\approx 0.3\%$
2. Deeper answer: too little trade in non-manufacturing (and relatively high θ)
   - In autarky, gains constrained by domestic demand
   - Domestic demand still binds when low-γ sectors non-traded
   - $\Rightarrow$ Larger gains in more open economies
   - $\Rightarrow$ Global gains will be small (since world economy closed as a whole)

Summary

- **New methods for estimating EES**
  - Trade data reveal right notion of sector productivity without need to get into within-sector details (preferences, technologies)
  - Foreign demand shocks drive exogenous variation in scale

- **Results:** large scale elasticities but small gains

- **Ongoing work:**
  - Incorporate intermediate goods linkages across sectors
  - Estimate θ_s
  - Other EES spillovers (cross-sector, cross-country?)