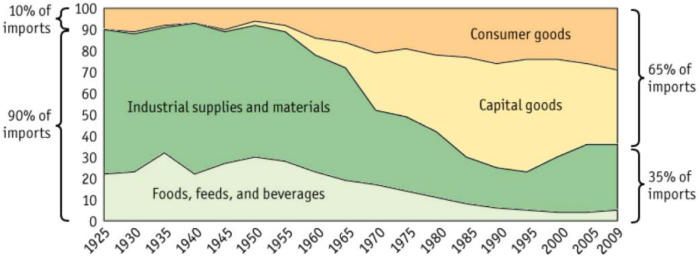
Stylized Facts About International Trade

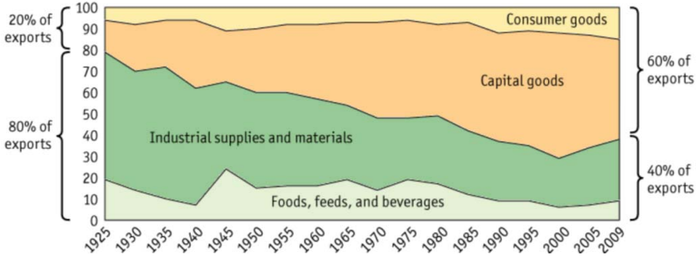
Some Definitions

- Trade: Movements of goods and services between areas (e.g., countries) e.g., manufactured goods, financial services, raw materials, electronics, etc.
- Trade Balance: difference between the total value of a country's imports (M) and exports (X), i.e., X-M.
- Trade rarely balances (X-M $= 0$).
  - When X-M> 0, we say a country has a *trade surplus*.
  - When X-M< 0, we say a country has a *trade deficit*.

Changing Composition of US Imports & Exports

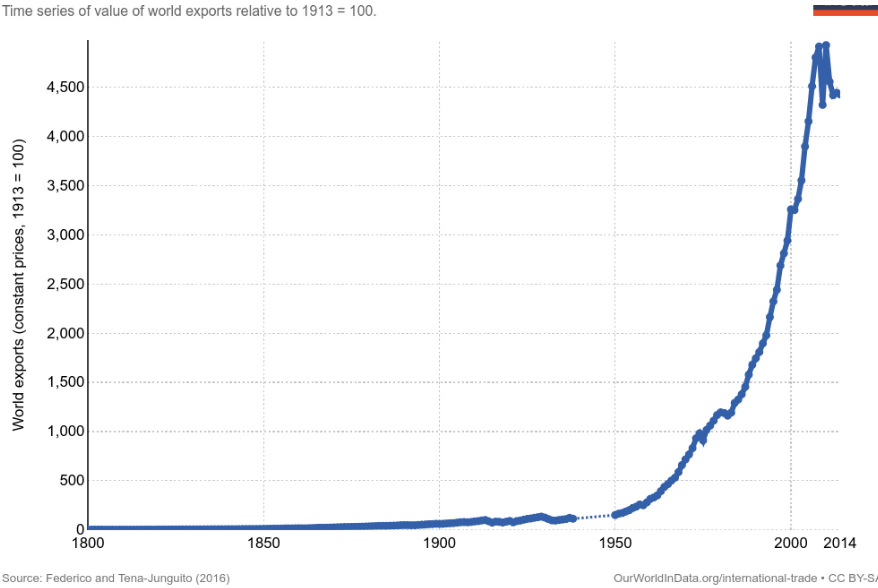


(a) Imports



(b) Exports

World Trade Flows

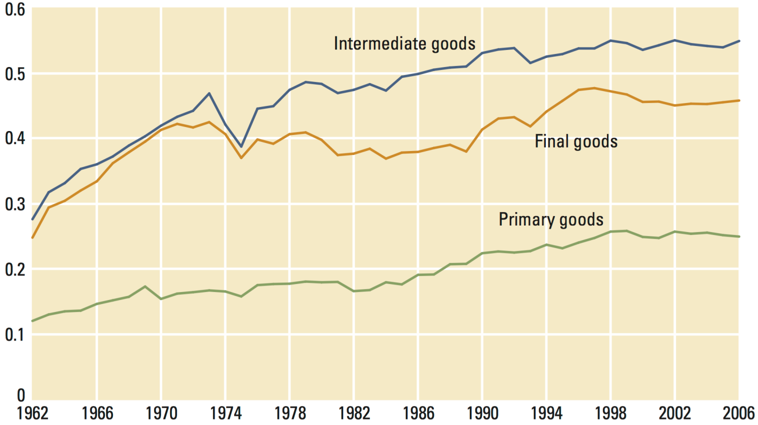


How Important is Trade?

Figure: Trade as a % of GDP (2008)

Country	Trade/GDP (%)	GDP ($ billion)
Hong Kong, China	207%	215%
Malaysia	116	222
Hungary	81	155
Thailand	75	272
Switzerland	65	492
Austria	56	414
Denmark	54	341
Sweden	50	479
Germany	44	3,649
Norway	38	452
South Africa	37	276
Canada	33	1,501
China	33	4,327
United Kingdom	30	2,674
Indonesia	29	511
Italy	29	2,303
Mexico	29	1,088
Spain	29	1,604
Greece	28	356
France	28	2,857
Turkey	26	735
Russian Federation	26	1,679
Venezuela	25	314
India	25	1,159
Argentina	23	328
Pakistan	18	165
Japan	16	4,911
United States	15	14,093
Brazil	14	1,575

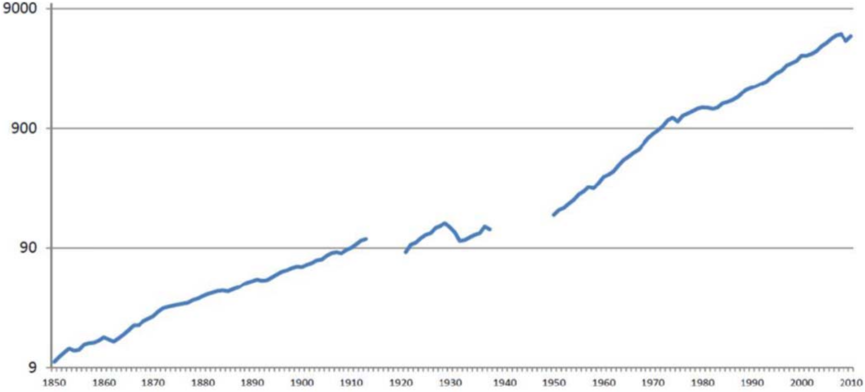
Growth in Intra-Industry Trade



- Firms produce and trade intermediate manufactured goods, not just in finished goods (e.g., iPhones).
- Trade in intermediate goods are increasingly important → global supply chains are increasingly important.
- Today, roughly 25% of manufacturing trade is in intermediates.

Growth in Trade

Figure: Volume in World Trade, log-scale (1850-2010)



- International trade has grown significantly over time.
- Possible reasons:
  - Changes in policy.
  - Reductions in trade costs.
  - Better technology.
  - Something else?

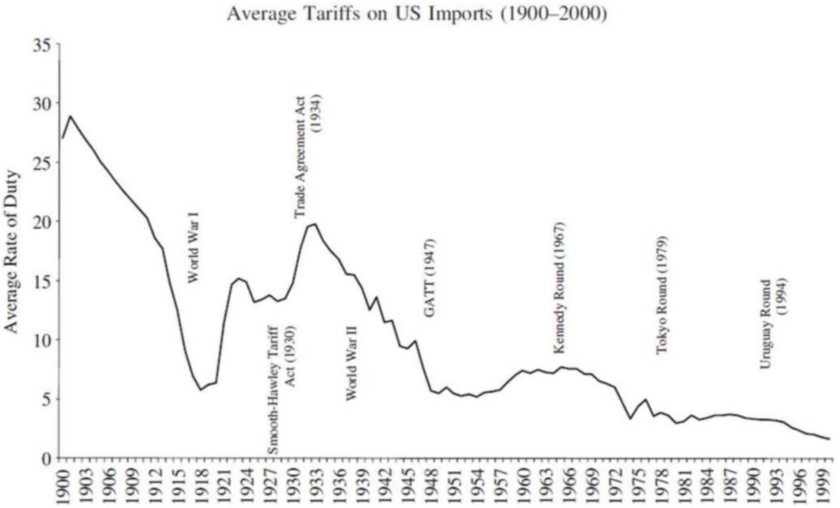
Trade Policies

- Governments can influence trade flows via policy:

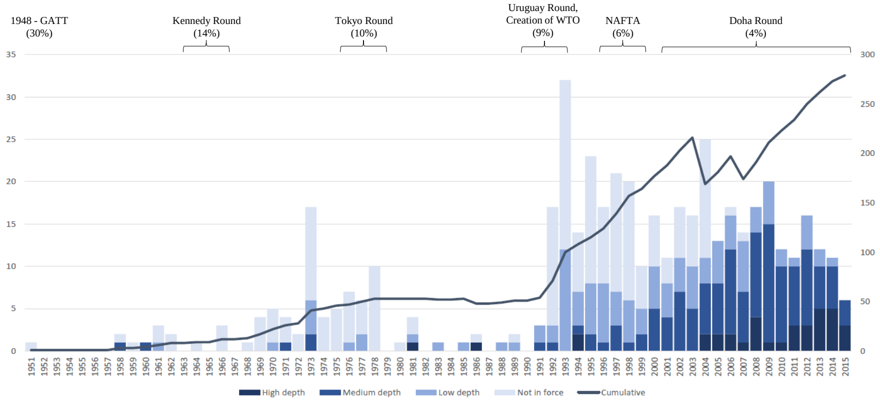
Target	Import	Export
Price	tariff	subsidy
Quantity	quota	quota

- Also non-tariff policies: innovation & patent rights, product standards, emissions policies.
- Policies can be influenced by special interest groups: what are the costs of such policies?
- Also, countries face a strategic game where the Nash Equilibrium is to protect domestic industry.
- Bilateral and multilateral negotiations allow countries to coordinate.

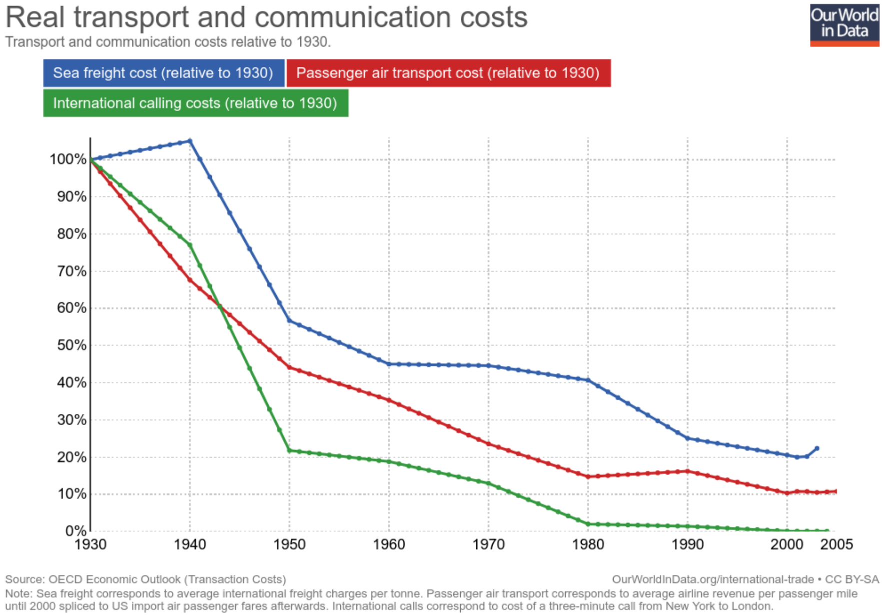
Lowering US Trade Barriers



Lowering Trade Barriers via Agreements



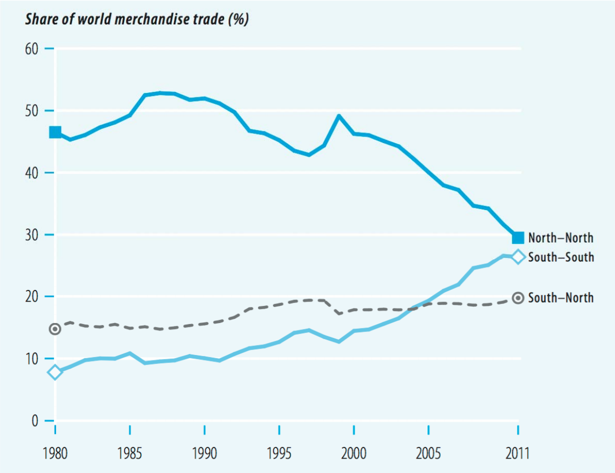
Lowering Trade Costs



Lowering Trade Costs - Containerization

- 80% of world trade (weight) goes by water
- 50% of world trade (value) goes by water.
- Standardization of shipping containers in the late 1960s, early 1970s dramatically reduced shipping costs.

What Countries Participate in International Trade?



Note: North in 1980 refers to Australia, Canada, Japan, New Zealand, the United States and Western Europe.
Source: HDRO calculations based on UNSD (2012).

What Firms Participate in International Trade?

- US exporting is rare.
  →*Of 5.5 million US firms in 2002, only 4 percent exported.*
  →*15 percent of manufacturing, mining, and agricultural firms.*
  →*38 percent of computer and electronics firms.*

- Exporters look different (e.g., they tend to be more "productive").

$$\log Y_j = \beta\{\text{Export Dummy}\} + X_j\gamma + \epsilon_j$$

Exporter Premia in U.S. Manufacturing, 2002

	Exporter premia		
	(1)	*(2)*	*(3)*
Log employment	1.19	0.97	
Log shipments	1.48	1.08	0.08
Log value-added per worker	0.26	0.11	0.10
Log TFP	0.02	0.03	0.05
Log wage	0.17	0.06	0.06
Log capital per worker	0.32	0.12	0.04
Log skill per worker	0.19	0.11	0.19
Additional covariates	None	Industry fixed effects	Industry fixed effects, log employment

What Firms Participate in International Trade?

- US importing is also rare.

NAICS industry	*Percent of all firms*	*Percent of firms that export*	*Percent of firms that import*	*Percent of firms that import & export*
311 Food Manufacturing	7	17	10	7
312 Beverage and Tobacco Product	1	28	19	13
313 Textile Mills	1	47	31	24
314 Textile Product Mills	2	19	13	9
315 Apparel Manufacturing	6	16	15	9
316 Leather and Allied Product	0	43	43	30
321 Wood Product Manufacturing	5	15	5	3
322 Paper Manufacturing	1	42	18	15
323 Printing and Related Support	13	10	3	2
324 Petroleum and Coal Products	0	32	17	14
325 Chemical Manufacturing	3	56	30	26
326 Plastics and Rubber Products	5	42	20	16
327 Nonmetallic Mineral Product	4	16	11	7
331 Primary Metal Manufacturing	1	51	23	21
332 Fabricated Metal Product	20	21	8	6
333 Machinery Manufacturing	9	47	22	19
334 Computer and Electronic Product	4	65	40	37
335 Electrical Equipment, Appliance	2	58	35	30
336 Transportation Equipment	3	40	22	18
337 Furniture and Related Product	6	13	8	5
339 Miscellaneous Manufacturing	7	31	19	15
Aggregate manufacturing	**100**	**27**	**14**	**11**

What Firms Participate in International Trade?

- Trade is concentrated. In 2000:

  $\rightarrow$ *The top 1% of trading firms by value (X+M) accounted for 80% of trade (X+M).*

  $\rightarrow$ *The top 10% of trading firms by value (X+M) accounted for 95% of trade (X+M).*

- Trade is actually quite scarce. Differences in factor endowments across countries imply there should be much more trade between countries.

  Treffler (1995). "The Case of the Missing Trade and Other Mysteries." AER.

- When firms export, most (64%) export to a single destination.

- Firms exporting ≥ 5 products (26% of exporting firms) account for 98% of export value.

Topics

1. Aggregate Trade Models and Gravity.
2. Countries Don't Trade, Firms Do.
3. The Ricardian Model of Trade — Theory.
4. The Ricardian Model of Trade — Empirical.
5. Extensive vs Intensive Margins of Trade.
6. Models: What are They Good For?
7. Effects of Trade Liberalization.
8. Unequal Gains from Trade: Measuring Misallocation.
9. Trade as a Determinant of Firm Investment and Innovation.
10. International Trade Across the Business Cycle.

1. Aggregate Trade Models and Gravity

McCallum (1995) "National Borders Matter: Canada-U.S. Regional Trade Patterns." American Economic Review.

- Research Question: has integration resulted frictionless trade between countries? Does a border matter?
- Why Important: Substantial growth in international economic agreements pertaining to trade, resulting in tariff rates near zero. But countries can still employ domestic policies to protect industry. Are they?

Empirical Approach

- Use data on bilateral trade between US states and Canadian provinces to test whether crossing the border leads to a large decrease in trade.
- If so, there must be some kind of "barrier" which is artificially increasing cost.

Gravity Model

- In physics, Newtonian classical mechanics tells us that the gravitational force between two objects is proportional to the product of their masses (m) and inversely proportional to the square of the distance (d) between them:
$$F_g = G \times \frac{m_i m_j}{d_{ij}^2}.$$
- The gravity theory of trade replaces this force with bilateral trade flows, the masses with GDP, and the distance with... you guessed it ... distance.
- Turns out this fits the data really well (see Bergstrand 1985, 1989).

Gravity Model

- McCallum runs the following regression:

$$\log x_{ij} = \beta_1 + \beta_2 y_i + \beta_3 y_j + \beta_4 d_{ij} + \beta_5 \{\text{Border Dummy}\} + \epsilon_{ij}. \quad (1)$$

  where "Border Dummy" is one for province-province trade and zero for province-state trade.

- Results:
  1. Border dummy is ≈ 3 and significant.
  2. This means that after controlling for size and distance, Canadian provinces trade with each other 20x more than with US states.
  3. Puzzling since there are few legal / policy barriers.
  4. High R^2 $(0.8 - 0.9)$ shows these models do a really good job at "explaining" bilateral trade.

Policy Implications

AVW (2003). "Gravity with Gravitas."

- Anderson and Van Wincoop (2003) challenge McCallum's atheoretic result by developing a structural model which they can take to the data to understand the border puzzle.
- Environment:
  - Consumer preferences are "Constant Elasticity of Substitution (CES)"

$$U_j = \left(\sum_i \beta_i^{(1-\sigma)/\sigma} c_{ij}^{(1-\sigma)/\sigma} \right)^{\sigma/(\sigma-1)}$$

  subject to $\sum_i p_{ij} c_{ij} \leq y_j$.

  - Armington (1965) weights $\beta \geq 0$ are country-specific.
  - Elasticity of substitution σ.

Deriving Demand from CES Preferences

- Constant elasticity of substitution preferences will show up often in international trade since they're are a simple way to aggregate over many goods.

- Consider the case with a continuum of goods.

$$\begin{aligned} \max_c U(c) &= \left(\int_0^1 b(i)c(i)^\rho di\right)^{1/\rho} & (2) \\ \text{s.t.} \int_0^1 p(i)c(i)di &\leq I \end{aligned}$$

- Usually assume $\rho \in (0,1)$ ... you'll see why in a bit.
- FONCs are (wrt good i'):

$$\left(\int_0^1 b(i)c(i)^\rho di\right)^{1/\rho-1} b(i')c(i')^{\rho-1} = \lambda p(i'), \quad i' \in [0,1]. \tag{3}$$

Deriving Demand from CES Preferences

- Multiply each FONC by $c(i')$ and integrate over them:

$$\begin{aligned}
\left(\int_0^1 b(i)c(i)^\rho di\right)^{1/\rho-1} b(i')c(i')^\rho &= \lambda p(i')c(i') \\
\left(\int_0^1 b(i)c(i)^\rho di\right)^{1/\rho-1} \int_0^1 b(i')c(i')^\rho di' &= \lambda \int_0^1 p(i')c(i')di' \\
\left(\int_0^1 b(i)c(i)^\rho di\right)^{1/\rho} &= \lambda \int_0^1 p(i')c(i')di' \quad (4)
\end{aligned}$$

- Define utility in terms of consumption:

$$C = \left(\int_0^1 b(i)c(i)^\rho di\right)^{1/\rho}$$

- Then we have $C\lambda^{-1} = I$ from the budget constraint and utility maximization. Define $P \equiv \lambda^{-1}$ as the price of a unit of utility.

Solve for P

- From FONC, solve for $c(i')^\rho$ and mult. by $b(i')$:

$$\begin{aligned} c(i')^\rho &= \lambda^{\rho/(\rho-1)} b(i')^{-\rho/(\rho-1)} p(i')^{\rho/(\rho-1)} \left(\int_0^1 b(i) c(i)^\rho di \right) \\ b(i') c(i')^\rho &= \lambda^{\rho/(\rho-1)} b(i')^{-1/(\rho-1)} p(i')^{\rho/(\rho-1)} \left(\int_0^1 b(i) c(i)^\rho di \right) \end{aligned}$$

- Now integrate over i:

$$\begin{aligned} \int_0^1 b(i') c(i')^\rho di' &= \lambda^{\rho/(\rho-1)} \int_0^1 b(i')^{-1/(\rho-1)} p(i')^{\rho/(\rho-1)} di' \left(\int_0^1 b(i) c(i)^\rho di \right) \\ \Rightarrow 1 &= \lambda^{\rho/(\rho-1)} \int_0^1 b(i')^{-1/(\rho-1)} p(i')^{\rho/(\rho-1)} di' \end{aligned}$$

- Finally we get what's called the "price index":

$$P = \lambda^{-1} = \left(\int_0^1 b(i)^{\frac{-1}{\rho-1}} p(i)^{\frac{\rho}{\rho-1}} di \right)^{\frac{\rho-1}{\rho}} \tag{5}$$

Properties

- Plug the price index into the FONC to get demand for product i:

$$c(i) = b(i)^{\frac{1}{1-\rho}} \times \left(\frac{p(i)}{P}\right)^{\frac{-1}{1-\rho}} C$$

$$\text{or equivalently } c(i) = p(i)^{\frac{-1}{1-\rho}} b(i)^{\frac{1}{1-\rho}} \times P^{\frac{\rho}{1-\rho}} \times I$$

  where I could be GDP in the data.

- If product i is small so $\frac{\partial P}{\partial p(i)} = 0$, the own price elasticity is $1/(1-\rho)$ for all goods. Note that this elasticity is fixed by assumption (i.e., constant) and does not change with technology, policy, etc.

  $\rightarrow \sigma = \frac{1}{1-\rho}$ is known as THE "elasticity of substitution."

- Firms charge constant markup $p_j = \frac{c_j}{\rho}$.

- Limiting Cases:
  1. As $\rho \downarrow 0$ we get Cobb-Douglas.
  2. As $\rho \uparrow 1$ we get perfect substitutes.
  3. As $\rho \uparrow \infty$ we get Leontief.

- Authors estimate $\sigma \in [2, 8]$ so $\rho \in [.5, .875]$
  $\rightarrow$ firms are differentiated and have market power: shocking!

An Aside: There are Different Ways to Incorporate CES

1. Preferences. That's what we did.
2. Two-stage budgeting where the CES is a nest. Often the first nest is Cobb-Douglas so PC is pinned down by the aggregate spend and the coefficient over the CES nest.
3. Production. Assume utility is linear (or log) in the production of a final good C which is produced with intermediate goods using a CES production function.

Back to Solving the AVW Model

- Demand:

$$x_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} p_j \tag{6}$$

where P is called the "price index".

$$P_j = \left(\sum_i (\beta_i p_i t_{ij})^{1-\sigma}\right)^{1/(1-\sigma)} \tag{7}$$

- Aggregate production: (6) plus $y_i = \sum_j x_{ij}$ means

$$y_i = (\beta_i p_i)^{1-\sigma} \sum_j (t_{ij}/P_j)^{1-\sigma} y_j \tag{8}$$

- Trade flows:

$$x_{ij} = \frac{y_i y_j}{y_w} \left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \tag{9}$$

$$\Pi_i = \left(\sum_j (t_{ij}/P_j)^{1-\sigma} \theta_j\right)^{1/(1-\sigma)} \tag{10}$$

$$\Theta_j \equiv y_j / y_w$$

Solving the Model

- Price index: using (8) in (7) to get

$$P_j = \left(\sum_i (t_{ij}/\Pi_i)^{1-\sigma} \theta_i \right)^{1/(1-\sigma)} \tag{11}$$

- (10) and (11) form a system of Nx2 equations and Nx2 unknowns $\{\Pi_i, P_i\}$ $\Rightarrow$ unique solution exists.
- If we assume trade costs are symmetric ($t_{ij} = t_{ji}$) then $\Pi_i = P_i$ and

$$x_{ij} = \frac{y_i y_j}{y_w} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \tag{12}$$

$$P_j = \left(\sum_i (t_{ij}/P_i)^{1-\sigma} \theta_i \right)^{1/(1-\sigma)} \tag{13}$$

- Authors refer to P_j as "Multilateral Resistance" terms since they have costs and market sizes.
- Notice that taking logs of (12) yields a gravity equation!

Features of Gravity Based on Theory

$$x_{ij} = \frac{y_i y_j}{y_w} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \tag{14}$$

- Bilateral trade flows decrease with trade costs between i and j, ceteris peribus.
- Bilateral trade flows increase with the size of i or j, ceteris peribus.
- The effect of trade costs and multilateral resistance are amplified / modulated by the elasticity of substitution $\sigma > 1$.
- Bilateral trade flows are homogenous of degree one in $t \equiv$ vector of trade costs.

Empirical Approach

- Make trade costs a function of observable characteristics (e.g., distance).

$$t_{ij} = b^{1-\delta_{ij}} d_{ij}^{\rho}$$

  where $\delta_{ij} = 1$ if i, j located in the same country.

- Gravity equation is then

$$\log \frac{x_{ij}}{y_i y_j} = a_0 + a_1 \log d_{ij} + a_2(1 - \delta_{ij}) + \log P_i^{1-\sigma} + \log P_j^{1-\sigma} + \epsilon_{ij} \quad (15)$$

- Recall McCallum's regression equation:

$$\log x_{ij} = b_0 + b_1 \log d_{ij} + b_2 \delta_{ij} + b_3 y_i + b_4 y_j + \epsilon_{ij}.$$

- Two differences:
  1. McCallum estimates income elasticities (b_3, b_4) but theory says to restrict to be one.
  2. McCallum suffers from omitted variable bias as he ignored multilateral resistance terms. Theory says equilibrium trade flows depend on the set of bilateral trade "barriers."

Results

		Two-country model	Multicountry model
Parameters	$(1-\sigma)\rho$	−0.79	−0.82
		(0.03)	(0.03)
	$(1-\sigma)\ln b_{US,CA}$	−1.65	−1.59
		(0.08)	(0.08)
	$(1-\sigma)\ln b_{US,ROW}$		−1.68
			(0.07)
	$(1-\sigma)\ln b_{CA,ROW}$		−2.31
			(0.08)
	$(1-\sigma)\ln b_{ROW,ROW}$		−1.66
			(0.06)
Average error terms:	US–US	0.06	0.06
	CA–CA	−0.17	−0.02
	US–CA	−0.05	−0.04

Notes: The table reports parameter estimates from the two-country model and the multicountry model. Robust standard errors are in parentheses. The table also reports average error terms for interstate, interprovincial, and state–province trade.

- Regression gives us $a_1 = (1-\sigma)\rho$ and $a_2 = (1-\sigma)\log b$.
- Value of σ is debated but often assumed around 5.
- Authors find that border leads Canadian provinces to trade 1.5x more with each other. Seems much more reasonable (though still big) than McCallum's value of 20.

2. Countries Don't Trade, Firms Do.

Roberts and Tybout (1997). "The Decision to Export"

- Motivation: Export supply elasticities are very sensitive to the country and time-period used in the estimation. Why?
- Hypothesis: sunk entry costs into export markets could lead to hysteresis in export participation where past export experience influences whether or not to export today.
- Objective: Empirically test the *Sunk Cost Hypothesis* put forth by Baldwin (88,89), Dixit (89), and Krugman (89).

Empirical Approach

- Write-down a dynamic discrete-choice model of export participation to infer the importance of sunk costs.
- Estimate reduced-form version of the model using plant-level data from Colombia.

Data

TABLE 1—COLOMBIAN MANUFACTURED EXPORTS 1981–1989 (19 THREE-DIGIT ISIC INDUSTRIES)

Variable	1981	1982	1983	1984	1985	1986	1987	1988	1989
Real effective exchange rate index (1975 = 100)[a]	84.0	79.5	80.5	89.8	102.2	113.6	113.7	112.3	115.3
Quantity of exports (1986 = 100)[b]	58.5	64.1	63.8	59.1	66.4	100.0	88.6	103.1	127.2
Export subsidy rate	0.055	0.055	0.066	0.099	0.092	0.047	0.047	0.042	0.044
Number of exporting plants	667	676	615	585	653	705	707	735	816
Proportion of plants that export	0.129	0.128	0.113	0.107	0.117	0.112	0.119	0.124	0.135

[a]Source: José Ocampo and Leonardo Villar (1995). An increase in this variable corresponds to a devaluation of the Colombian peso.

[b]Source: Roberts et al. (1995). Figures describe export-oriented industries only.

- Colombian manufacturing plants (1981-1989). Census including all plants with $\geq$ 10 employees.

  e.g., plant location, industry, age, ownership, labor & materials expense, capital stock, value of domestic and exported output.

- Differences between "intensive" vs "extensive" margins.
- Not a lot of export participation ($\approx$ 12%).
- Likelihood of exporting follows exchange rate but asymmetric.
  $\Rightarrow$ took a large (28%) and persistent devaluation to induce a modest increase (10.7% to 13.5%) in export participation.

Key Stylized Data Fact

- Conditional on not exporting today, a firm is unlikely (97%) to export tomorrow.
- Conditional on exporting today, a firm is likely (90%) to export tomorrow.

TABLE 2—PLANT TRANSITION RATES IN THE EXPORT MARKET 1982–1989

Year-t status	Year-(t + 1) status	1982–1983	1983–1984	1984–1985	1985–1986	1986–1987	1987–1988	1988–1989	Average, 1982–1989
A. *Nineteen three-digit manufacturing industries:*									
No exports	No exports	0.974	0.971	0.957	0.963	0.973	0.972	0.958	0.967
	Exports	0.026	0.029	0.043	0.037	0.026	0.028	0.042	0.033
Exports	No exports	0.168	0.135	0.131	0.108	0.158	0.086	0.107	0.128
	Exports	0.832	0.865	0.869	0.892	0.842	0.914	0.893	0.872
B. *Four major exporting industries:*									
No exports	No exports	0.971	0.969	0.972	0.960	0.983	0.972	0.985	0.973
	Exports	0.029	0.031	0.028	0.040	0.017	0.028	0.015	0.027
Exports	No exports	0.108	0.101	0.152	0.124	0.149	0.085	0.054	0.110
	Exports	0.892	0.899	0.848	0.876	0.851	0.915	0.946	0.890

Mechanism

- Exporting today provides experience which increases the likelihood of exporting tomorrow (i.e., lower exporting cost tomorrow).
- Need firm-level data to disentangle intensive and extensive margins.
- Identification:
  1. If firms enter and exit often, little role for sunk fixed costs.
  2. If shocks are perceived as transitory, no effect on participation. Only persistent shocks matter.
  3. Firms entering / exiting export markets controlling for observables identifies common fixed costs rather than macro shocks, firm-specific factors.

Possible Explanations

- Exporting conveys some kind of knowledge which lowers the cost of exporting in the future, but this knowledge depreciates (sunk cost hysteresis theory).
- Persistent differences across plants in gross exporting profits – underlying plant heterogeneity. Maybe exporting plants just sell particular set of goods which are amenable for exporting.
- Others?

Combine theory with detailed data to discriminate / test these competing theories.

Model Environment

- Each period t, each firm chooses to export or not.
- If exporting conveys knowledge which decreases future costs, decision to export is dynamic.
- Profits also may depend upon observed (to the econometrician) and serially-correlated unobserved state variables specific to the plant.
- Macro-economic shocks (exogenous).
- Partial-equilibrium.

Econometrics

- Estimate:

$$Y_{it} = \begin{cases} 1 & \text{if } 0 \leq \mu_i + \beta Z_{it} \\ & \quad + \gamma^0 Y_{i,t-1} + \sum_{j=2}^{J} \gamma^j \tilde{Y}_{t,j-1} + \epsilon_{it} \\ 0 & \text{else} \end{cases} \tag{16}$$

where

$$\begin{aligned} Z &\equiv \text{vector of plant-specific characteristics (industry, age)} \\ \gamma^j &= F^0 - F^j,\ j = 2, ..., J \\ \gamma^0 &= F^0 + X \end{aligned}$$

- Answer research question by testing
  H0: $\gamma^0, \gamma^j = 0$.
  $\Rightarrow$ sunk costs play no role in exporting decision.
- Can compare magnitudes in γ^j to evaluate decay of experience.

Econometrics

- Assume:

$$\begin{aligned}
\epsilon_{it} &= \alpha_i + \omega_{it},\ \alpha \sim N \\
\text{where} & \\
\omega_{it} &= \rho\omega_{i,t-1} + \eta_{it},\ \eta \sim N \\
cov(\alpha_i, \omega_i t) &= 0 \\
cov(Z_{it}, \epsilon_{it}) &= 0
\end{aligned}$$

- Add adjustment for initial period.
- Estimate Two Ways:
  1. Simulated Method of Moments,
  2. Maximum-likelihood.

Results

	Model 1	Model 2		Model 3	
Explanatory variable	(i) MSM	(ii) MSM	(iii) ML	(iv) MSM	(v) ML
Intercept	−7.105*	−7.058*	−7.039*	−6.856*	−7.033*
	(1.222)	(1.215)	(1.021)	(1.149)	(0.988)
Y_{t-1}	1.036*	0.971	1.140*	0.702*	0.885*
	(0.326)	(0.261)	(0.211)	(−0.154)	(0.135)
$\tilde{Y}_{t-2}$	0.326	0.331	0.401*	—	—
	(0.190)	(0.181)	(−0.145)		
$\tilde{Y}_{t-3}$	0.069	0.068	0.130	—	—
	(0.182)	(0.176)	(−0.164)		
1985 dummy	−0.156	−0.160	−0.168	−0.140	−0.154
	(0.133)	(0.109)	(0.106)	(0.100)	(0.097)
1986 dummy	−0.013	−0.022	−0.026	−0.017	−0.021
	(0.111)	(0.106)	(0.108)	(0.093)	(0.098)
1987 dummy	−0.309*	−0.312*	−0.340*	−0.286*	−0.318*
	(0.109)	(0.107)	(0.112)	(0.098)	(0.103)
1988 dummy	−0.148	−0.161	−0.187	−0.155	−0.178
	(0.119)	(0.115)	(0.114)	(0.102)	(0.104)
1989 dummy	−0.313*	−0.322*	−0.355*	−0.305*	−0.343*
	(0.111)	(0.110)	(0.118)	(0.098)	(0.109)
ln($Wage_{t-1}$)	0.142	0.136	0.174	0.115	0.173
	(0.127)	(0.126)	(0.107)	(0.116)	(0.101)
ln(Export $price_{t-1}$)	−0.029	−0.027	−0.065	−0.025	−0.059
	(0.055)	(0.055)	(0.046)	(0.052)	(0.047)
ln(K_{t-1})	0.207*	0.211*	0.222*	0.207*	0.221*
	(0.032)	(0.032)	(0.031)	(0.031)	(0.033)
ln(Age_{t-1})	0.471*	0.471*	0.349*	0.506*	0.396*
	(0.126)	(0.126)	(0.096)	(0.123)	(0.089)
Corporation	0.383*	0.386*	0.271*	0.450*	0.308*
	(0.156)	(0.152)	(0.115)	(0.148)	(0.111)
Textiles industry dummy	0.817*	0.815*	0.681*	0.839*	0.698*
	(0.159)	(0.159)	(0.135)	(0.158)	(0.158)
Paper industry dummy	0.310	0.305	0.165	0.319*	0.163
	(0.184)	(0.183)	(0.147)	(0.191)	(0.145)
Chemical industry dummy	0.762*	0.760*	0.640*	0.811*	0.689*
	(0.203)	(0.199)	(0.134)	(0.200)	(0.130)
Cali/Medellín	0.112	0.119	−0.017	0.119	−0.052
	(0.131)	(0.133)	(0.117)	(0.135)	(0.129)
Other region	0.479*	0.487*	0.453*	0.504*	0.471*
	(0.134)	(0.135)	(0.104)	(0.137)	(0.098)
Var(α)	0.668*	0.687*	0.620*	0.764*	0.688*
	(0.119)	(0.096)	(0.078)	(0.061)	(0.051)
Corr(α,α^{P})	0.898*	0.894*	0.899*	0.906*	0.901*
	(0.039)	(0.038)	(0.017)	(0.032)	(0.017)
ρ	−0.019	—	—	—	—
	(0.028)				
Log likelihood:	−854.8[a]	−854.1[a]	−837.7	−857.8[a]	−842.700

* Statistically significant at the 5-percent level.
[a] Simulated with 1,000 draws of the errors.

Goodness of Fit

- Assess model fit by comparing actual versus predicted patterns of export participation.
- How? Use estimated parameters (ML Model 2) to simulate 200 paths for each plant.

Trajectory type	Observed frequencies	Predicted frequencies
Always a nonexporter	0.763	0.737
Begin as a nonexporter, switch once	0.045	0.044
Begin as a nonexporter, switch at least twice	0.029	0.033
Always an exporter	0.109	0.116
Begin as an exporter, switch once	0.022	0.037
Begin as an exporter, switch at least twice	0.032	0.034

- Model predicts export participation in-line with observed data.
- Is this surprising?

Melitz (2003). "Impact of Trade on Productivity"

- Recall that Exporting in the US is rare.
  →*Of 5.5 million US firms in 2002, only 4 percent exported.*
  →*15 percent of manufacturing, mining, and agricultural firms.*

- **Exporter Premia in U.S. Manufacturing, 2002**

	Exporter premia		
	(1)	*(2)*	*(3)*
Log employment	1.19	0.97	
Log shipments	1.48	1.08	0.08
Log value-added per worker	0.26	0.11	0.10
Log TFP	0.02	0.03	0.05
Log wage	0.17	0.06	0.06
Log capital per worker	0.32	0.12	0.04
Log skill per worker	0.19	0.11	0.19
Additional covariates	None	Industry fixed effects	Industry fixed effects, log employment

Melitz (2003). "Impact of Trade on Productivity"

- Empirical literature documents
  1. Productivity (and size) differences amongst firms in narrowly defined industries.
  2. More productive / larger firms are more likely to export.
     - Bernard, Jensen, Redding, & Schott (2007)
  3. Within a sector market share reallocations towards exporting firms account for 20% of US mfg growth.
     - Bernard & Jensen (1999)
  4. Anecdotal evidence that not all firms benefit from trade.
     - Aw, Chung, & Roberts (2000), Pavcnik (2002)

- Question: What is the effect of globalization on industry structure and aggregate variables such as productivity and welfare?

Empirical Approach

- Embed firm heterogeneity model (Hopenhayn, 1992) in Krugman (1980) model of international trade.
- Equilibrium firm heterogeneity due to ex post "productivity" realizations.
- Firm size (employment) and profits are increasing in firm productivity.
- Fixed trade costs limit exporting to only largest/ most productive firms.

Model Environment

- CES preferences over continuum of goods.
- Firm entry/ exit dynamics as in Hopenhayn (1992).
- Iceberg trade costs $\tau \geq 1$ as in Krugman (1980).
- Timing: Given distribution $\mu(\varphi)$ of firms,
  1. Firms exit at rate δ.
  2. Firms enter and pay f_e.
  3. Entering firms observe φ and decide whether to stay $\rightarrow \mu'$.
  4. Firms decide whether to export.
  5. Firms earn profits $\pi(\varphi, \mu')$.
- Output produced with labor and CRS production.
- Labor is fixed, supplied inelastically, and numeraire.
- Symmetric countries $\Rightarrow$ wages normalized to one.

Closed Economy Equilibrium

- Zero profit condition:

$$\overline{\pi} = fk(\varphi^{\star})$$

- Free entry:

$$\overline{\pi} = \frac{\delta f_e}{1 - G(\varphi^{\star})}$$

- Entry = exit:

$$M_e p_{\text{in}} = \delta M$$

- Payments to workers:

$$wL_p = R - \Pi$$

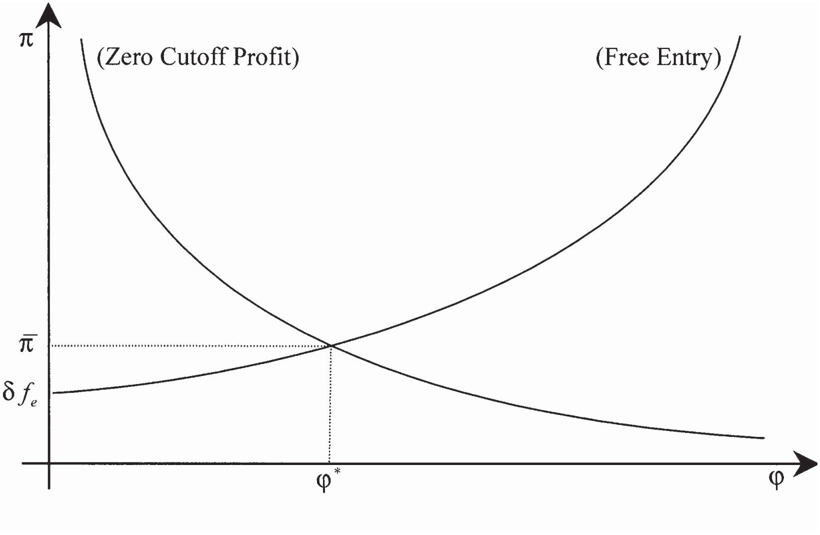
- Payments to entry workers:

$$wL_e = M_e f_e$$

- Labor resource constraint:

$$L = L_p + L_e$$

Free Entry



Open Economy

- Iceberg trade costs $\tau \geq 1$.
- Fixed export costs $f_x \Rightarrow$ export iff

$$\pi_x = \frac{r_x(\varphi;\mu)}{\sigma} - f_x \geq 0$$

- Symmetric countries. Define n as the number of other countries.
- Export iff $\varphi^\star > \varphi_x^\star$ where

$$\varphi_x = \frac{1 - G(\varphi_x^\star)}{1 - G(\varphi^\star)}$$

- Define weighted avg of firm productivity:

$$\tilde{\varphi}_t = \left[\frac{1}{M_t} \times \left(M\tilde{\varphi}^{\sigma-1} + nM_x\left(\tilde{\tau}^{-1}\varphi_x\right)^{\sigma-1}\right)\right]^{\frac{1}{\sigma-1}}$$

Impact of Trade

1. What happens to the range of firm productivity?
2. Do all firms benefit?
3. What is the effect on aggregate productivity and welfare?

Impact of Trade

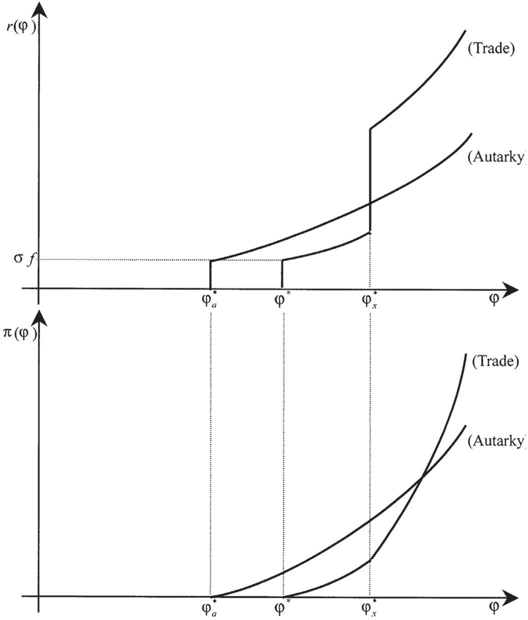
1. What happens to the range of firm productivity?

$$\begin{aligned} \overline{\pi} &= fk(\varphi^\star) + p_x n f_x k(\varphi_x^\star) \quad \text{(Free Trade)} \\ \overline{\pi} &= fk(\varphi_a^\star) \quad \text{(Autarky)} \end{aligned}$$

   Cut-off shifts up ($\varphi_a^\star < \varphi^\star$) so the range shrinks as least productive firms exit!

2. Intuition:
   - Competition (via price index) depends on both number of firms and their productivity.
   - Fixed exporting costs $\Rightarrow$ only most productive firms export.
   - Domestic variable profits fall so low productivity firms exit.

Trade Induces Intra-Industry Reallocation



Impact of Trade

1. What happens to the range of firm productivity?
2. Do all firms benefit?
3. What is the effect on aggregate productivity and welfare?
   - Globalization leads to the exit of the least productive firms and market shares reallocate to more productive firms so aggregate productivity increases.
   - Also see the number of varieties increase so welfare increases as well. This is due to the "love of varieties" aspect of Dixit-Stiglitz preferences.

$$W = \frac{R}{L} M_t^{\frac{1}{\sigma - 1}} p(\tilde{\varphi}_t)$$

3. The Ricardian Model: Theory.

Eaton & Kortum (2002). "Technology, Geography, & Trade"

- Motivation: "New Trade" models had difficulty accounting for the following stylized data facts simultaneously:
  1. Trade diminishes dramatically with distance
  2. Prices vary across locations with greater differences between places further apart
  3. Factor rewards are far from equal across countries
  4. Countries relative productivities vary substantially across industries
- Points 1 and 2 $\Rightarrow$ "geography" matters while 3 and 4 $\Rightarrow$ cross-country differences in technology matters.
- Objective: Develop a Ricardian model to deliver these facts.
- Important paper because it delivers a simple set of estimable equations which enables reasearchers to back-out cross-country differences in productivity across industries / sectors.

Cross-Country Variation in Technology and Trade

Trade, Labor, and Income Data

Country	Imports % of Mfg. Spending	Imports from Sample as % of All Imports	Mfg. Wage (U.S. = 1)	Human-Capital Adj. Mfg. Wage (U.S. = 1)	Human-Capital Adj. Mfg. Labor (U.S. = 1)	Mfg. Labor's % Share of GDP
Australia	23.8	75.8	0.61	0.75	0.050	8.6
Austria	40.4	84.2	0.70	0.87	0.036	13.4
Belgium	74.8	86.7	0.92	1.08	0.035	13.2
Canada	37.3	89.6	0.88	0.99	0.087	10.5
Denmark	50.8	85.2	0.80	1.10	0.020	11.5
Finland	31.3	82.2	1.02	1.10	0.022	12.5
France	29.6	82.3	0.92	1.07	0.205	12.6
Germany	25.0	77.3	0.97	1.08	0.421	20.6
Greece	42.9	80.8	0.40	0.50	0.015	6.1
Italy	21.3	76.8	0.74	0.88	0.225	12.4
Japan	6.4	50.0	0.78	0.91	0.686	14.4
Netherlands	66.9	83.0	0.91	1.06	0.043	11.0
New Zealand	36.3	80.9	0.48	0.57	0.011	9.6
Norway	43.6	85.2	0.99	1.18	0.012	8.7
Portugal	41.6	84.9	0.23	0.32	0.033	10.7
Spain	24.5	82.0	0.56	0.65	0.128	11.6
Sweden	37.3	86.3	0.96	1.11	0.043	14.2
United Kingdom	31.3	79.1	0.73	0.91	0.232	14.7
United States	14.5	62.0	1.00	1.00	1.000	12.4

Notes: All data except GDP are for the manufacturing sector in 1990. Spending on manufactures is gross manufacturing production less exports of manufactures plus imports of manufactures. Imports from the other 18 excludes imports of manufactures from outside our sample of countries. To adjust the manufacturing wage and manufacturing employment for human capital, we multiply the wage in country i by $e^{-0.06H_i}$ and employment in country i by $e^{0.06H_i}$, where H_i is average years of schooling in country i as measured by Kyriacou (1991). See the Appendix for a complete description of all data sources.

Empirical Approach

- Develop Ricardian model from first principles.
- Model incorporates absolute and comparative advantage (i.e., Ricardian concepts) while collapsing into a gravity equation so can be taken to the data.
- Estimation yields structural parameters which enable us to decompose the relative importance of cross-country differences in technology, distance, and wages towards determining trade.
- Counterfactual policy experiments elucidate the economic mechanisms rather than thought of as measuring magnitudes. Authors note the model is "too stylized" to take magnitudes "seriously."

Theory

- N countries, each with a different technology T_i.
- Country i consumers maximize CES objective

$$U_i = \left[\int_0^1 Q_i(j)^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}}, \ \sigma > 1 \equiv \text{elas. of subst.}$$

- Continuum of goods: $z_i(j) \equiv$ country i's efficiency at producing good j.
- Input costs c_i. Endogenize later s.t. $c_i = w_i^{\beta} p_i^{1-\beta}$.
- CRS production so cost of producing good j is

$$\frac{c_i}{z_i(j)}$$

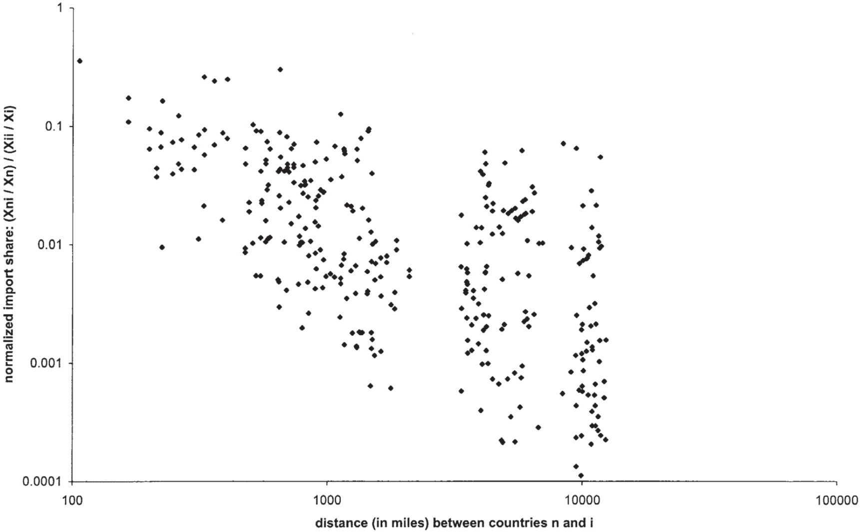
- Iceberg trade costs $d_{ni} \geq 1$.
- Perfect competition so equilibrium price for good j is

$$\begin{aligned} p_{ni}(j) &= \frac{c_i}{z_i(j)} \times d_{ni} \\ \text{where } n &= \text{destination country} \\ i &= \text{source country} \end{aligned}$$

- Firms/ consumers buy good j from the least expensive source:

$$p_n(j) = \min\{p_{n1}(j), p_{n2}(j), ..., p_{nN}(j)\}$$

Geography and Trade



International Prices (i.e., $D_{ni} \approx \frac{p_n d_{ni}}{p_i}$)

PRICE MEASURE STATISTICS

Country	Foreign Sources		Foreign Destinations	
	Minimum	Maximum	Minimum	Maximum
Australia (AL)	NE (1.44)	PO (2.25)	BE (1.41)	US (2.03)
Austria (AS)	SW (1.39)	NZ (2.16)	UK (1.47)	JP (1.97)
Belgium (BE)	GE (1.25)	JP (2.02)	GE (1.35)	SW (1.77)
Canada (CA)	US (1.58)	NZ (2.57)	AS (1.57)	US (2.14)
Denmark (DK)	FI (1.36)	PO (2.21)	NE (1.48)	US (2.41)
Finland (FI)	SW (1.38)	PO (2.61)	DK (1.36)	US (2.87)
France (FR)	GE (1.33)	NZ (2.42)	BE (1.40)	JP (2.40)
Germany (GE)	BE (1.35)	NZ (2.28)	BE (1.25)	US (2.22)
Greece (GR)	SP (1.61)	NZ (2.71)	NE (1.48)	US (2.27)
Italy (IT)	FR (1.45)	NZ (2.19)	AS (1.46)	JP (2.10)
Japan (JP)	BE (1.62)	PO (3.25)	AL (1.72)	US (3.08)
Netherlands (NE)	GE (1.30)	NZ (2.17)	DK (1.39)	NZ (2.01)
New Zealand (NZ)	CA (1.60)	PO (2.08)	AL (1.64)	GR (2.71)
Norway (NO)	FI (1.45)	JP (2.84)	SW (1.36)	US (2.31)
Portugal (PO)	BE (1.49)	JP (2.56)	SP (1.59)	JP (3.25)
Spain (SP)	BE (1.39)	JP (2.47)	NO (1.51)	JP (3.05)
Sweden (SW)	NO (1.36)	US (2.70)	FI (1.38)	US (2.01)
United Kingdom (UK)	NE (1.46)	JP (2.37)	FR (1.52)	NZ (2.04)
United States (US)	FR (1.57)	JP (3.08)	CA (1.58)	SW (2.70)

Notes: The price measure D_{ni} is defined in equation (13). For destination country n, the minimum Foreign Source is $\min_{i \neq n} \exp D_{ni}$. For source country i, the minimum Foreign Destination is $\min_{n \neq i} \exp D_{ni}$.

Prices and Distance

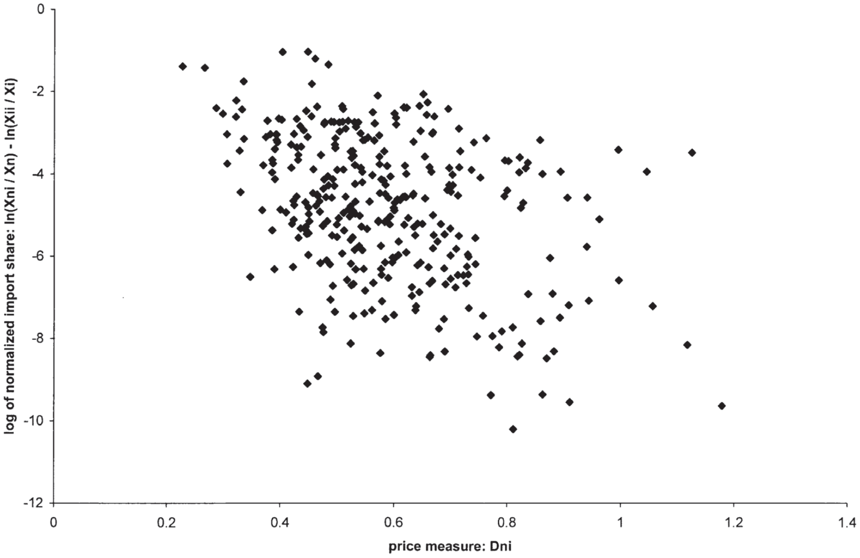


FIGURE 2.—Trade and prices.

Implied Structural Parameters

Variable		est.	s.e.
Distance [0, 375)	$-\theta d_1$	−3.10	(0.16)
Distance [375, 750)	$-\theta d_2$	−3.66	(0.11)
Distance [750, 1500)	$-\theta d_3$	−4.03	(0.10)
Distance [1500, 3000)	$-\theta d_4$	−4.22	(0.16)
Distance [3000, 6000)	$-\theta d_5$	−6.06	(0.09)
Distance [6000, maximum]	$-\theta d_6$	−6.56	(0.10)
Shared border	$-\theta b$	0.30	(0.14)
Shared language	$-\theta l$	0.51	(0.15)
European Community	$-\theta e_1$	0.04	(0.13)
EFTA	$-\theta e_2$	0.54	(0.19)

	Source Country			Destination Country		
Country		est.	s.e.		est.	s.e.
Australia	S_1	0.19	(0.15)	$-\theta m_1$	0.24	(0.27)
Austria	S_2	−1.16	(0.12)	$-\theta m_2$	−1.68	(0.21)
Belgium	S_3	−3.34	(0.11)	$-\theta m_3$	1.12	(0.19)
Canada	S_4	0.41	(0.14)	$-\theta m_4$	0.69	(0.25)
Denmark	S_5	−1.75	(0.12)	$-\theta m_5$	−0.51	(0.19)
Finland	S_6	−0.52	(0.12)	$-\theta m_6$	−1.33	(0.22)
France	S_7	1.28	(0.11)	$-\theta m_7$	0.22	(0.19)
Germany	S_8	2.35	(0.12)	$-\theta m_8$	1.00	(0.19)
Greece	S_9	−2.81	(0.12)	$-\theta m_9$	−2.36	(0.20)
Italy	S_{10}	1.78	(0.11)	$-\theta m_{10}$	0.07	(0.19)
Japan	S_{11}	4.20	(0.13)	$-\theta m_{11}$	1.59	(0.22)
Netherlands	S_{12}	−2.19	(0.11)	$-\theta m_{12}$	1.00	(0.19)
New Zealand	S_{13}	−1.20	(0.15)	$-\theta m_{13}$	0.07	(0.27)
Norway	S_{14}	−1.35	(0.12)	$-\theta m_{14}$	−1.00	(0.21)
Portugal	S_{15}	−1.57	(0.12)	$-\theta m_{15}$	−1.21	(0.21)
Spain	S_{16}	0.30	(0.12)	$-\theta m_{16}$	−1.16	(0.19)
Sweden	S_{17}	0.01	(0.12)	$-\theta m_{17}$	−0.02	(0.22)
United Kingdom	S_{18}	1.37	(0.12)	$-\theta m_{18}$	0.81	(0.19)
United States	S_{19}	3.98	(0.14)	$-\theta m_{19}$	2.46	(0.25)

Total Sum of squares	2937	Error Variance:	
Sum of squared residuals	71	Two-way ($\theta^2\sigma_2^2$)	0.05
Number of observations	342	One-way ($\theta^2\sigma_1^2$)	0.16

Technology and Absolute Advantage

Country	Estimated Source-country Competitiveness	Implied States of Technology		
		$\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Australia	0.19	0.27	0.36	0.20
Austria	−1.16	0.26	0.30	0.23
Belgium	−3.34	0.24	0.22	0.26
Canada	0.41	0.46	0.47	0.46
Denmark	−1.75	0.35	0.32	0.38
Finland	−0.52	0.45	0.41	0.50
France	1.28	0.64	0.60	0.69
Germany	2.35	0.81	0.75	0.86
Greece	−2.81	0.07	0.14	0.04
Italy	1.78	0.50	0.57	0.45
Japan	4.20	0.89	0.97	0.81
Netherlands	−2.19	0.30	0.28	0.32
New Zealand	−1.20	0.12	0.22	0.07
Norway	−1.35	0.43	0.37	0.50
Portugal	−1.57	0.04	0.13	0.01
Spain	0.30	0.21	0.33	0.14
Sweden	0.01	0.51	0.47	0.57
United Kingdom	1.37	0.49	0.53	0.44
United States	3.98	1.00	1.00	1.00

Notes: The estimates of source-country competitiveness are the same as those shown in Table III. For an estimated parameter $\widehat{S}_i$, the implied state of technology is $T_i = (e^{\widehat{S}_i} w_i^{\theta})^{\beta}$. States of technology are normalized relative to the U.S. value.

"Geographic" Barriers

Source of Barrier	Estimated Geography Parameters	Implied Barrier's % Effect on Cost		
		$\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Distance [0, 375)	−3.10	45.39	136.51	27.25
Distance [375, 750)	−3.66	55.67	176.74	32.97
Distance [750, 1500)	−4.03	62.77	206.65	36.85
Distance [1500, 3000)	−4.22	66.44	222.75	38.82
Distance [3000, 6000)	−6.06	108.02	439.04	60.25
Distance [6000, maximum]	−6.56	120.82	518.43	66.54
Shared border	0.30	−3.51	−7.89	−2.27
Shared language	0.51	−5.99	−13.25	−3.90
European Community	0.04	−0.44	−1.02	−0.29
EFTA	0.54	−6.28	−13.85	−4.09
Destination country:				
Australia	0.24	−2.81	−6.35	−1.82
Austria	−1.68	22.46	59.37	13.94
Belgium	1.12	−12.65	−26.74	−8.34
Canada	0.69	−7.99	−17.42	−5.22
Denmark	−0.51	6.33	15.15	4.03
Finland	−1.33	17.49	44.88	10.94
France	0.22	−2.61	−5.90	−1.69
Germany	1.00	−11.39	−24.27	−7.49
Greece	−2.36	32.93	92.45	20.11
Italy	0.07	−0.86	−1.97	−0.56
Japan	1.59	−17.43	−35.62	−11.60
Netherlands	1.00	−11.42	−24.33	−7.51
New Zealand	0.07	−0.80	−1.83	−0.52
Norway	−1.00	12.85	32.06	8.10
Portugal	−1.21	15.69	39.82	9.84
Spain	−1.16	14.98	37.85	9.40
Sweden	−0.02	0.30	0.69	0.19
United Kingdom	0.81	−9.36	−20.23	−6.13
United States	2.46	−25.70	−49.49	−17.40

Notes: The estimated parameters governing geographic barriers are the same as those shown in Table III. For an estimated parameter $\hat{d}$, the implied percentage effect on cost is $100(e^{-\hat{d}/\theta} - 1)$.

Gains From Trade

Country	Percentage Change from Baseline to Autarky					
	Mobile Labor			Immobile Labor		
	Welfare	Mfg. Prices	Mfg. Labor	Welfare	Mfg. Prices	Mfg. Wages
Australia	−1.5	11.1	48.7	−3.0	65.6	54.5
Austria	−3.2	24.1	3.9	−3.3	28.6	4.5
Belgium	−10.3	76.0	2.8	−10.3	79.2	3.2
Canada	−6.5	48.4	6.6	−6.6	55.9	7.6
Denmark	−5.5	40.5	16.3	−5.6	59.1	18.6
Finland	−2.4	18.1	8.5	−2.5	27.9	9.7
France	−2.5	18.2	8.6	−2.5	28.0	9.8
Germany	−1.7	12.8	−38.7	−3.1	−33.6	−46.3
Greece	−3.2	24.1	84.9	−7.3	117.5	93.4
Italy	−1.7	12.7	7.3	−1.7	21.1	8.4
Japan	−0.2	1.6	−8.6	−0.3	−8.4	−10.0
Netherlands	−8.7	64.2	18.4	−8.9	85.2	21.0
New Zealand	−2.9	21.2	36.8	−3.8	62.7	41.4
Norway	−4.3	32.1	41.1	−5.4	78.3	46.2
Portugal	−3.4	25.3	25.1	−3.9	53.8	28.4
Spain	−1.4	10.4	19.8	−1.7	32.9	22.5
Sweden	−3.2	23.6	−3.7	−3.2	19.3	−4.3
United Kingdom	−2.6	19.2	−6.0	−2.6	12.3	−6.9
United States	−0.8	6.3	8.1	−0.9	15.5	9.3

Notes: All percentage changes are calculated as $100\ln(x'/x)$ where x' is the outcome under autarky ($d_{ni} \to \infty$ for $n \neq i$) and x is the outcome in the baseline.

Equilibrium Effects of Technology Improvements

	Welfare Consequences of Improved Technology			
	Higher U.S. State of Technology		Higher German State of Technology	
Country	Mobile Labor	Immobile Labor	Mobile Labor	Immobile Labor
Australia	27.1	14.9	12.3	4.4
Austria	9.3	2.9	61.8	5.4
Belgium	13.2	3.0	50.7	4.8
Canada	87.4	19.9	9.3	1.3
Denmark	12.2	6.2	62.5	7.1
Finland	11.3	4.3	37.5	3.0
France	10.1	4.2	39.2	3.0
Germany	9.7	−11.6	100.0	100.0
Greece	14.0	18.3	38.9	8.0
Italy	9.7	3.9	38.4	3.0
Japan	6.6	−0.8	5.9	−0.2
Netherlands	12.8	6.8	63.5	8.3
New Zealand	33.8	13.5	15.6	3.9
Norway	13.2	11.7	43.8	6.1
Portugal	14.3	8.6	39.6	4.7
Spain	9.6	7.0	27.3	3.3
Sweden	12.8	1.1	42.7	2.3
United Kingdom	14.6	0.5	38.3	1.6
United States	100.0	100.0	9.7	1.4

Notes: All numbers are expressed relative to the percentage welfare gain in the country whose technology expands. Based on a counterfactual 20 per cent increase in the state of technology for either the United States or Germany.

4. The Ricardian Model: Empirics.

Hummels & Skiba (2004). "Shipping the Good Apples Out"

- Motivation: Alchian and Allen (1964) argued the presence of per unit transaction costs lowers the relative price of high "quality" goods.
- But modern trade models assume trade costs are multiplicative (i.e., iceberg) in order to generate a gravity model.
- If true, per unit transport costs would induce exporting firms to ship high quality products abroad while selling low quality products domestically.
- **Research Question:** Does the Alchian-Allen (AA) conjecture exist in international trade data?

Empirical Approach

1. Develop simple theory to demonstrate key economic mechanism as well as inform later regressions.
2. Test the AA conjecture using a unique data set of imports to six countries

Data

- Import data for six countries at 6-digit HS level.
  - Argentina, Brazil, Chile, Paraguay, Uruguay, United States.
  - Total freight bill paid (F_{ijk}).
  - "Freight on Board" (f.o.b.) shipment values ($V_{ijk} - F_{ijk}$).
  - Weight (WGT_{ijk}).
  - Ad valorem tariffs (t_{ijk}).
- Per unit freight is

$$f_{ijk} = \frac{F_{ijk}}{WGT_{ijk}}$$

- f.o.b. price is

$$p_{ijk} = \frac{V_{ijk} - F_{ijk}}{WGT_{ijk}}$$

$\Rightarrow$ "price" is a bundle of low and high quality products.

Results: Elasticity of Freight Rates

Determinants of Freight Costs
Dependent Variable: ln(Freight Cost)

	Variables (in Logs)				
	Price β	Distance δ	Quantity ω	R^2	Observations
			All Countries		
OLS	.64 (.0012)	.26 (.0019)	−.12 (.0005)	.64	275,398
IV	.61 (.0048)	.25 (.0020)	−.18 (.0022)	…	254,031
			U.S. Sample		
OLS	.716 (.0017)	.114 (.0017)	−.219 (.0024)	.83	299,409
IV	.125 (.0138)	.221 (.0050)	−.480 (.0142)	…	277,756

Note.—The estimating equation is eq. (10) in the text. For the instrumental variable estimates, price and quantity are instrumented by tariffs and exporter and importer GDP per capita.

- (Top Panel) Elasticity wrt price (β) is ≈ 0.6 but iceberg trade costs $\Rightarrow$ it's one.
- (Bottom Panel) As goods become for homogenous, shipping technology best represented by per unit costs (i.e., elas β is small).

Results: Test for AA Conjecture

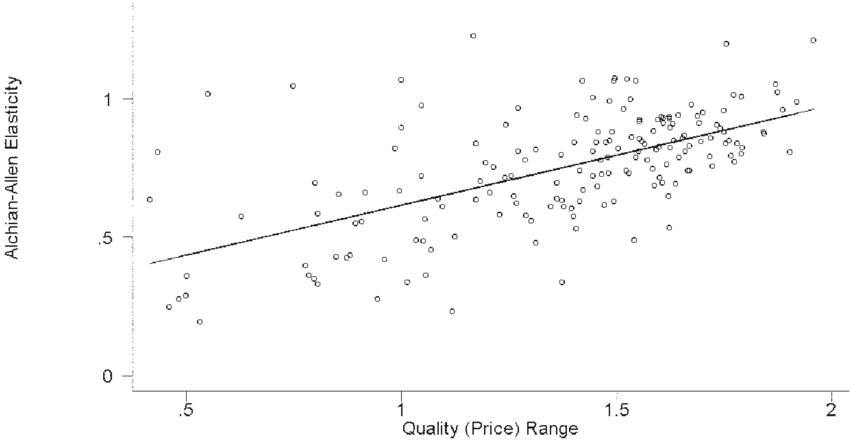
Dependent Variable: ln(Price)

	Variables (in Logs)				
	Freight Cost ϕ	Tariff τ	GDP per Capita (Importer) γ_1	GDP per Capita (Exporter) γ_2	Observations
	Instruments: Shipment Weight and Distance				
Eq. (11)	.798	−1.56	.46	.20	254,031
	(.0023)	(.0368)	(.0044)	(.0029)	
Eq. (12)	.84	−1.46	.53	...	275,398
	(.0026)	(.0289)	(.0036)		
	Instruments: Lagged Values of Price				
Eq. (11)	1.33	−2.56	.34	−.03	91,989
	(.0072)	(.0787)	(.0092)	(.0067)	
Eq. (12)	1.41	−2.28	.62	...	100,118
	(.0144)	(.0689)	(.0087)		

Note.—For eq. (11), all variables are commodity differenced. For eq. (12), all variables are exporter commodity differenced.

- Price variation **increasing** in per unit freight costs.
- Price variation **decreasing** in ad valorem tariffs.

Results: AA and Product Heterogeneity



- Theory predicts greater AA effect in industries with larger differences in price.
- Figure 1 seems to support this.

Waugh (2010). "International Trade and Income Differences"

- Motivation:
  1. All countries exhibit "home bias."
  2. Low pc gdp (i.e., poor) countries import a lot from rich countries but the opposite is not true.
  3. There exists little price variation in aggregate tradable goods across countries.
  4. EK02 has difficulty matching the pattern of trade when poor countries are included.
- **Research Questions:**
  1. What trade costs between rich, poor countries are necessary to reconcile these data facts?
  2. If trade costs changed (e.g., trade liberalization), how would cross-country income differences change?

Data Fact 1: Home Bias Across Rich and Poor.

Table 1—1996 Trade Share Data, X_{ij}, in Percent for Selected Countries

	US	Canada	Japan	Mexico	China	Senegal	Malawi	Zaire
US	83.25	39.73	2.27	31.62	3.63	2.16	1.57	2.93
Canada	3.78	49.21	0.21	0.72	0.32	0.56	0.67	0.51
Japan	3.04	2.01	92.56	1.59	6.99	1.34	2.65	0.82
Mexico	1.88	1.33	0.02	61.09	0.057	0.01	0	0.007
China	1.78	1.41	1.44	0.30	77.61	2.69	2.50	6.81
Senegal	0*	0*	0*	0	0*	52.68	0	0
Malawi	0*	0*	0*	0	0	0	41.52	0
Zaire	0.003	0.005	0.003	0*	0*	0	0	51.53

Notes: Entry in row *i*, column *j*, is the fraction of goods country *j* imports from country *i*. Zeros with stars indicate the value is less than 10^{-4}. Zeros without stars are zeros in the data.

Data Fact 2: Systematically Asymmetric Trade Flows.

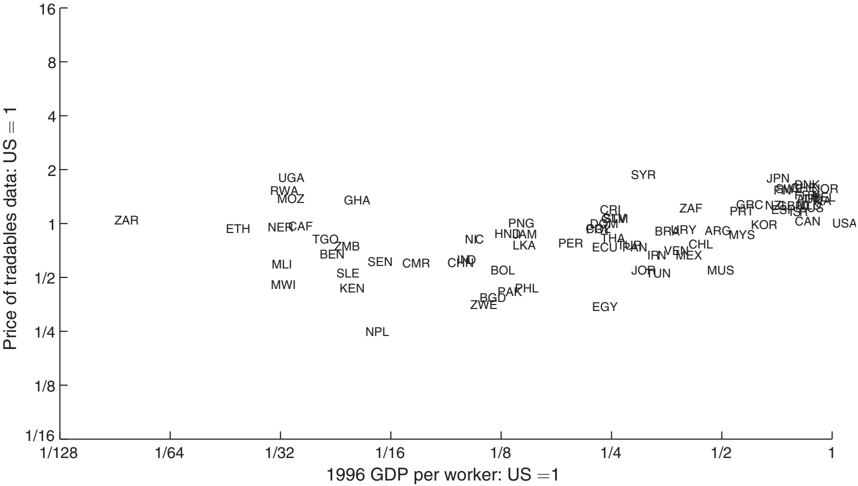
TABLE 1—1996 TRADE SHARE DATA, X_{ij}, IN PERCENT FOR SELECTED COUNTRIES

	US	Canada	Japan	Mexico	China	Senegal	Malawi	Zaire
US	83.25	39.73	2.27	31.62	3.63	2.16	1.57	2.93
Canada	3.78	49.21	0.21	0.72	0.32	0.56	0.67	0.51
Japan	3.04	2.01	92.56	1.59	6.99	1.34	2.65	0.82
Mexico	1.88	1.33	0.02	61.09	0.057	0.01	0	0.007
China	1.78	1.41	1.44	0.30	77.61	2.69	2.50	6.81
Senegal	0^*	0^*	0^*	0	0^*	52.68	0	0
Malawi	0^*	0^*	0^*	0	0	0	41.52	0
Zaire	0.003	0.005	0.003	0^*	0^*	0	0	51.53

Notes: Entry in row i, column j, is the fraction of goods country j imports from country i. Zeros with stars indicate the value is less than 10^{-4}. Zeros without stars are zeros in the data.

- Poor countries import from rich (NE quadrant).
- Rich countries import little from poor (SW quadrant).

Data Fact 3: Prices of Tradable Goods Vary Little.



- Data from UN International Comparison Program which collects prices on comparable goods.
- Others find a similar result.

Mechanism

- Trade occurs because of differences in prices (via high productivity, low wages) or trade costs.

$$\frac{X_{ij}}{X_{jj}} = \tau_{ij}^{-1/\theta} \times \left(\frac{p_j}{p_i}\right)^{-1/\theta}$$

- Divide this equation for country j by the same for country i:

$$\underbrace{\left(\frac{X_{ij}}{X_{ji}}\frac{X_{ii}}{X_{jj}}\right)}_{\text{Obs 1 and 2}} \times \underbrace{\left(\frac{p_j}{p_i}\right)^{2/\theta}}_{\text{Obs 3}} = \left(\frac{\tau_{ij}}{\tau_{ji}}\right)^{-1/\theta}$$

- In symmetric world, $\left(\frac{X_{ij}}{X_{ji}}\frac{X_{ii}}{X_{jj}}\right) = 1$. Observations 1,2 tell us this is not the case.
- Since $\frac{p_j}{p_i} \approx 1$, trade costs most be systematically different across rich and poor countries.

Empirical Approach

- Combine standard GE gravity model (EK02) with neoclassical growth model.

  - Modify EK02 to include capital and importer fixed effects.

  - Trade costs include exporter fixed effect $\Rightarrow$ exporter fixed effect in gravity model.

  - EK02 used exporter fixed effects.

- Illustrate key mechanisms in a simple three country version.
- Estimate key parameters of the full model.
  - Shows the model is able to replicate the motivating data facts.
- Illustrate quantitative importance of the asymmetries in cost via CF experiments.

Solving the Equilibrium

- Estimate (d_k, b_{ij}, S_i, S_j) using gravity equation:

$$\begin{aligned} \log\left(\frac{X_{ij}}{X_{ii}}\right) &= S_j - S_i - \frac{1}{\theta}\log\tau_{ij} \\ \text{where } \tau_{ij} &= d_k + b_{ij} + ex_j + \epsilon_{ij} \\ \Rightarrow \tilde{S}_j &= S_j - \frac{1}{\theta}ex_j \end{aligned}$$

- Compute price indices:

$$\hat{p}_i = \Upsilon\left(\sum_{j=1}^{N} exp(\hat{S}_j)\hat{\tau}_{ij}\right).$$

- Assume trade balances to recover wages:

$$w_i = \sum_{j=1}^{N}\frac{L_j}{L_i}w_j X_{ji}, \text{ where } L = \text{population}.$$

- Wages + capital-labor rates $\Rightarrow$ capital rental rates $\{r_i\}$.
- Put everything together to get $\{\lambda_i\}$.

Other Stuff

- Estimate θ using price data following EK02.
- Real GDP in the data is different than in model so need a mapping.

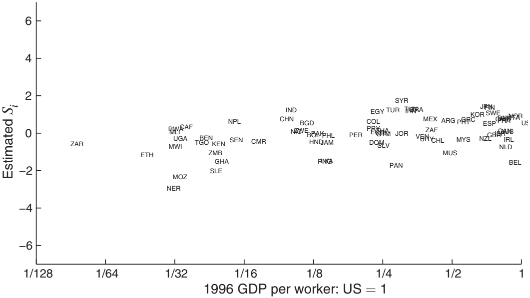
$$\underbrace{y_i}_{\text{GDP/worker}} = A_i k_i^{\alpha}$$

$$\text{where } A_i = X_{ii}^{\left(\frac{-\theta(1-\gamma)}{\beta}\right)} \lambda_i^{\left(\frac{\theta(1-\gamma)}{\beta}\right)}$$

⋆ If λ is fixed then TFP, GDP/worker (y_i) are only a function of the import share (i.e., of openness).

Exporter (Top) vs Importer (Bottom) FEs

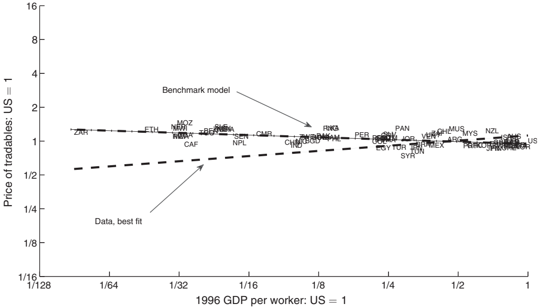
Panel A. S_i from model with exporter fixed effect



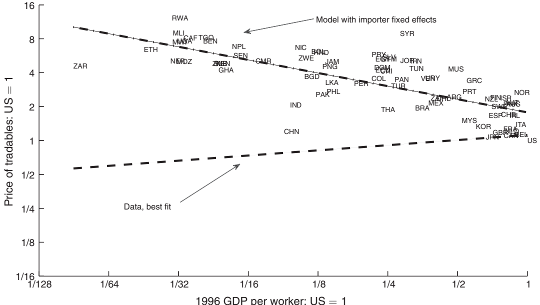
Panel B. S_i from model with importer fixed effect

Exporter (Top) vs Importer (Bottom) FEs

Panel A. Price data and benchmark model



Panel B. Price data and model with importer fixed effects



Real Income per Worker Across Countries

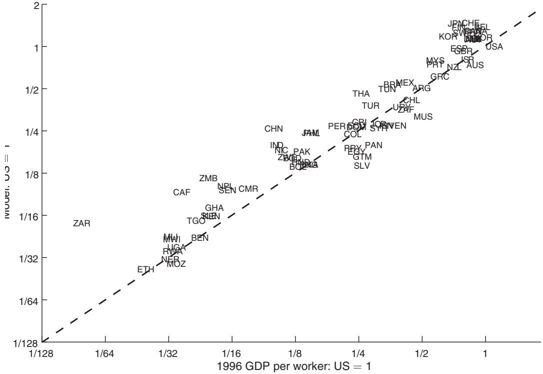


Figure 5. Income per Worker: Data and Benchmark Model

Implications

TABLE 4—INCOME DIFFERENCES WITH COUNTERFACTUAL TRADE COSTS

	Baseline	Autarky	$\min(\tau_{ij},\tau_{ji})$	OECD τ	$\tau_{ij} = 1$
var $[\log(y)]$	1.30	1.35	1.05	1.13	0.76
y_{90}/y_{10}	25.7	23.5	17.3	19.8	11.4
Mean change in y, percent	—	−10.5	24.2	10.0	128.0

- Eliminating trade cost asymmetries ("$\min(\tau_{ij}, \tau_{ji})$" column) reduces inequality (y_{90}/y_{10}) significantly (32%).
- Eliminating asymmetry achieves 59% of the reduction in income differences achieved under frictionless trade.
- Imposing autarky has little effect on income differences.

Implications

- Trade cost asymmetries matter for understanding differences in income across the world.
- But what are these differences? To what extent are they:
  - Technology,
  - Policy,
  - Cultural,
  - Other?

Fieler (2010). "Nonhomotheticity and Bilateral Trade"

- Motivation:
  1. Most trade theory (i.e., gravity models) predicts trade is increasing in GDP but not correlated with GDP per capita.
  2. But rich countries tend to trade with other rich countries.
  3. And poor countries tend to not trade at all.
- **Research Question:**
  1. Can differences in the income elasticity of trade reconcile this?

Mechanism

- Non-homothetic preferences plus technology parameters that differ by country type allows countries to specialize.
- Rich countries consume and trade differentiated goods (good A).
- Poor countries consume homogenous, low cost goods (good B).

Mechanism

- Utility

$$U_i = \sum_{\tau=1}^{S} \left[\underbrace{\alpha^{\frac{1}{\sigma_\tau}}}_{\text{weight}} \left(\frac{\sigma_\tau}{\sigma_\tau - 1} \right) \underbrace{\int_0^1 q_{j_\tau}^{\left(\frac{\sigma_\tau - 1}{\sigma_\tau}\right)} dj_\tau}_{\substack{\text{goods purchased from} \\ \text{N countries}}} \right]$$

where $1 < \sigma_\tau \equiv$ elasticity of substitution for good τ.

- From FOCs, spending on type 1 relative to type two implies:

$$\frac{X_1}{X_2} = \lambda^{\sigma_2 - \sigma_1} \left(\frac{\alpha_1 p_1^{1-\sigma_1}}{\alpha_2 p_2^{1-\sigma_2}} \right)$$

where $\lambda \equiv$ Lagrange multiplier on income.

- If $\sigma_1 > \sigma_2$, $\frac{X_1}{X_2}$ decreasing in λ and increasing in income.

Trade Patterns

- Demand is

$$\frac{X_{nA}}{X_{nB}} = (\lambda_n)^{\sigma_B - \sigma_A} \left(\frac{\alpha_A p_{nA}^{1-\sigma_A}}{\alpha_B p_{nB}^{1-\sigma_B}} \right)$$

  ⋆ if $\sigma_A > \sigma_B$ rich countries consume for of A than B.

- Supply is

$$\begin{aligned} \frac{X_{niA}}{X_{nnA}} &= \frac{T_i}{T_n} \left(\frac{d_{ni} w_i}{w_n} \right)^{-\theta_A} \\ \frac{X_{niB}}{X_{nnB}} &= \frac{T_i}{T_n} \left(\frac{d_{ni} w_i}{w_n} \right)^{-\theta_B} \end{aligned}$$

  ⋆ if $\theta_A > \theta_B$ rich countries consume products where tech. differences matter while poor countries consume products where only cost matters.

- Rich countries trade more b/c they "care" more about $\{T_i\}$ and less about trade barriers (i.e., costs). They trade more with rich countries b/c in equilibrium these countries have higher Ts (equivalently, data + model tells us they have greater Ts).

A Problem

- Model does not generate a gravity equation so estimating trade costs is much more difficult.
- She shows this might be a worth-while effort if you're interested in a question about income inequality.

Solving the Model

- Use data for L, w where GDP per capita used as a proxy for wages (w).
- Guess $\Theta = \{d_{ni}, \alpha_A, \theta_B, \sigma_A\}$.
- Solve for $\{T_i\}$.
- Solve for trade flows $z_{ni}(\Theta; w, L, \tilde{Y}) = \frac{X_{ni}(\Theta; w, L, \tilde{Y})}{X_n(\Theta; w, L, \tilde{Y}) \times X_i(\Theta; w, L, \tilde{Y})}$.
- Solve (via NLLS) for the Θ vector s.t. the model generates normalized trade flows z as close as possible to what we observe in the data:

$$z^d - z(\Theta; w, L, \tilde{Y}) = \epsilon$$

where z^d is the vector of normalized trade flows in the data, Θ is the parameter vector and $\tilde{Y}$ are "geopolitical characterstics" such as distance, common border, etc.

* NB, my notation differs from the author's.

Estimation Results

	EK Model		New Model	
	OECD Only	Full Sample	Specification 1	Specification 2
Normalized parameters				
θ_A	8.28	8.28	8.28	8.28
σ_A			5.00	
Estimated parameters				
γ_1	1.24	1.96	1.38	1.28
	(0.10)	(0.08)	(0.04)	(0.07)
γ_2	0.84	0.26	0.20	0.13
	(0.23)	(0.09)	(0.03)	(0.03)
γ_3	−0.21	0.00	−0.01	0.00
	(0.09)	(0.03)	(0.00)	(0.00)
Border	0.98	0.85	0.99	0.94
	(0.06)	(0.05)	(0.07)	(0.05)
Language	1.01	0.92	0.93	0.93
	(0.10)	(0.06)	(0.05)	(0.05)
Trade agreement	0.91	1.27	1.22	1.24
	(0.04)	(0.12)	(0.12)	(0.09)
θ_B			14.34	19.27
			(0.95)	(3.89)
$(\alpha_A)^{1/\sigma_A}$			0.82	
			(0.03)	
σ_B			1.29	
			(0.10)	
R^2	74%	34%	42%	67%
Number of observations	342	25,810	25,810	25,810

[a] Standard errors in parentheses are clustered by importer and exporter.

- Three new parameters: $\sigma_A, \sigma_B, \theta_B$.
- Model better predicts trade flows ($R^2 = \{42\%, 67\%\} > 34\%$.)

Trade Shares and Income per Capita

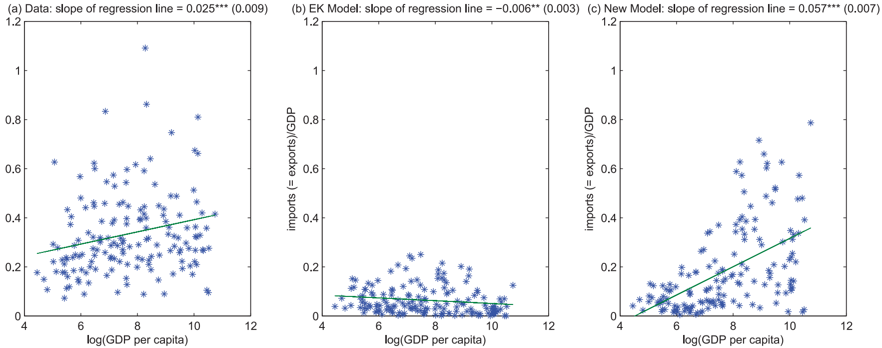
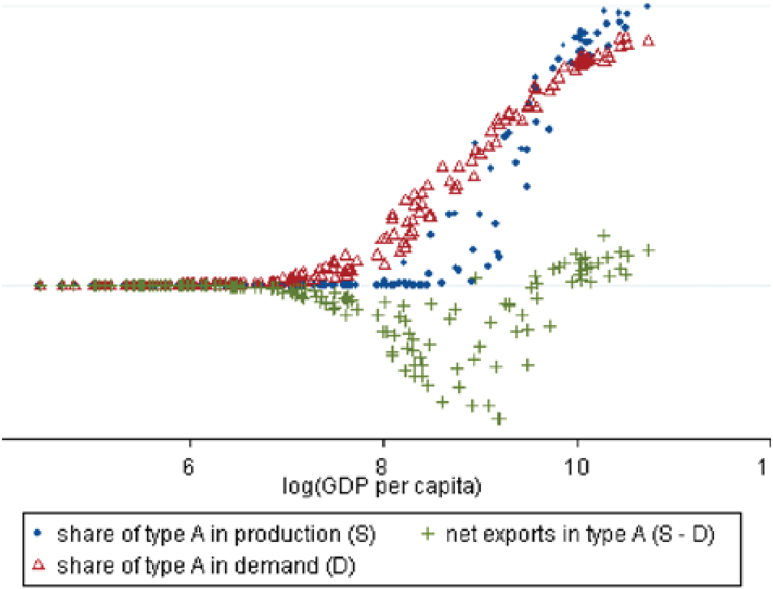


FIGURE 3.—Income per capita × trade share.

- Trade shares are increasing in GDPpc (left panel).
- EK02 isn't flexible enough to generate this (middle panel).
- Model with non-homothetic preferences can (right panel).

Pattern of Trade



Experiments

- Experiments intended to illustrate mechanisms rather than provide policy guidance.
- Increase Chinese technology (T) until wage increases 300% relative to world. This experiment is meant to mirror the observed growth of China.
  - China becomes rich so consumes more A.
  - Demand for A increases so $P_A \uparrow$.
  - Welfare in rich increases because they produce A.
  - Rich countries consumer less B so $P_B \downarrow$ and poor countries benefit.
  - Middle income countries have high w but low T and import A so they're worse off.
  - So Chinese getting richer benefits rich and poor while hurting middle-income (consistent with data: Leamer-2007).
- US shock inverts China result since greater US T decreases P_A.

5. The Extensive Margin

Hummels & Klenow (2005). “The Variety and Quality of a Nation's Exports'

- Motivation: Theory accurately predicts that large countries export more in absolute value than small countries. They differ in the mechanism:
  - Armington - all intensive margin.
  - Krugman - all extensive margin.
  - Grossman - differences in quality.
- We care b/c theories $\Rightarrow$ different welfare affects.
  1. If intensive margin, trade occurs at lower prices.
  2. If more varieties (or higher quality), prices still high so trade exacerbates income inequality (unless technology diffusion and/or diminishing returns.
- **Research Question:** What is the composition of trade and how does it vary across country size / wealth?

Empirical Approach & Identification

1. Develop simple theory to decompose aggregate trade flows into share from intensive and extensive margins.
2. Merge with detailed trade data (HS six-digit) including shipment values and quantities for 126 countries.
3. Margins and correlations with country size are identified by differences in value, price, and quantity of trade flows across countries.

Model

- Consumer utility:

$$U_m = \left[\sum_{j=1}^{J} \sum_{i=1}^{I} Q_{jmi} N_{jmi} x_{jmi}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

subject to $\sum_{j=1}^{J} \sum_{i=1}^{I} N_{jmi} p_{jmi} x_{jmi} \leq Y_m$

- $I \equiv$ industry, $Q \equiv$ quality, $N \equiv$ varieties,$x \equiv$ quantity, $V = N \times I$.

Predictions

- Armington: country j exports quantities and prices are

$$\begin{aligned} lnx_j &= \frac{\sigma}{\sigma-1} ln\left(\frac{Y_j}{L_j}\right) + \frac{\sigma}{\sigma-1} lnL_j \\ lnp_j &= \frac{-1}{\sigma-1} ln\left(\frac{Y_j}{L_j}\right) + \frac{-1}{\sigma-1} lnL_j \end{aligned}$$

  so large countries export high quantities at low prices.

- Krugman:
  - Neither prices nor quantity vary with gdppc.
- Quality:
  - Quantity per variety correlated with employment but not gdppc.
  - Price per variety correlated with gddpc but not employment.

$$\begin{aligned} x_j &= L_j \\ p_j &= Q_j L_j^{-1/\sigma} \\ \frac{Y_j}{L_j} &= Q_j L_j^{-1/\sigma} \end{aligned}$$

Predictions

TABLE 1—MODEL PREDICTIONS FOR EXPORT MARGINS

	Intensive (px)	Extensive (V)	Price (p)	Quantity (x)
Armington	1	0	$-1/(\sigma - 1)$	$\sigma/(\sigma - 1)$
Acemoglu & Ventura				
Y/L	1	0	-0.6	1.6
L	0	1	0	0
Krugman	0	1	0	0
Quality differentiation	1	0		
Y/L			1	0
L			0	1

Notes: For discussion of each model, see Section I in the text. Entries are model predictions for how exports increase with respect to exporter size. A single entry indicates the same elasticity with respect to both Y/L (GDP per worker) and L (employment). The Acemoglu and Ventura price and quantity elasticities with respect to Y/L are equal to $-1/(\sigma - 1)$ and $\sigma/(\sigma - 1)$, but these take on the values -0.6 and 1.6 for their case of $\sigma = 2.6$.

Data

- Use trade data for 126 countries at the HS six-digit level (5,017 "goods").
- Data includes shipment values and quantities.
- Include employment and GDP data.
- Construct empirical counterparts of the model to decompose margins:
  - intensive margin (px).
  - category extensive margins (I).
  - price (p).
  - quantity (x).

Empirical Extensive and Intensive Margins

- "Extensive Margin" (EM)

$$EM_{jm} = \frac{\sum_{i \in I_{jm}} p_{kmi} x_{kmi}}{\sum_{i \in I_{m}} p_{kmi} x_{kmi}}$$

  $\approx$ weighted count of j's exports relative to country $k \equiv$ a reference country (ROW). If all categories are of equal importance, EM_{jm} is the fraction of country j goods exported to m.

- "Intensive Margin" (IM)

$$IM_{jm} = \frac{\sum_{i \in I_{jm}} p_{jmi} x_{jmi}}{\sum_{i \in I_{jm}} p_{kmi} x_{kmi}}$$

  $\equiv$ country j's nominal exports to country m relative to k's in categories which j exports to m.

Aggregate Variables

- Apply geometric means to get variables of interest:

$$
\begin{aligned}
IM_j &= \Pi_m \left(IM_{jm}\right)^{a_{jm}} \\
EX_j &= \Pi_m \left(EX_{jm}\right)^{a_{jm}} \\
P_j &= \Pi_m \left(P_{jm}\right)^{a_{jm}} \\
X_j &= \Pi_m \left(X_{jm}\right)^{a_{jm}}
\end{aligned}
$$

where $a_{jm} \equiv$ logarithmic mean of the shares of m in exports of j s.t. sum to one.

Data + Empirics

- Use trade data for 126 countries at the HS six-digit level (5,017 “goods”).
- Data includes shipment values and quantities.
- Include employment and GDP data.
- Construct empirical counterparts of the model to decompose margins:
  - intensive margin: $px \rightarrow IM_j$.
  - category extensive margins: $I_j \rightarrow EX_j$.
  - price: $p_j \rightarrow P_j$.
  - quantity: $x_j \rightarrow X_j$.

- Regress log of each on GDP share (size), GDP per worker, log employment.

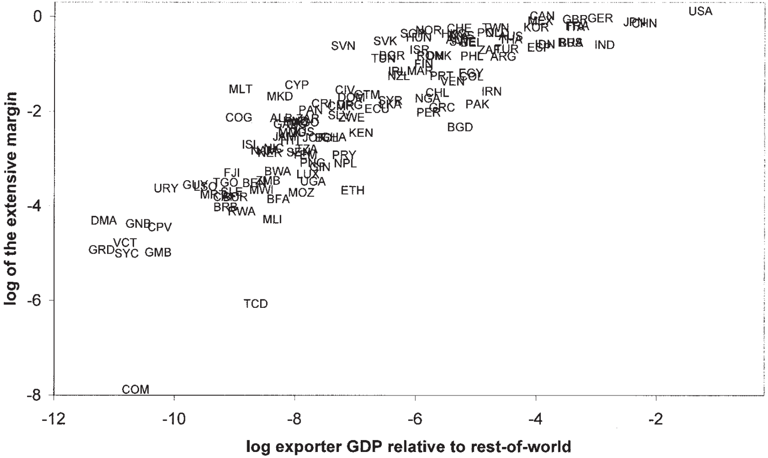
Results

TABLE 2—EXTENSIVE AND INTENSIVE MARGINS

Independent variable → Dependent variable ↓	Y/L	L	Adj. R^2	Y	Adj. R^2
Overall exports	1.29 (0.07)	0.89 (0.04)	0.86	1.00 (0.04)	0.83
Intensive margin	0.44 (0.05) 34%	0.36 (0.03) 41%	0.60	0.38 (0.03) 38%	0.60
Extensive margin	0.85 (0.05) 66%	0.53 (0.03) 59%	0.79	0.61 (0.03) 62%	0.74

- Results don't support any one model.
- 38% of trade is intensive margine vs 62% extensive margin.
- Extensive margin more importance for richer countries (66%) than for countries with more workers (59%).
- Richer countries export more volume (34%).

Results



- Extensive margin increases in importance as a country gets richer.

Results

TABLE 3—PRICE AND QUANTITY COMPONENTS OF THE INTENSIVE MARGIN

Independent variable → Dependent variable ↓	Y/L	L	Adj. R^2	Y	Adj. R^2
Prices	0.09 (0.02)	−0.01 (0.01)	0.14	0.02 (0.01)	0.01
Quantities	0.34 (0.05)	0.37 (0.03)	0.58	0.36 (0.03)	0.58

- Results don't support any one model.
- Countries with 2x employment export 37% more but charge no higher prices.
- Richer countries export more volume (34%) **and charge higher prices**.

Reconciling the Data

- Extensive margin matters so need varieties.
- Need diminishing returns or technology diffusion to keep the income distribution stable. Why?
- Need quality differentiation to explain price facts.
- Need fixed export costs to explain why not all firms export.

Dickstein & Morales (2016). "What do Exporters Know?'

- Motivation: Much of the variation international trade is driven by the extensive margin.
  e.g., There exist a lot of zeros in bilateral trade flows: Helman, Melitz Rubinstein (QJE 2008).
- Predicting how exports may change due to lower trade costs, lower tariffs, exchange rate movements, or other policies requires knowledge of how firms make export participation decisions.
- **Research Question:** What do exporters know?

Empirical Approach

- Build two-period, partial equilibrium model of export participation with uncertainty.
- Show how modeling the firm's decision problem / information set impacts estimated export fixed costs and therefore policy implications.
- Use moment inequalities to identify variables which are informative for firm export decisions.
- Demonstrate the implications for trade policy of different estimates.

The Burden of Moment Inequalities

- Estimating the model will be more difficult than when the researcher imposes how firms make expectations.
- Need to show that placing less restrictions on firm expectations matters for both the estimates of export costs and predictions for export participation, flows under counterfactual trade costs.
- The estimation will generate sets of parameters which are consistent with the data (versus a single value as in OLS). These bounds must be small enough to be informative.

Model

- Two periods
- Partial equilibrium.
- Firms choose whether to export but face uncertainty about foreign market profits.
- Timing:
  1. Firms choose the set of countries they wish to export to.
  2. Firms acquire all information required to set optimal prices. They produce, pay trade costs, and earn export profits.

Model

- Isoelastic demand (e.g., CES)
- Export revenue

$$
\begin{aligned}
r_{ijt} &= \left[\frac{\eta}{\eta-1} \times \frac{\tau_{jt} c_{it}}{P_j t}\right]^{1-\eta} Y_{jt} \\
\eta > 1 &\equiv \text{elasticity of substition} \\
c_{it} &\equiv \text{marginal cost of firm i} \\
\tau_{jt} &\equiv \text{iceberg trade cost} \\
P_{jt} &\equiv \text{price index which captures competition in country j} \\
Y_{jt} &\equiv \text{market size}
\end{aligned}
$$

- Export profits

$$
\begin{aligned}
\pi_{ijt} &= \frac{r_{ijt}}{\eta} - f_{ijt} \\
f_{ijt} &\equiv \text{fixed export costs of firm i} \\
&= \beta_0 + \beta_1 dist_j + \nu_{ijt} \\
\nu_{ijt} &\sim N(0, \sigma^2)
\end{aligned}
$$

Decision to Export

- Period 1 expected export profits

$$\mathbb{E}[\pi_{ijt}|\mathcal{J}_{ijt}, dist_j, \nu_{ijt}] = \eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j - \nu_{ijt}, \tag{6}$$

where $\mathcal{J}_{ijt} \equiv$ firm i information set about export market j in period t.

- Firm exports if expected profit greater than fixed export costs:

$$d_{ijt} = \mathbb{1}\{\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j - \nu_{ijt} \geq 0\}, \tag{7}$$

- Probability firm i exports to j conditional on information set $\mathcal{J}$:

$$\begin{aligned}\mathcal{P}(d_{ijt} = 1|\mathcal{J}_{ijt}, dist_j) &= \int_\nu \mathbb{1}\{\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j - \nu \geq 0\}\phi(\nu)d\nu \\ &= \Phi\big(\sigma^{-1}\big(\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j\big)\big), \end{aligned} \tag{8}$$

- Set $\eta = 5$. Need to estimate $\theta = \{\beta_0, \beta_1, \sigma^2\} \equiv f_{ijt}$.

Data

- Two sources:
  1. Chilean customs covering all exports of Chilean firms from 1995 to 2005.
  2. Chilean Annual Industrial Survey which surveys all manufacturing plants with at least 10 workers.
- Two sectors: manufacturing of chemicals, food products.
- Observe exporting to 22 countries in chemicals, 34 countries in food.

Year	Share of exporters	Exports per exporter (mean)	Exports per exporter (med)	Domestic sales per firm (mean)	Domestic sales per exporter (mean)	Destinations per exporter (mean)
Chemical Products						
1996	35.7%	2.18	0.15	13.23	23.10	4.24
1997	36.1%	2.40	0.19	13.29	22.99	4.54
1998	42.5%	2.41	0.17	14.31	22.25	4.35
1999	38.7%	2.60	0.19	14.43	23.95	4.53
2000	37.6%	2.55	0.21	14.41	25.93	4.94
2001	39.8%	2.35	0.12	12.89	21.92	4.68
2002	38.7%	2.37	0.15	13.25	23.73	4.95
2003	38.0%	3.08	0.17	10.41	19.54	5.11
2004	37.6%	3.27	0.15	10.05	18.70	5.17
2005	38.0%	3.58	0.11	12.50	21.65	5.19
Food						
1996	30.1%	7.47	2.59	9.86	13.68	5.93
1997	33.1%	6.97	2.82	10.56	15.32	6.23
1998	33.3%	7.49	2.86	10.05	14.80	6.34
1999	32.3%	6.71	2.37	9.67	14.88	6.74
2000	30.6%	6.49	2.21	8.44	13.33	5.93
2001	28.0%	6.48	1.74	8.70	14.08	6.09
2002	27.2%	7.82	2.01	7.83	13.59	6.86
2003	29.8%	7.60	1.68	7.15	12.79	6.15
2004	28.5%	9.25	1.68	8.05	13.85	6.69
2005	25.8%	10.72	2.43	9.88	16.27	7.05

Notes: All variables (except "share of exporters") are reported in millions of USD in year 2000 terms.

- Observe 266 firms in chemical sector:
  - 38% export to at least one market in a year.
  - Avg firm exports to 4-5 countries.
- Observe 372 firms in food sector:
  - 30% export to at least one market in a year.
  - Avg firm exports to 6-7 countries.

Empirical Approach

- Estimating θ requires placing restrictions on $\mathcal{J}$, i.e., we have to place restrictions on what firms know when they make export decisions.
- Three options explored:
  1. Perfect foresight so firms predict revenues exactly: $E[r_{ijt}|\mathcal{J}_{ijt}] = r_{ijt}$.
  2. Assume information set is previous domestic sales, aggregate exports to j in previous year, distance to j.
  3. Assume what researcher sees $Z_{ijt} \subset \mathcal{J}_{ijt}$ is a subset of available info.

A Problem

- We need measures of export revenues for firms which export and those which do not.

  But we only observe export revenues for those firms that actually export!
- Use model to extrapolate revenues for non-exporters (i.e, solve for revenues they would have received had they exported.)
- Model implies
$$r_{ijt}^{obs} = \alpha_{jt} r_{iht}$$
- We observe domestic revenues for all firms (r_{iht}).
- Estimate α_{jt} using export profits
$$E_{jt}\left[r_{ijt}^{obs} - \alpha_{jt} r_{iht} | r_{iht}, d_{ijt} = 1\right] = 0$$

  assuming $r_{iht}^{obs} = d_{ijt}(r_{iht} + e_{iht})$ and $e_{iht} \equiv$ measurement error where the mean is $\perp$ of domestic revenue and export decision.

Estimates of Export Revenue Shifters

- Theory implies:

$$\alpha_{jt} \equiv \left[\frac{\tau_{jt}}{\tau_{ht}} \times \frac{P_{ht}}{P_{jt}} \right]^{1-\eta} \frac{Y_{jt}}{Y_{ht}}$$

  1. Increasing in destination country size Y_{jt}.
  2. Decreasing in distance.

	Chemicals			Food		
	Argentina	Japan	United States	Argentina	Japan	United States
Mean	0.59%	3.27%	3.37%	1.22%	14.39%	19.45%
Standard Deviation	0.38%	1.16%	4.28%	0.84%	4.18%	14.35%
Autocorrelation Coef.	0.68	0.36	0.18	-0.17	-0.08	0.24

Notes: For country-sector combination indicated by the first two rows, this table reports the mean, standard deviation and autocorrelation coefficient of the estimates of $\{\alpha_{jt}\}_{t=1995}^{t=2005}$.

- Results also indicate:
  - Sensible Home bias / Trade costs: $\tau_{jt} > \tau_{ht}$.
  - Autocorrelation: $E[\alpha_{jt+1}|\alpha_{jt}] \neq E[\alpha_{jt+1}]$.

Perfect Knowledge of the Information Set

- Estimate θ as the vector which maximizes the log-likelihood function:

$$\mathcal{L}(\theta|d, \mathcal{J}^a, dist) = \sum_{i,j,t} d_{ijt} \ln(\mathcal{P}(d_{jt} = 1|\mathcal{J}^a_{ijt}, dist_j; \theta)) + (1 - d_{ijt}) \ln(\mathcal{P}(d_{jt} = 0|\mathcal{J}^a_{ijt}, dist_j; \theta)), \quad (12)$$

where

$$\mathcal{P}(d_{jt} = 1|\mathcal{J}^a_{ijt}, dist_j; \theta) = \Phi\big(\theta_2^{-1}\big(\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}^a_{ijt}] - \theta_0 - \theta_1 dist_j\big)\big). \quad (13)$$

- Need to compute $\mathbb{E}[r_{ijt}|\mathcal{J}^a_{ijt}]$:
  - Perfect Foresight: $\mathbb{E}[r_{ijt}|\mathcal{J}^a_{ijt}] = \alpha_{jt} r_{iht}$.
  - Observed covariates: estimate $\mathbb{E}[r_{ijt}|\mathcal{J}^a_{ijt}]$ by projecting $\alpha_{jt} r_{iht}$ onto $\mathcal{J}^a_{ijt}$.

Partial Knowledge of Information Sets

- Researcher assumes he/she only observes a subset Z of the variables firms use to make their export decisions.
- Authors show you can partially identify θ using two types of moment inequalities.
- Odds-based moment inequalities:

$$\mathcal{M}^{ob}(Z_{ijt};\theta) = \mathbb{E}\left[\begin{array}{c} m_l^{ob}(d_{ijt}, r_{ijt}, dist_j;\theta) \\ m_u^{ob}(d_{ijt}, r_{ijt}, dist_j;\theta) \end{array} \middle| Z_{ijt} \right] \geq 0, \tag{15a}$$

where

$$m_l^{ob}(\cdot) = d_{ijt}\frac{1-\Phi\big(\theta_2^{-1}\big(\eta^{-1}r_{ijt}-\theta_0-\theta_1 dist_j\big)\big)}{\Phi\big(\theta_2^{-1}\big(\eta^{-1}r_{ijt}-\theta_0-\theta_1 dist_j\big)\big)} - (1-d_{ijt}), \tag{15b}$$

$$m_u^{ob}(\cdot) = (1-d_{ijt})\frac{\Phi\big(\theta_2^{-1}\big(\eta^{-1}r_{ijt}-\theta_0-\theta_1 dist_j\big)\big)}{1-\Phi\big(\theta_2^{-1}\big(\eta^{-1}r_{ijt}-\theta_0-\theta_1 dist_j\big)\big)} - d_{ijt}. \tag{15c}$$

- Ooof. Those inequalities are ugly! Where do they come from?

Intuition

- At true θ, revealed preference implies for an exporting firm:

$$\mathbb{1}\{\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j - \nu_{ijt} \geq 0\} - d_{ijt} = 0. \tag{16}$$

- But this requires us to specify unobserved ν and $\mathcal{J}$.
- Use assumption about ν to get rid of it by taking expectation conditional on $(\mathcal{J}, dist)$:

$$\mathbb{E}\left[(1-d_{ijt})\frac{\Phi(\sigma^{-1}(\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j))}{1-\Phi(\sigma^{-1}(\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j))} - d_{ijt}\middle|\mathcal{J}_{ijt}, dist_j\right] = 0. \tag{17}$$

- Still can't use this since don't know $\mathcal{J}$. Instead, replace $\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] = r_{ijt}$ and take expectation based on $Z \subset \mathcal{J}$.
- Expression becomes inequality 15c. Similar intuition behind 15b.
- 15b and 15c not redundant. Both needed to identify bounds.

  e.g., 15b decreasing in θ_0 so identifies upper bound while 15c increasing in θ_0 so identifies lower bound.

Partial Knowledge of Information Sets

- Revealed-preference moment inequalities:

$$\mathcal{M}^r(Z_{ijt};\theta) = \mathbb{E}\left[\begin{array}{c} m_l^r(d_{ijt}, r_{ijt}, dist_j;\theta) \\ m_u^r(d_{ijt}, r_{ijt}, dist_j;\theta) \end{array} \middle| Z_{ijt} \right] \geq 0, \tag{18a}$$

where

$$m_l^r(\cdot) = -(1-d_{ijt})\big(\eta^{-1}r_{ijt} - \theta_0 - \theta_1 dist_j\big) + d_{ijt}\theta_2 \frac{\phi\big(\theta_2^{-1}(\eta^{-1}r_{ijt} - \theta_0 - \theta_1 dist_j)\big)}{\Phi\big(\theta_2^{-1}(\eta^{-1}r_{ijt} - \theta_0 - \theta_1 dist_j)\big)}, \tag{18b}$$

$$m_u^r(\cdot) = d_{ijt}\big(\eta^{-1}r_{ijt} - \theta_0 - \theta_1 dist_j\big) + (1-d_{ijt})\theta_2 \frac{\phi\big(\theta_2^{-1}(\eta^{-1}r_{ijt} - \theta_0 - \theta_1 dist_j)\big)}{1-\Phi\big(\theta_2^{-1}(\eta^{-1}r_{ijt} - \theta_0 - \theta_1 dist_j)\big)}. \tag{18c}$$

Intuition

- If firm i exports to j in period t then by revealed preference it earns positive profits:

$$d_{ijt}\left(\frac{\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_o - \beta_1 dist_j - \nu_{ijt}}{\eta}\right) \geq 0$$

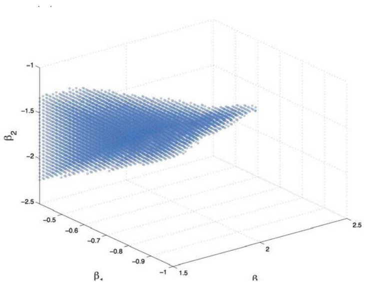
- In expectation this becomes

$$d_{ijt}\big(\eta^{-1}\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] - \beta_0 - \beta_1 dist_j\big) + S_{ijt} \geq 0, \qquad (19)$$

  where $S_{ijt} = \mathbb{E}[-d_{ijt}\nu_{ijt}|d_{ijt}, \mathcal{J}_{ijt}, dist_j]$ is a selection correction which accounts for the effect of ν on firm export decisions.

- As before, can't actually use (19) since we only know $Z \subset \mathcal{J}$. Replace $\mathbb{E}[r_{ijt}|\mathcal{J}_{ijt}] = r_{ijt}$ and take expectation based on $Z \subset \mathcal{J}$ to get inequality.

Point vs Set-Identification



- Relaxing restrictions comes at a cost since we can only identify parameters which satisfy the moment inequalities.

Results

Table 2: Parameter estimates

Estimator	Chemicals σ	Chemicals β_0	Chemicals β_1	Food σ	Food β_0	Food β_1
Perfect Foresight (MLE)	1,038.6 (11.7)	745.2 (8.9)	1,087.8 (12.9)	1,578.1 (16.9)	2,025.1 (3.7)	214.5 (23.6)
Minimal Information (MLE)	395.5 (2.6)	298.3 (2.2)	447.1 (6.1)	959.9 (8.1)	1,259.3 (2.2)	129.4 (18.1)
Moment Inequality	[85.1, 117.6]	[62.8, 82.4]	[142.6, 197.1]	[114.9, 160.0]	[167.1, 264.0]	[36.4, 81.3]

Notes: All parameters are reported in thousands of year 2000 USD and are conditional on the assumption that $\eta = 5$. For the two ML estimators, standard errors are reported in parentheses. For the moment inequality estimates, extreme points of the 95% confidence set are reported in square brackets. These confidence sets are projections of a confidence set for $(\beta_0, \beta_1, \sigma)$ computed according to the procedure described in Appendix A.5.

- Estimates are very different and don't overlap.

Results

Table 3: Average fixed export costs

Estimator	Chemicals Argentina	Chemicals Japan	Chemicals United States	Food Argentina	Food Japan	Food United States
Perfect Foresight (MLE)	868.0 (51.7)	2,621.4 (159.4)	1,645.0 (97.6)	2,049.3 (87.2)	2,395.1 (103.9)	2,202.5 (93.5)
Minimal Information (MLE)	348.7 (12.9)	1,069.4 (40.9)	668.1 (24.2)	1,273.9 (43.1)	1,482.4 (50.3)	1,366.3 (45.5)
Moment Inequality	[79.1, 104.1]	[309.2, 420.5]	[181.3, 243.6]	[175.6, 270.1]	[269.1, 361.0]	[227.3, 308.9]

Notes: All parameters are reported in thousands of year 2000 USD and are conditional on the assumption that $\eta = 5$. For the two ML estimators, standard errors are reported in parentheses. For the moment inequality estimates, extreme points of the 95% confidence set are reported in square brackets. These confidence sets are projections of a confidence set for $(\beta_0, \beta_1, \sigma)$ computed according to the procedure described in Appendix A.5.

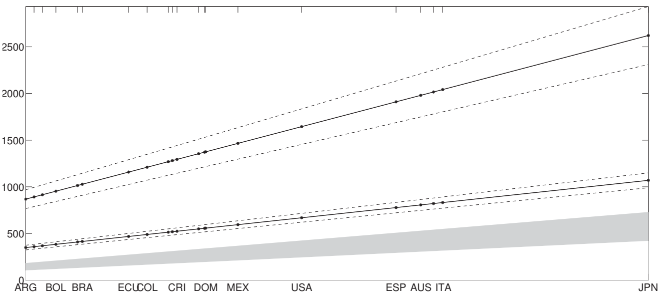
Table 4: Average fixed export costs relative to perfect foresight estimates

Estimator	Chemicals Argentina	Chemicals Japan	Chemicals United States	Food Argentina	Food Japan	Food United States
Minimal Info.	40.2%	40.8%	40.6%	62.1%	61.8%	62.0%
Moment Ineq.	[9.1%, 11.9%]	[11.0%, 14.8%]	[11.8%, 16.3%]	[8.6%, 13.1%]	[10.3%, 14.0%]	[11.2%, 15.0%]

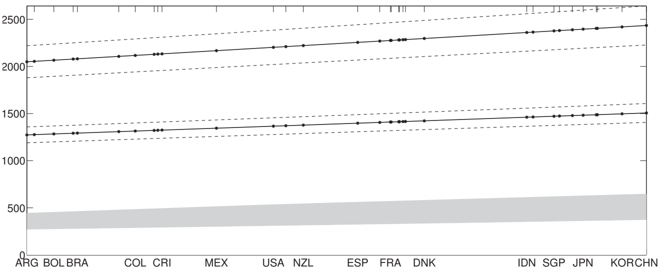
Notes: This table reports the ratio of both the minimal information ML point estimates and the extremes of the moment inequality confidence set and the perfect foresight ML point estimate. All numbers reported in this table are independent of the value of η chosen as normalizing constant.

Fixed Exporting Costs by Destination Country

(a) Chemicals



(b) Food



Testing Content of Information Sets

Set of Firms	Set of Export Destinations	Variable Tested	Chemicals Reject at 5%	Chemicals p-value RC	Food Reject at 5%	Food p-value RC
All	All	$(dist_j, r_{iht-1}, R_{jt-1})$	No	0.140	No	0.975
All	All	$(\alpha_{jt} r_{iht})$	Yes	0.005	Yes	0.005
Large	Popular	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	No	0.110	No	0.940
Large	Unpopular	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	No	0.110	No	0.970
Small	Popular	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	Yes	0.005	Yes	0.005
Small	Unpopular	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	Yes	0.020	Yes	0.005
Small & Exporter$_{t-1}$	All	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	Yes	0.005	Yes	0.005
Large & Non-exporter$_{t-1}$	All	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	No	0.145	No	0.990
Small & Non-Exporter$_{t-1}$	All	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	Yes	0.005	Yes	0.005
Large & Exporter$_{t-1}$	All	$(dist_j, r_{iht-1}, R_{jt-1}, \alpha_{jt-1})$	No	0.105	No	0.985

Notes: *Large* firms are those with above median domestic sales in the previous year. Conversely, firm i at period t is defined as *Small* if its domestic sales fall below the median. *Popular* export destinations are those with above median

- Fail to reject that firms know $dist_j, r_{iht-1}, R_{jt-1}$ (row one)
- Reject that firms know revenue (row two).
- Large firms have more information than small (3-6).
- Information about destination market does not depend on market size (3-6).

Policy Implications

- Decrease exporter fixed cost by 40%.
- What happens to export participation?

Table 6: Impact of 40% Reduction in Fixed Costs in Chemicals

	1996			2005		
Estimator	Argentina	Japan	United States	Argentina	Japan	United States
% Change in Number of Exporters						
Perfect Foresight	52.6	663.7	201.1	51.6	632.7	201.9
Minimal Info.	54.9	486.2	125.6	53.5	755.1	135.8
Moment Inequality	[54.9, 64.5]	[135.7, 1796.7]	[433.1, 521.1]	[45.1, 56.6]	[0,1678.2]	[444.1, 534.6]
Counterfactual Number of Exporters						
Perfect Foresight	67	38	51	70	37	72
Minimal Info.	68	29	38	71	43	56
Moment Inequality	[68, 72]	[12, 95]	[91, 106]	[68, 72]	[5, 89]	[131, 152]

Notes: For the moment inequality estimates, the minimum and maximum predicted values obtained by projecting the 95% confidence set for θ are reported in squared brackets. Counterfactual numbers of exporters are computed by rounding the outcome of multiplying the observed number of exporters by the counterfactual changes predicted by each of the three models. For the chemicals sector, observed number of exporters to Argentina, Japan and United States in 2005 are 46, 5 and 24, respectively. Analogous numbers for 1996 are 44, 5, 17. All numbers reported in this table are independent of the value of η chosen as normalizing constant.

6. General Equilibrium Results

Arkolakis, Costinot, Rodriguez-Clare (2012) "New Trade Models, Same Old Gains?"

- "New New Trade" Models: Micro-level data have lead to new questions in international trade:
  - How many firms export?
  - How large are exporters?
  - How many products do they export?
- These models highlighted new margins of adjustment:
  - From inter-industry to intra-industry to intra-firm reallocations
- Observation: Despite new bells and whistles to incorporate these new margins, these trade models (e.g., Melitz, Eaton & Kortum) generate similar gains from trade (GT) as Krugman and Armington models.
- Old question: How large are the GT?
- ACR's question:

  Do "New New Trade" models actually say anything new about the gains from trade?

Simple Example- Armington

- Perfect competition + DS preferences.
- Price index is

$$P_j = \left[\sum_{i=1}^{N} (w_i \tau_{ij})^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

- Demand:

$$X_{ij} = \left(\frac{w_i \tau_{ij}}{P_j} \right)^{1-\sigma} Y_j$$

- Welfare:

$$W_j = \frac{Y_j}{P_j}$$

- Exercise: Consider a shock to another country that affects relative trade costs or the relative labor endowment.
- Country j labor is numeraire and since trade is balanced in equilibrium:

$$dlnW_j = \underbrace{dlnY_j}_{=0} - dlnP_j$$

Simple Example- Armington, cont'd

- Change in real income:

$$dlnW_j = -\sum_{i=1}^{N} \lambda_{ij} \times (dlnw_i + dln\tau_{ij}),\ \lambda_{ij} \equiv \frac{X_{ij}}{Y_j}$$

- From demand:

$$dln\lambda_{ij} - dln\lambda_{jj} = (1-\sigma)\left[dlnw_i + dln\tau_{ij}\right]$$

- Combining and noting that $\sum \lambda_{ij} = 1$:

$$dlnW_j = \frac{\sum_{i=1}^{N} \lambda_{ij} \times (dln\lambda_{jj} + dln\lambda_{ij})}{1-\sigma} = \frac{dln\lambda_{jj}}{1-\sigma}$$

- Integration and evaluation at equilibrium pre and post shock yields:

$$\hat{W}_j = \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$$

where $\hat{x} = \frac{x'}{x}$.

Big Idea

- Welfare changes depend only upon changes in the terms of trade (i.e., relative prices).
- But these changes can be inferred from changes in relative demand.
- We can measure GT by just looking at import shares (since $\lambda_{jj} = 0$ in Autarky).

ACR's Main Equivalence Result

- ACR focus on gravity models:
  PC: Armington and Eaton & Kortum '02
  MC: Krugman '80 and many variations of Melitz '03
- Within that class, welfare changes are:

$$\hat{W}_j = \hat{\lambda}_{jj}^{\frac{1}{\epsilon}}$$

- Two sufficient statistics to evaluate GT are:
  1. Share of domestic expenditure, λ_{jj}, before and after the shock;
  2. Trade elasticity, ϵ (equal to $1 - \sigma$ in Armington model).
- Two views on ACR's result:
  1. Optimistic: welfare predictions of Armington model are very robust.
  2. Pessimistic: micro-level data (mechanisms) do not matter in these models. Calls into question whether gravity models are actually any good at measuring GT.

What These Models Share

- Simplistic micro-level Foundations:
  1. Dixit-Stiglitz preferences (aggregation);
  2. one factor of production;
  3. linear cost functions; and
  4. perfect or monopolistic competition (i.e., simple market structure).
- Plus macro-level restrictions:
  1. balanced trade;
  2. aggregate profits which are a constant share of aggregate revenues; and
  3. a CES import demand system.

Atkeson & Burstein "Innovation, Firm Dynamics, & International Trade (JPE 2010)

- Large empirical literature documented a reduction in international trade costs impact firms' decisions to exit, export, and invest in research and development: both to improve the cost or quality of existing products.
- Research Question:

  Do falling trade costs and the subsequent effects on firm export, innovation, and entry/exit decisions impact macroeconomic welfare?

Mechanism

- Recall ACR:
$$\hat{W}_j = \hat{\lambda}_{jj}^{\frac{1}{\epsilon}}$$
- In trade models firms enter until the value of creating a new product / firm is zero.
- A reduction in trade costs increases firm profit.
- From free entry condition, more firms enter and real wage increases.
- On net, nothing new happens to the welfare.
- Adding new margins (e.g., innovation) amounts relabeling the causes for GFT.
- Caveat: Increased GFT if the model has positive interest rates and an elastic innovation process.

Model

- 2 symmetric countries, each endowed with L identical households.
- Final, nontraded good used for consumption.

$$Y_t = \left[\sum_{n_x} \int a_t(z,\ n_x)^{1-1/\rho} M_t(z,\ n_x) dz + \sum_{n_x} \int x_t^*(z,\ n_x) b_t(z,\ n_x)^{1-1/\rho} M_t^*(z,\ n_x) dz \right]^{\rho/(\rho-1)}, \quad (3)$$

- Continuum of differentiated goods that may be traded.
- Intermediate goods firms heterogenous in productivity and may innovate:

  "Product Innovation" $\rightarrow$ new varieties.
  "Process Innovation" $\rightarrow$ higher productivity (ie, more efficient).

Monopolistic Competition

- Firms heterogenous in productivity:

$$y = exp(z)^{\frac{1}{\rho-1}} l$$

- Firms can trade but subject to fixed and variable export costs:

$$a_t(s) + x_t(s) D a_t^{\star}(s) = y_t(s)$$

where s $= (z, n_x) \equiv$ state variable for the firm, n_x (fixed export cost) follows Markov process $\Gamma(n_x | n_x)$, x $\equiv \{0, 1\}$ export indicator, and $D \equiv$ iceberg trade cost.

Monopolistic Competition, cont'd.

- Solving consumer's problem to get price index and demand:

$$P_t = \left[\sum_{n_x} \int p_{at}(z,\ n_x)^{1-\rho} M_t(z,\ n_x) dz + \sum_{n_x} \int x_t^*(z,\ n_x) p_{bt}(z,\ n_x)^{1-\rho} M_t^*(z,\ n_x) dz\right]^{1/(1-\rho)} \quad (4)$$

and are related to quantities by

$$\frac{a_t(s)}{Y_t} = \left[\frac{p_{at}(s)}{P_t}\right]^{-\rho} \quad \text{and} \quad \frac{b_t(s)}{Y_t} = \left[\frac{p_{bt}(s)}{P_t}\right]^{-\rho}. \quad (5)$$

Research Good

- Firms invest in a "research good" produced by PC firms using CRS technology:

$$\max_{L_r, Y_r} w_{rt} \underbrace{L_{rt}^{\lambda} Y_{rt}^{1-\lambda}}_{\text{production}} - w_t L_{rt} - P_t Y_{rt}$$

- Domestic research good used as numeraire so $W_{rt} = 1$.

- Cost minimization requires following FONCs:

$$\frac{\lambda}{1-\lambda} \frac{Y_{rt}}{L_{rt}} = \frac{W_t}{P_t}, \quad \frac{\lambda}{1-\lambda} \frac{Y_{rt}^*}{L_{rt}^*} = \frac{W_t^*}{P_t^*}, \tag{6}$$

and that, given our choice of numeraire,

$$1 = \lambda^{-\lambda}(1-\lambda)^{-(1-\lambda)}(W_t)^{\lambda}(P_t)^{1-\lambda},$$

$$W_{rt}^* = \lambda^{-\lambda}(1-\lambda)^{-(1-\lambda)}(W_t^*)^{\lambda}(P_t^*)^{1-\lambda}. \tag{7}$$

- As $\lambda \uparrow 1$ ($\downarrow 0$) R&D done with labor (final good).

Optimization - Static

- Each period firms choose $y, l, p_a, p_a^\star, a, a^\star, x$ to solve

$$\Pi_t(s) = \max_{y,l,p_a,p_a^*,a,a*,x\in\{0,1\}} p_a a + x p_a^* a^* - W_t l - x n_x \tag{8}$$

- Usual pricing rules:

$$\begin{aligned} p_a(s) &= \frac{\rho}{\rho-1}\frac{w}{exp(z)^{\frac{1}{\rho-1}}} \\ p_a^\star(s) &= \frac{\rho}{\rho-1}\frac{Dw}{exp(z)^{\frac{1}{\rho-1}}} \\ &= D \times p_a(s) \end{aligned}$$

- Firm profits increasing in productivity (z), increasing in price index, and decreasing in trade costs.

Optimization - Dynamic

- Firms choose to invest to improve productivity state (z) ala Ericson & Pakes (1995):

$$\begin{aligned} V_t^o(z,\ n_x) \ = & \max_{q \in [0,1]} \Pi_t(z,\ n_x) - \exp(z)c(q) - n_f \\ & + (1-\delta)\frac{1}{R_t}\sum_{n'_x}[qV_{t+1}(z+\Delta_z,\ n'_x) \\ & + (1-q)V_{t+1}(z-\Delta_z,\ n'_x)]\Gamma(n'_x|n_x), \end{aligned} \quad (10)$$

- Choose probability of success $q(s) \in [0,1]$ and pay $exp(z)c(q)$ units of research good (numeraire).

- Exit at exogenous rate $\delta \in (0,1)$.

- Endogenous exit if fixed production cost $n_f > 0$.

Optimization - Entry

- Ex ante identical firms choose whether to enter.
- If they enter, draw initial state (s, n_x) from distribution G and pay n_e units of research good.
- We have the following free entry condition:

$$n_e = \frac{1}{R_t} \sum_{n_x} \int V_{t+1}(z,\ n_x) G(z,\ n_x) dz. \tag{11}$$

- Choose probability of success $q(s) \in [0, 1]$ and pay $exp(z)c(q)$ units of research good (numeraire).
- Exit at exogenous rate $\delta \in (0, 1)$.

Law of Motion

- Mass of firms $M_t(z, n_x)$ evolves according to the following endogenous process:

$$
\begin{aligned}
M_{t+1}(z',\ n_x') = {} & M_{et}G(z',\ n_x') \\
& + (1-\delta)\sum_{n_x} q_t(z-\Delta_z,\ n_x)M_t(z-\Delta_z,\ n_x)\Gamma(n_x'|n_x) \\
& + (1-\delta)\sum_{n_x} [1-q_t(z+\Delta_z,\ n_x)]M_t(z+\Delta_z,\ n_x)\Gamma(n_x'|n_x).
\end{aligned} \tag{16}
$$

Households

- Preferences:

$$\sum_{t=0}^{\infty} \beta_t log(C_t)$$

- Budget constraint:

$$P_0 C_0 - W_0 L + \sum_{t=1}^{\infty} \left(\prod_{j=1}^{t} \frac{1}{R_j} \right) (P_t C_t - W_t L) \leq \overline{W}, \tag{12}$$

- Welfare is real wage defined as W_t / P_t.

Symmetric Steady State - Definitions

- Normalized distribution of firms:

$$\tilde{M}(s) = M(s)/M_e$$

- Average (ie, expected) expenditures of research good per M_e:

$$\Upsilon = n_e + \sum_{n_x} \int [n_f + x(z,\ n_x)n_x + \exp(z)c(q(z,\ n_x))]\tilde{M}(z,\ n_x)dz. \quad (24)$$

- Productivity indices:

$$Z_d = \sum_{n_x} \int [1 - x(z,\ n_x)] \exp(z)\tilde{M}(z,\ n_x)dz,$$

$$Z_x = \sum_{n_x} \int x(z,\ n_x) \exp(z)\tilde{M}(z,\ n_x)dz. \quad (21)$$

- Ratio of total variable profits to total expenditures on the research good:

$$\zeta = \Pi_d \times \left(M_e[Z_d + (1 + D^{1-\rho}Z_e)]\right)^{1/(\rho-1)}$$

Symmetric Steady State, Equilibrium Conditions.

$$\frac{W}{P} = \frac{\rho - 1}{\rho}\{M_e[Z_d + (1 + D^{1-\rho})Z_x]\}^{1/(\rho-1)}, \tag{25}$$

$$Y = \{M_e[Z_d + (1 + D^{1-\rho})Z_x]\}^{1/(\rho-1)}(L - L_r), \tag{26}$$

$$L_r = \frac{\lambda}{\lambda + \zeta(\rho - 1)} L, \tag{27}$$

$$\Pi_d = \frac{\lambda^\lambda (1 - \lambda)^{1-\lambda}}{\rho^\rho (\rho - 1)^{1-\rho}} \left(\frac{W}{P}\right)^{1-\rho-\lambda} Y, \tag{28}$$

and

$$C = Y\left(1 - \frac{1 - \lambda}{\zeta\rho}\right), \tag{29}$$

Solving for SS Equilibrium

1. Use FE condition (11) to solve for Π_d.
   - Π_d sumamrizes equilibrium firm decisions on exit, export, and process innovation decisions.
   - In ACR, import share played the same role $\Rightarrow$ only need to know the change to solve for change in welfare.
2. Use (27) to compute L.
3. Use (25), (26), and (28) to solve for entry M_e
4. Equations (26) and (29) imply output and consumption.

Evolution of Profits

- Equilibrium profits:

$$\Pi_d = \frac{\lambda^\lambda (1-\lambda)^{1-\lambda}}{\rho^\rho (\rho - 1)^{1-\rho}} \left(\frac{W}{P}\right)^{1-\rho-\lambda} Y, \tag{28}$$

- Totally differentiate Π_d to see how it evolves.

$$\Delta \log \Pi_d = (2 - \rho - \lambda) \Delta \log Z + \Delta \log (L - L_r), \tag{31}$$

Evolution of Aggregate Productivity

- Welfare moves 1:1 with output and a change in output is equal to a change in aggregate productivity Z.

- Therefore need only look at changes in Z in response to change in D:

$$\Delta \log Z = \underbrace{-s_x \Delta \log D}_{\text{Direct Effect}} \tag{32}$$

$$+ \underbrace{\frac{1}{\rho - 1}\left[s_x \frac{1 + D^{1-\rho}}{D^{1-\rho}} \Delta \log Z_x + \left(1 - s_x \frac{1 + D^{1-\rho}}{D^{1-\rho}}\right) \Delta \log Z_d + \Delta \log M_e \right]}_{\text{Indirect Effect}}.$$

- Relative importance of direct and indirect effects

$$\frac{\text{Indirect Effect}}{\text{Direct Effect}} = \frac{1 - \lambda}{\rho + \lambda - 2}. \tag{35}$$

- Different models do not affect GFT, only our interpretation of the contributing factors.

- Calibrate model to show results under different specifications.

Special Cases

- All firms export ($n_x = 0$).
- No productivity dynamics ($\Delta_z = 0$) $\sim$ Melitz (2003).
- Exogenous selection (set $n_f = 0$ and fix Γ).
- Transition dynamics

Quantitative Experiments

- No interest rate, Different innovation elasticities.
  - Confirmation of analytical results.
- Positive interest rate, Inelastic innovation process.
  - Change in aggregate productivity smaller as indirect effect gets bigger.
- Positive interest rate, Elastic innovation process.
  - Large response in aggregate output (5x model with just direct effect).
  - Little difference in welfare.
- Large Change in Trade Costs (D).
  - Model generates small differences in welfare from Krugman-style model.

7. Measuring Misallocation

Hsieh & Klenow "Misallocation and Manufacturing TFP in China and India" (QJE 2009)

- Large differences in output per worker attributed to differences in measured TFP (a residual).
- General Open Question: What are the caused of these differences?
- Most research at the time focused on identifying inefficiency across countries.
  e.g., representative firm in each country.
- Research Objective: Provide quantitative evidence of the impact of resource misallocation on measured aggregate TFP.

Intuition Through a Simple Example

- Two firms (A,B) with identical technology: increasing, concave.
- Aggregate output maximized when both firms choose capital K^*.
- Firms are different only in their political connections:
  - Firm A has political connections and gets subsidized credit (i.e., can borrow at a low interest rate).
  - Firm B ha no connections so it borrows at (high) interest rates in international markets.
- Firms maximize profit $\Rightarrow$ choose capital s.t. MPK = interest rate.
  - Firm A faces low r so chooses a lot of K: $K^A > K^*$.
  - Firm B faces high r so chooses little of K: $K^B < K^*$.
- Political connections $\Rightarrow$ misallocation $\Rightarrow$ suboptimal aggregate output.

Empirical Approach

- Develop theory model to identify TFP in the data.
  - Closed economy.
  - Consumption of final good.
  - Monop. competition in intermediate goods.
  - Int. production requires capital (K) and labor (L).
  - Insert distortions for aggregate output and capital (labor implied).
    NB, similar approach to Chari, Kehoe, & McGrattan (2007).
- Model implies mapping between data and TFP $\Rightarrow$ we can then solve for the distribution of TFP in the data.
- Model implies TFP does not vary across plants within an industry unless there are distortions: Null Hypothesis.

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Model

- Final good production

$$Y = \Pi_{s=1}^{S} Y_s^{\theta_s},\ \sum_s \theta_s = 1$$

- Cost mimization implies $P_s Y_s = \theta_s PY,\ P = \Pi(P_s/\theta_s)_s^{\theta} = 1$ (numeraire).
- Monopolistically competitive intermediate goods firms:

$$\begin{aligned} Y_s &= \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \\ Y_{si} &= A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s} \\ A_{si} &\equiv \text{firm i TFP in industry s.} \end{aligned}$$

- Two distortions:
  - Output τ_{Ysi}.
  - Capital τ_{Ksi}.
  - Why not labor τ_{Lsi}?

Optimization

- Profits:

$$\pi_{si} = (1 - \tau_{Ysi}) P_{si} Y_{si} - wLsi - (1 + \tau_{Ksi}) R K_{si}$$

- Profit maximizing price:

$$P_{si} = \frac{\sigma}{1-\sigma} \left(\frac{R}{\alpha_s}\right)^{\alpha}_{s} \left(\frac{w}{1-\alpha_s}\right)^{1-\alpha_s} \left(\frac{(1-\tau_{Ksi})^{\alpha}_{s}}{A_{si}(1-\tau_{Ysi})}\right)$$

- Optimal Capital (K_{si}):

$$\text{MRPL}_{si} \triangleq (1-\alpha_S)\frac{\sigma-1}{\sigma}\frac{P_{si}Y_{si}}{L_{si}} = w\frac{1}{1-\tau_{Ysi}}. \tag{10}$$

- Optimal Labor (L_{si}):

Here,

- Intuition: After-"tax" MRPK, MRPL equalized across firms in industry s, but pre-"tax" MRPs are different (and so are K,L choices) as in the simple example.

Aggregation

- Industry labor and capital:

$$L_s \equiv \sum_{i=1}^{M_s} L_{si} = L \frac{(1-\alpha_s)\,\theta_s/\overline{\mathrm{MRPL}}_s}{\sum_{s'=1}^{S}(1-\alpha_{s'})\,\theta_{s'}/\overline{\mathrm{MRPL}}_{s'}}, \tag{12}$$

$$K_s \equiv \sum_{i=1}^{M_s} K_{si} = K \frac{\alpha_s\,\theta_s/\overline{\mathrm{MRPK}}_s}{\sum_{s'=1}^{S}\alpha_{s'}\,\theta_{s'}/\overline{\mathrm{MRPK}}_{s'}}. \tag{13}$$

Here,

$$\overline{\mathrm{MRPL}}_s \propto \left(\sum_{i=1}^{M_s} \frac{1}{1-\tau_{Ysi}} \frac{P_{si}Y_{si}}{P_s Y_s}\right),$$

$$\overline{\mathrm{MRPK}}_s \propto \left(\sum_{i=1}^{M_s} \frac{1+\tau_{Ksi}}{1-\tau_{Ysi}} \frac{P_{si}Y_{si}}{P_s Y_s}\right)$$

NB, aggregate capital (K) and "effective" labor (L) are fixed.

- Output:

$$Y = \prod_{s=1}^{S} \left(\mathrm{TFP}_s \cdot K_s^{\alpha_s} \cdot L_s^{1-\alpha_s}\right)^{\theta_s}. \tag{14}$$

Aggregation, cont'd

- "TFPQ" and "TFPR":

$$\mathrm{TFPQ}_{si} \triangleq A_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}$$
$$\mathrm{TFPR}_{si} \triangleq P_{si}A_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}.$$

plant-specific deflator yields TFPQ while industry deflator yields TFPR.

$$\mathrm{TFPR}_{si} \propto (\mathrm{MRPK}_{si})^{\alpha_s}(\mathrm{MRPL}_{si})^{1-\alpha_s} \propto \frac{(1+\tau_{Ksi})^{\alpha_s}}{1-\tau_{Ysi}}.$$

- Model implies TFPR does not vary across plants within an industry unless $\exists$ a distortion.
- W/O distortions, more K, L dedicated to plants with high TFPQ since more output but lower price and same TFPR.

Aggregation, cont'd

- TFP (main empirical equation):

$$\text{TFP}_s = \left[\sum_{i=1}^{M_s} \left(A_{si} \cdot \frac{\overline{\text{TFPR}}_s}{\text{TFPR}_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}}, \tag{15}$$

  where $\overline{TFPR}_s \propto (\overline{MPRK}_s)^{\alpha_s}(\overline{MPRL}_s)^{1-\alpha_s}$.

- If TFPQ, TFPR are distributed log-normal:

$$\log \text{TFP}_s = \frac{1}{\sigma - 1} \log \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right) - \frac{\sigma}{2} \text{var}\left(\log \text{TFPR}_{si}\right). \tag{16}$$

  so TFPR reduces measured TFP.

- Plant TFPQ:

$$TFPQ_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}$$

Considerations

1. Only averages (MRPs) matters. This comes from Cobb-Douglas Production $\Rightarrow$ unit-elastic demand.
2. Aggregate stock of capital (and labor) are fixed.
3. Number of firms is fixed (no entry/ exit).
4. Firms face same wage (w).

Data

- India (1987-1994)
  1. Annual Survey of Industries (ASI)
  2. Census of all mfg plants with more than 50 workers + random sample of plants if $\in [10, 50]$.
  3. Plant characteristics + financial performance.
  4. $\approx$ 40k plants per year.
- China (1998-2005)
  1. Annual Surveys of Industrial Production.
  2. Census of all nonstate firms w/ $>$5 mill yuan ($600k) + all state-owned firms.
  3. Plant characteristics + financial performance.
  4. 100k *firms* in 1998 and 200k in 2008.
- US (1977,1982,1987,1992,1997)
  1. Census of Manufacturers (CM)
  2. All mfg plants
  3. Plant characteristics + financial performance.
  4. 160k plants each year.
- Focus on four-digit industries.
- US capital shares.
- Windsorize data (drop outliers).

Mapping Model to Data

- Calibration
  1. Set $R = 10\%$, reflects 5% real interest rate and 5% depreciation.
  2. Set $\sigma = 3$.
  3. Capital share by industry α_s using US data.
     ⋆ NB, implicit assumption is that US is relatively less distorted so these numbers are better and there is no way to identify the "true" parameters. Issue here is that $\alpha_s, \tau_{Ys}, \tau_{Ks}$ not separately identified.

- Plant TFPQ:

$$A_{si} \equiv TFPQ_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}$$

- Data analog:

$$A_{si} \equiv TFPQ_{si} = \kappa_s \frac{(P_{si}Y_{si})^{\frac{\sigma}{\sigma-1}}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}$$

WLOG set $\kappa_s = 1$ (analysis is based on within industry variation and κ_s is common across all firms in industry). Observe nominal output $P_{si}Y_{si}$ and not real Y_{si}. Use assumed demand elasticity to identify price from real output.

TFPQ

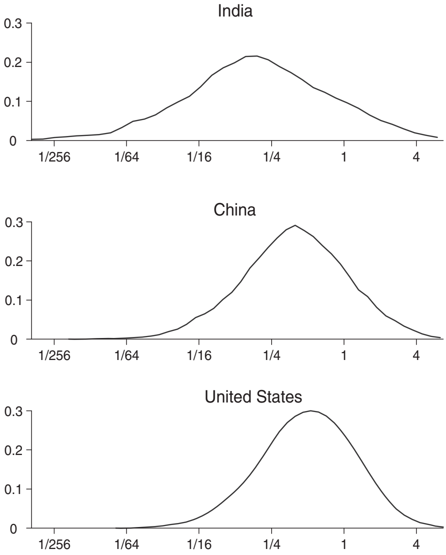


FIGURE I
Distribution of TFPQ

Distribution of TFPR

DISPERSION OF TFPR

China	1998	2001	2005
S.D.	0.74	0.68	0.63
75 − 25	0.97	0.88	0.82
90 − 10	1.87	1.71	1.59
India	1987	1991	1994
S.D.	0.69	0.67	0.67
75 − 25	0.79	0.81	0.81
90 − 10	1.73	1.64	1.60
United States	1977	1987	1997
S.D.	0.45	0.41	0.49
75 − 25	0.46	0.41	0.53
90 − 10	1.04	1.01	1.19

Notes. For plant i in industry s, $\text{TFPR}_{si} \equiv \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s}(w_{si}L_{si})^{1-\alpha_s}}$. Statistics are for deviations of log(TFPR) from industry means. S.D. = standard deviation, 75 − 25 is the difference between the 75th and 25th percentiles, and 90 − 10 the 90th vs. 10th percentiles. Industries are weighted by their value-added shares. Number of plants is the same as in Table I.

- Ratio for 90/10 in each country's last year:
  - China: 4.9 (difference= 1.59)
  - India: 5.0 (difference= 1.60)
  - US: 3.3 (difference= 1.19)
- Results consistent with more distortions in India/ China than US.

Are There Systematic Sources?

TABLE III
PERCENT SOURCES OF TFPR VARIATION WITHIN INDUSTRIES

	Ownership	Age	Size	Region
India	0.58	1.33	3.85	4.71
China	5.25	6.23	8.44	10.01

Notes. Entries are the cumulative percent of within-industry TFPR variance explained by dummies for ownership (state ownership categories), age (quartiles), size (quartiles), and region (provinces or states). The results are cumulative in that "age" includes dummies for both ownership and age, and so on.

- Project TFPR on observable characteristics. How much can they explain?
- Look at cumulative percentage of TFPR by dummies for characteristics:
  - Ownership (state-owned)
  - Age (quartiles)
  - Size (quartiles)
  - Region (provinces, states)
- Ownership less important in India.
- All these dummies account for less than 5% of total variance in India and 10% in China.
- Question: What else could explain the distortions?

Efficient Allocation

- When there are no distortions, industry TFP is

$$\overline{A}_s = \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

- For each industry, calculate actual TFP (15) to "efficient".
- Aggregating across industries yields:

$$(20) \qquad \frac{Y}{Y_{\text{efficient}}} = \prod_{s=1}^{S} \left[\sum_{i=1}^{M_s} \left(\frac{A_{si}}{\overline{A}_s} \frac{\overline{\text{TFPR}}_s}{\text{TFPR}_{si}} \right)^{\sigma-1} \right]^{\theta_s/(\sigma-1)}.$$

How Much Would TFP Improve Without Distortions?

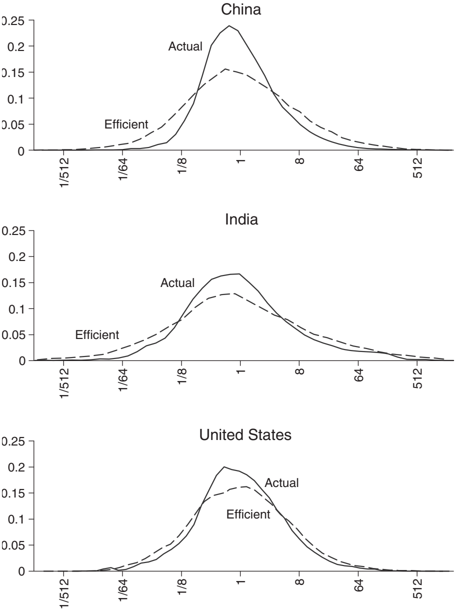
TFP GAINS FROM EQUALIZING TFPR WITHIN INDUSTRIES

China	1998	2001	2005
%	115.1	95.8	86.6
India	1987	1991	1994
%	100.4	102.1	127.5
United States	1977	1987	1997
%	36.1	30.7	42.9

Notes. Entries are $100(Y_{\text{efficient}}/Y - 1)$ where $Y/Y_{\text{efficient}} = \prod_{s=1}^{S}[\sum_{i=1}^{M_s}(\frac{A_{si}}{\bar{A}_s}\frac{\overline{\text{TFPR}}_s}{\text{TFPR}_{si}})^{\sigma-1}]^{\theta_s/(\sigma-1)}$ and $\text{TFPR}_{si} \equiv \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s}(w_{si}L_{si})^{1-\alpha_s}}$.

- How Much Would TFP Improve Without Distortions?
  - China: 86 to 115% improvement.
  - India: 100 to 127% improvement.
  - US: 30 to 42% improvement.
- Numbers assume correct specification, no measurement error. Probably not true.
- Still differences between (China, India) and USA are really big so something is likely going on.

Distribution of “Plant” Size



Distribution of "Plant" Size, cont'd.

PERCENT OF PLANTS, ACTUAL SIZE VS. EFFICIENT SIZE

China 2005	0–50	50–100	100–200	200+
Top size quartile	7.0	6.1	5.4	6.6
2nd quartile	7.3	5.9	5.3	6.6
3rd quartile	8.5	6.0	5.2	5.4
Bottom quartile	10.5	5.9	4.5	4.2
India 1994	0–50	50–100	100–200	200+
Top size quartile	8.7	4.7	4.6	7.1
2nd quartile	10.7	4.6	4.1	5.7
3rd quartile	11.4	5.0	4.0	4.7
Bottom quartile	13.8	3.9	3.3	3.8
United States 1997	0–50	50–100	100–200	200+
Top size quartile	4.4	10.0	6.7	3.9
2nd quartile	4.4	9.6	5.8	5.1
3rd quartile	4.5	9.8	5.4	5.4
Bottom quartile	4.7	12.0	4.3	4.1

Notes. In each country-year, plants are put into quartiles based on their actual value-added, with an equal number of plants in each quartile. The hypothetically efficient level of each plant's output is then calculated, assuming distortions are removed so that TFPR levels are equalized within industries. The entries above show the percent of plants with efficient/actual output levels in the four bins 0%–50% (efficient output less than half actual output), 50%–100%, 100%–200%, and 200%+ (efficient output more than double actual output). The rows add up to 25%, and the rows and columns together to 100%.

- What happens to the plants when we remove distortions?
  - In all countries, efficient distribution is more dispersed.
  - In China and India, more firms should shrink (largest numbers in 0-50% column ⇒ shrink by more than half)
  - In US, many firms should shrink but effect is smaller (50-100% is most popular column).

What if China and India had US Distortions?

TABLE VI
TFP GAINS FROM EQUALIZING TFPR RELATIVE TO 1997 U.S. GAINS

China	1998	2001	2005
%	50.5	37.0	30.5
India	1987	1991	1994
%	40.2	41.4	59.2

Notes. For each country-year, we calculated $Y_{\text{efficient}}/Y$ using $Y/Y_{\text{efficient}} = \prod_{s=1}^{S} \left[\sum_{i=1}^{M_s} \left(\frac{A_{si}}{\bar{A}_s} \frac{\overline{\text{TFPR}}_s}{\text{TFPR}_{si}} \right)^{\sigma-1} \right]^{\theta_s/(\sigma-1)}$ and $\text{TFPR}_{si} \equiv \frac{P_{si} Y_{si}}{K_{si}^{\alpha_s} (w_{si} L_{si})^{1-\alpha_s}}$.

We then took the ratio of $Y_{\text{efficient}}/Y$ to the U.S. ratio in 1997, subtracted 1, and multiplied by 100 to

- Experiment: "Plug" US distortions into Chinese and Indian economies.
- How? In Table 4, take $Y_{\text{Efficient}}/Y$, multiply by US ratio $Y_{\text{Efficient}}/Y$ in 1997, subtract 1, multiply by 100.
- Results:
  - China: TFP improves 50% in 1998, 30% in 2005.
  - India: TFP improves 40% in 1987, 59% in 1994.

Could Policies Explain Misallocation?

- If TFPR dispersion is real (ie, not measurement error), we should be able to map to policy.
- China: Of the 15% reduction in the gains from reallocation (less misallocation), 39% is due to shrinking TFPR gap between SOEs and other plants. (less distortions implied by SOE).
  Caveat: I don't understand where these numbers come from...
- India: Delicensing and size restrictions.

	(1)	(2)	(3)
Delicensed 1991	−0.298		−0.298
	(0.117)		(0.117)
Delicensed 1991 × post-1991	0.032		−0.056
	(0.036)		(0.040)
Size restriction		0.368	
		(0.173)	
Delicensed 1991 × post 1991 × size restriction			0.415
			(0.120)

Notes. The dependent variable is the variance of log TFPR in sector s in year t. Entries are coefficients on the following independent variables: (1) delicensed 1991: indicator for whether industry was delicensed in 1991; (2) delicensed 1991 × post 1991: product of an indicator for an industry delicensed in 1991 and an indicator for observations after 1991; (3) size restriction: % of value-added of an industry subject to reservations for small firms and; (4) delicensed 1991 × post 1991 × size restriction: product of size restriction, indicator variable for observations after 1991, and a dummy variable for industries delicensed after 1991. All regressions include indicator variables for year (1987 through 1994) and are weighted by the value-added share of the sector. Regressions (1) and (3) also include a dummy for industries delicensed in 1985. The omitted group consists of industries not delicensed in either 1985 or 1991. Standard errors are clustered by sector. Number of observations = 2,644.

Alternative Explanations

- Markups that are correlated with market size.
  (ie, non-CES/ isoelastic demand).
- Adjustment costs.
  (ie, Chinese, Indian plants may be younger and face adjustment costs).
- Unobserved investments.
  (ie, learning by doing, unobserved investments).
- Capital shares that vary by industry.

Asker, Collard-Wexler, & De Loecker "Dynamic Inputs and Resource (Mis)Allocation" (JPE 2014)

- Large differences in productivity within even narrowly defined industries.
- Large cross-country differences, especially across different stages of development.
- Also observe large dispersion in the marginal revenue product of inputs, especially capital.
- Misallocation of capital could have significant effects on aggregate productivity. Mechanisms?
- **Research Question:** Could adjustment costs in dynamically chosen outputs explain the distribution of marginal product of capital?

Mechanism

- Firms:
  1. face costs to adjust capital stock,
  2. can acquire all inputs in a frictionless market (i.e., no inefficiency), and
  3. face idiosyncratic TFP shocks.
- Dynamic optimization $\Rightarrow$ endogenous distribution of marginal revenue product of capital.
- Resource allocation appears sub-optimal in a static setting but is efficient when one considers the dynamic setting.

Empirical Approach

1. Proof-of-concept comparative statics with partial equilibrium model of dynamic optimization.
2. Establish reduced-form data facts using detailed data across several countries.
3. Quantify the importance of the mechanism via structural model.

Theoretical Framework

- CRS Technology:

$$Q_{it} = A_{it} K_{it}^{\alpha_K} L_{it}^{\alpha_L} M_{it}^{\alpha_M}, \tag{1}$$

- Demand:

$$Q_{it} = B_{it} P_{it}^{-\epsilon}. \tag{2}$$

- Sales:

$$S_{it} = \Omega_{it} K_{it}^{\beta_K} L_{it}^{\beta_L} M_{it}^{\beta_M}, \tag{3}$$

where $\Omega_{it} = A_{it}^{1/\epsilon} B_{it}^{1/\epsilon} b$, $\beta_X = \alpha_X(1 - 1\epsilon)$ for $X \in \{K, L, M\}$, and $\omega = \log \Omega$.

Static Profit Maximization with No Frictions

- Marginal Revenue Product:

$$\frac{\partial S_{it}}{\partial K_{it}} = \beta_K \frac{\Omega_{it} K_{it}^{\beta_K} L_{it}^{\beta_L} M_{it}^{\beta_M}}{K_{it}}. \tag{4}$$

  and applying logs we get:

$$MRPK_{it} = \log(\beta_K) + \log(S_{it}) - \log(K_{it}) = \log(\beta_K) + s_{it} - k_{it}. \tag{5}$$

- If firms all face the same capital rental rate, the distribution of MRPK will be degenerate.

Dynamic Investment

- Firms hire labor at wage p_L and materials at p_M.
- Capital stock (K) is a state variable.
- Profits:

$$\pi(\Omega_{it}, K_{it}) = \lambda \Omega_{it}^{\frac{1}{\beta_K + \epsilon^{-1}}} K_{it}^{\frac{\beta_K}{\beta_K + \epsilon^{-1}}}, \tag{6}$$

where $\lambda = \left(\beta_K + \epsilon^{-1}\right) \left(\frac{\beta_L}{p_L}\right)^{\frac{\beta_L}{\beta_K + \epsilon^{-1}}} \left(\frac{\beta_M}{p_M}\right)^{\frac{\beta_M}{\beta_K + \epsilon^{-1}}}$.

- Invest in capital each period:
  - Time to build,
  - Fixed and variable adjustment costs.

$$C(I_{it}, K_{it}, \Omega_{it}) = I_{it} + C_K^F \mathbb{I}\{I_{it} \neq 0\} \pi(\Omega_{it}, K_{it}) + C_K^Q K_{it} \left(\frac{I_{it}}{K_{it}}\right)^2. \tag{7}$$

- TFP shocks AR(1):

$$\omega_{it} = \mu + \rho \omega_{it-1} + \sigma \nu_{it}, \tag{8}$$

implies transition function for $\omega : \phi(\Omega_{t+1} | \Omega_t)$.

Optimization

- Value Function:

$$V(\Omega_{it}, K_{it}) = \max_{I_{it}} \pi(\Omega_{it}, K_{it}) - C(I_{it}, K_{it}, \Omega_{it}) + \beta \int_{\Omega_{it+1}} V(\Omega_{it+1}, \delta K_{it} + I_{it}) \phi(\Omega_{it+1} | \Omega_{it}) \, d\Omega_{it+1}, \quad (9)$$

where optimal investment is $I(\Omega_{it}, K_{it})$.

- No entry or exit + exogenous TFP implies ergodic distribution for TFPR:

$$\text{Std.}(\omega_{it}) = \frac{\sigma}{\sqrt{1-\rho^2}}. \quad (10)$$

so higher σ (i.e., larger shocks) increases dispersion.

Moments of Interest

1. Dispersion in static MRPK:

$$Std_{st}(MRPK_{it})$$

   where "st" subscript indicates std dev taken within industry-country s in year t.

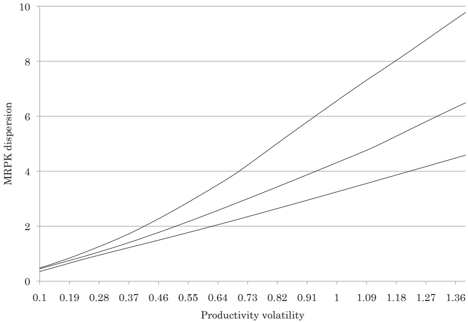
2. Volatility in static MRPK:

$$Std_{st}(\Delta MRPK_{it}) = Std_{st}(MRPK_{it} - MRPK_{it-1})$$

3. Volatility in firms' capital:

$$Std_{st}(\Delta k) = Std_{st}(k_{it} - k_{it-1})$$

Comparative Statics



- Figure shows how dispersion of MRPK, $Std_{st}(MRPK_i t)$, changes as volatility in TFPR (via σ) changes.
- Lines correspond to different levels of persistence: from top to bottom $\rho = \{0.94, 0.85, 0.65\}$.
- Measures of persistence correspond to 90th percentile, median, and 10th percentile in US Census data, respectively.

Reduced Form Evidence: Data

- Multiple data sources to explore cross-industry and cross-country evidence.
- "Tier 1" data sources:

Country	Plant	Firm	Provider – Survey Type	Size Threshold	Years Covered	Obs/Year
United States	X	X	U.S. RDC - Census	More than 5 workers	1972-1997	69,231
Chile	X		INE – Census	More than 10 workers	1979-1986	4,700
France		X	BvD Amadeus – Tax Records	No	1999-2007	44,444
India		X	CMIE (Prowess) – Balance Sheet	Large Firms	1989-2003	2,047
Mexico	X		SEC-OFI – Sample	Medium/Big Plants	1984-1990	3,026
Romania		X	BvD Amadeus – Tax Records	No	1999-2007	19,444
Slovenia	X		Statistical Office – Census	No	1994-2000	4,151
Spain		X	BvD Amadeus – Tax Records	No	1999-2007	55,556

Note: The X refers to which unit of observation the specific data records. Datasets can comprise both firm- and plant-level data if the plant-level data contains firm identifiers. For the U.S., Obs/Year is plant observations per year. The Obs/year is the average number of firms/plants per year calculated from the total firm/plant-year observations and the number of years covered.

Measurement of TFPR

Model implies log-linear relationship between sales, inputs, and TFPR

$$\omega_{it} = s_{it} - \beta_K k_{it} - \beta_L l_{it} - \beta_M m_{it}. \tag{16}$$

where

$$\beta_X^{sc} = median\left(\left\{\frac{P_{it}^X X_{it}}{S_{it}}\right\}\right) \qquad \text{for } X \in \{L, M\}, i \in sc. \tag{14}$$

and

$$\beta_K = \frac{\epsilon - 1}{\epsilon} - \beta_L - \beta_K. \tag{15}$$

Dispersion and Volatility Across Countries

Country	Coefficient	R^2	Industry-Year Obs.
U.S. [Plants]	0.76*** (0.04)	0.47	4,037
U.S. [Firms]	0.68*** (0.07)	0.44	4,037
Chile	0.54* (0.29)	0.13	55
France	1.03*** (0.33)	0.28	167
Mexico	0.19** (0.07)	0.07	296
India	0.61** (0.17)	0.28	279
Romania	0.44*** (0.13)	0.21	126
Slovenia	0.53** (0.21)	0.09	108
Spain	0.56* (0.33)	0.35	181
All I (unweighted)	0.55*** (0.15)	0.67	5,326
All II (weighted)	0.74*** (0.03)	0.50	5,326

Structural Analysis

- Calibrate theoretical model to establish the degree to which the model can generate the dispersion in MRPK in the data.
- Two versions:
  1. Simple version with only TFPR shocks.
  2. TFPR + industry-specific, various adjustment shock specification.
- Estimate C_K^F, C_K^Q adjustment costs using minimum-distance (indirect inference).

Estimated Adjustment Costs

Country	Adjustment Costs		Data Moments on Change in Log Capital		
	Convex	Fixed	Less than 5%	More than 20%	Standard Deviation
U.S.	8.80	0.09	0.39	0.09	0.21
Chile	4.10	0.07	0.19	0.11	0.28
India	3.46	0.12	0.29	0.19	0.30
France	0.21	0.00	0.13	0.57	0.57
Spain	0.74	0.00	0.20	0.41	0.59
Mexico	1.15	0.22	0.08	0.73	0.66
Romania	0.66	0.03	0.08	0.61	0.72
Slovenia	0.35	0.00	0.15	0.52	0.76

- US has high fixed and variable adjustment costs to account for 39% of firms adjusting capital little 9% do so often.
- US fixed cost is equivalent to 1.5 months of output (i.e., plant shuts down for 1.5 months).
- Mexican fixed costs are larger, but variable adjustment cost if smaller.
- In France, Spain, and Slovenia $\exists$ no fixed cost of adjustment.

Model generates dispersion in MPRK!

Country	Specification (1)	(2)	(3)	(4)	(5)
United States	0.223	0.806	0.806	0.643	0.820
France	0.892	0.702	0.899	0.944	0.651
Chile	0.994	0.983	0.987	0.963	0.785
India	0.984	0.941	0.964	0.976	0.596
Mexico	0.879	0.813	0.883	0.908	0.634
Romania	0.983	0.923	0.817	0.702	0.846
Slovenia	0.967	0.774	0.967	0.984	0.683
Spain	0.718	0.627	0.600	0.530	0.495
All (ex U.S.)	0.879	0.777	0.820	0.800	0.640
All	0.674	0.786	0.816	0.748	0.696
Specification details:					
All U.S. adj. costs	X		X		
Own country adj. costs		X			
All 2x U.S. adj. costs				X	
1 period time-to-build only					X
U.S. avg. β's	X				
Industry-country β's		X	X	X	X

Discussion

- Authors show that a standard model of investment with time-to-build, adjustment costs can generate a non-degenerate distribution of MPRK.
- Note that this model was efficient.
- Therefore observing a distribution of MPRK alone does not imply $\exists$ misallocation.
- Does this mean there's no room for policy? Maybe. Depends on whether or not policy affects TFP process.

Gandhi, Navarro & Rivers "How Heterogenous is Productivity" (2016)

- Large literature documenting differences in productivity across firms, countries, etc.

- Identification and estimation of production functions is an old empirical problem.

- If firms make decisions based on observed (to them) TFP shocks, simple-minded OLS regressions will be biased.

  $\rightarrow$ We call this "transmission bias".

- Solution has been the "proxy variable" approach of Olley & Pakes (1996) refined by:
  - Levinsohn & Petrin (ReStud 2003)
  - Wooldridge (EL 2009)
  - Ackerberg, Caves, & Frazer (Ecma 2015)

- **Research Question**: Does the proxy variable technique solve the identification problem of transmission bias?

Approach

1. Demonstrate identification problem.
2. Establish non-identification under standard techniques.
3. Show what's needed to fix the issue.

   → need an estimate of the *"Flexible Input Elasticity"*.
4. Outline non-parametric estimation technique
5. Demonstrate quantitative implications with commonly-used data sets (Colombia, Chile).

Model

1. Production:

$$\begin{aligned} Y_t &= F(k_t, l_t, m_t)\, e^{\nu_t} \iff \\ y_t &= f(k_t, l_t, m_t) + \nu_t \end{aligned} \tag{2}$$

where the Hick's neutral productivity shock $\nu_t = \omega_t + \epsilon_t$. ω_t known to firm when making decisions, ϵ_t is an ex post shock.

2. Stochastic Behavior:

Assumption 2. *$\omega_t \in \mathcal{I}_t$ is known to the firm at the time of making its period t decisions, whereas $\varepsilon_t \notin \mathcal{I}_t$ is not. Furthermore ω_t is Markovian so that its distribution can be written as $P_\omega(\omega_t \mid \mathcal{I}_{t-1}) = P_\omega(\omega_t \mid \omega_{t-1})$. The function $h(\omega_{t-1}) = E[\omega_t \mid \omega_{t-1}]$ is continuous. The shock ε_t on the other hand is independent of the within period variation in information sets, $P_\varepsilon(\varepsilon_t \mid \mathcal{I}_t) = P_\varepsilon(\varepsilon_t)$.*

can express $\omega_t = h(\omega_{t-1}) + \eta_t$ where η satisfies $E[\eta_y|\mathcal{I}_{t-1}] = 0$.
$\rightarrow \eta_t \equiv$ unanticipated at $t-1$ innovation to the firm's persistent productivity ω_t in period t.

Scalar invertibility

- WLOG assume inputs M are flexibly chosen:

$$m_t = \mathbb{M}(\mathcal{I}_t) = \mathbb{M}(k_t, l_t, \omega_t). \tag{3}$$

- If we assume that $\mathbb{M}$ is strictly monotone in ω, we have the following inversion:

$$\omega_t = \mathbb{M}^{-1}(k_t, l_t, m_t).$$

Transmission Bias

- Regress log output on log inputs. Elasticity is:

$$\frac{\partial}{\partial x_t} E\left[y_t \mid k_t, l_t, m_t\right] = \frac{\partial}{\partial x_t} f\left(k_t, l_t, m_t\right) + \frac{\partial}{\partial x_t} E\left[\omega_t \mid k_t, l_t, m_t\right]$$

- Under proxy variable approach, we define a first-stage random variable ϕ:

$$E\left[y_t \mid k_t, l_t, m_t\right] \quad = \quad f\left(k_t, l_t, m_t\right) + \mathbb{M}^{-1}\left(k_t, l_t, m_t\right) \equiv \phi\left(k_t, l_t, m_t\right). \tag{4}$$

- Question: Can we identify the part of ϕ attributable to $f(k, l, m)$ from ω in the second stage?

$$\begin{aligned} y_t &= f\left(k_t, l_t, m_t\right) + \omega_t + \varepsilon_t \\ &= f\left(k_t, l_t, m_t\right) + h\left(\phi_{t-1} - f\left(k_{t-1}, l_{t-1}, m_{t-1}\right)\right) + \eta_t + \varepsilon_t. \end{aligned} \tag{5}$$

Transmission Bias

$$\begin{aligned} y_t &= f(k_t, l_t, m_t) + \omega_t + \varepsilon_t \\ &= f(k_t, l_t, m_t) + h(\phi_{t-1} - f(k_{t-1}, l_{t-1}, m_{t-1})) + \eta_t + \varepsilon_t. \end{aligned} \tag{5}$$

- Issue: m_t is an endogenous variable which is correlated with η_t.
- Common Approach:
  1. Instrument by exploiting orthogonality conditions.
  2. Assumption 2 implies that for any transformation $\Gamma_t = \Gamma(\mathcal{I}_{t-1})$ we have $E[\eta_t + \epsilon_t | \Gamma_t] = 0$.
  3. Therefore any transformations based on period $t-1$ information are valid instruments.

Does this Approach Work?

$$\begin{aligned} E\left[y_t \mid \Gamma_t\right] &= E\left[f\left(k_t, l_t, m_t\right) \mid \Gamma_t\right] + E\left[\omega_t \mid \Gamma_t\right] \\ &= E\left[f\left(k_t, l_t, m_t\right) \mid \Gamma_t\right] + h\left(\phi_{t-1} - f\left(k_{t-1}, l_{t-1}, m_{t-1}\right)\right), \quad (6) \end{aligned}$$

- $\phi_{t-1} \equiv \phi(k_{t-1}, l_{t-1}, \omega_{t-1})$ known from first stage.
- Test: The "true" (f^0, h^0) are identified is $\exists$ no other $(\tilde{f}, \tilde{h})$ pair which satisfies (6) given DGP.
- Intuitively, (f^0, h^0) are the unique primitives of the underlying model (i.e., the DGP) which explain $E[y_t|\Gamma_t]$.

Lemma 1

Lemma 1. *If* (f, h) *solve the functional restriction* (6)*, then it must be the case that*

$$E\left[\phi_t - f_t \mid \Gamma_t\right] = h\left(\phi_{t-1} - f_{t-1}\right)$$

Proof. Observe that

$$\begin{aligned} E\left[y_t \mid \Gamma_t\right] &= E\left[E\left[y_t \mid k_t, l_t, m_t\right] \mid \Gamma_t\right] \\ &= E\left[\phi_t \mid \Gamma_t\right] \end{aligned}$$

by construction of ϕ_t. From the definition of y_t it follows that

$$E\left[\phi_t \mid \Gamma_t\right] = E\left[f_t \mid \Gamma_t\right] + h\left(\phi_{t-1} - f_{t-1}\right).$$

Re-arranging terms gives us the Lemma. □

Theorem 1

Theorem 1. *Under the model defined by Assumptions 1 - 3, and given* $\phi_t \equiv \phi(k_t, l_t, m_t)$ *identified from the first stage equation* (4)*, there exists a continuum of alternative* $\left(\tilde{f}, \tilde{h}\right)$ *defined by*

$$\begin{aligned} \tilde{f} &\equiv (1-a)\, f^0 + a\phi_t \\ \tilde{h}(x) &\equiv (1-a)\, h^0\left(\frac{1}{(1-a)}x\right) \end{aligned}$$

for any $a \in (0,1)$*, that satisfy the same functional restriction* (6) *as the true* (f^0, h^0).

- Theorem 1 follows immediately from Lemma 1.
- There are an infinite set of functions $(\tilde{f}, \tilde{h})$ which satisfy $E[y_t|\Gamma_t]$!

Intuition

- We replace ω in (3)

$$m_t = \mathbb{M}\left(k_t, l_t, h\left(\mathbb{M}^{-1}\left(k_{t-1}, l_{t-1}, m_{t-1}\right)\right) + \eta_t\right).$$

- The only variation in m_t after conditioning on Γ_t is the unobservable η_t.

- Despite an abundance of potential instruments in Γ_t, all are orthogonal to η_t and therefore have no power as instruments!

Issue

- Theorem 1 says the estimation is nonparametrically non-identified under the standard two-stage/ GMM approach.
- Need additional "moments" for consistent estimation.
- Authors employing the standard approach assume a "flexible production" for f $\rightarrow$ they unwittingly imposed additional structure to get identification.

What's the Source of Under-identification?

- How does production change with different input choices? Fundamental Theorem of Calculus:

$$\int \frac{\partial}{\partial m_t} f(k_t, l_t, m_t)\, dm_t \;=\; f(k_t, l_t, m_t) + \mathscr{C}(k_t, l_t). \tag{7}$$

- Then we have an "observable" random variable like with ϕ.

$$\mathcal{Y}_t \equiv y_t - \varepsilon_t - \int \frac{\partial}{\partial m_t} f(k_t, l_t, m_t)\, dm_t = -\mathscr{C}(k_t, l_t) + \omega_t. \tag{8}$$

- Apply Markovian structure:

$$\mathcal{Y}_t \;=\; -\mathscr{C}(k_t, l_t) + h(\mathcal{Y}_{t-1} + \mathscr{C}(k_{t-1}, l_{t-1})) + \eta_t. \tag{9}$$

- Identification (up to a constant):

$$E[\mathcal{Y}_t \mid k_t, l_t, \mathcal{Y}_{t-1}, k_{t-1}, l_{t-1}] = -\mathscr{C}(k_t, l_t) + h(\mathcal{Y}_{t-1} + \mathscr{C}(k_{t-1}, l_{t-1})). \tag{10}$$

What's the Source of Under-identification?

- If we new the flexible input elasticity $\frac{\partial}{\partial m_t} f(k_t, l_t, m_t)$, we could identify the production function.
- Standard approach is too weak to identify this elasticity though. Authors employing this approach have been imposing the elasticity via an assumed functional form for production.

Can We Identify the Flexible Input Elasticity?

- Recall:

$$\begin{aligned} y_t &= f(k_t, l_t, m_t) + \omega_t + \epsilon_t \\ m_t &= \mathbb{M}(k_t, l_t, \omega_t) \end{aligned}$$

- Elasticity identified by how output y_t varies with m_t holding (k_t, l_t) fixed.
- m_t is a choice which is a function of the same productivity shock ω_t which impacts output y_t.
- $\exists$ no variation in m_t due to outside factors. It only moves with y_t.
- How to identify the elasticity then?
  - Allow shifters which enter flexible input demand $\mathbb{M}$ but not production. For example, input/ output prices which vary by firm.
  - Use restrictions from theory to identify the elasticity.

How do Firms Choose Inputs?

- For simplicity, assume firms are price-takers in output and input markets.
- Firm solves

$$\mathbb{M}(k_t, l_t, \omega_t) = \arg\max_{M_t} P_t E\left[F(k_t, l_t, m_t)\, e^{\omega_t + \varepsilon_t} \mid \mathcal{I}_t\right] - \rho_t M_t, \tag{13}$$

- First-order condition:

$$P_t \frac{\partial}{\partial M_t} F(k_t, l_t, m_t)\, e^{\omega_t} \mathcal{E} = \rho_t, \tag{14}$$

- Taking logs of (14) and differencing with (2):

$$\begin{aligned} s_t &= \ln \mathcal{E} + \ln\left(\frac{\partial}{\partial m_t} f(k_t, l_t, m_t)\right) - \varepsilon_t \\ &\equiv \ln D^{\mathcal{E}}(k_t, l_t, m_t) - \varepsilon_t \end{aligned} \tag{15}$$

where $s_t \equiv \log\left(\frac{\rho_t M_t}{P_t Y_t}\right)$ and $\mathcal{E} = E[e^{\epsilon_t}]$.

Identification

Theorem 4. *Under Assumptions 1, 2, 4, 5, and that* ρ_t, P_t *(or price-deflators) are observed, the share regression in equation* (15) *nonparametrically identifies the flexible input elasticity* $\frac{\partial}{\partial m_t} f(k_t, l_t, m_t)$ *of the production function almost everywhere in* (k_t, l_t, m_t).

- By using the optimal behavior of firms we can identify the flexible input elasticity.

A Simple Estimator

- Estimate (15) to recover flexible input elasticity by polynomial approximation. For example,

$$\min_{\gamma'} \sum_{j,t} \left\{ s_{jt} - \ln \left(\begin{array}{c} \gamma'_0 + \gamma'_k k_{jt} + \gamma'_l l_{jt} + \gamma'_m m_{jt} + \gamma'_{kk} k_{jt}^2 + \gamma'_{ll} l_{jt}^2 \\ +\gamma'_{mm} m_{jt}^2 + \gamma'_{kl} k_{jt} l_{jt} + \gamma'_{km} k_{jt} m_{jt} + \gamma'_{lm} l_{jt} m_{jt} \end{array} \right) \right\}^2 .$$

The solution to this problem is an estimator

$$D_r^{\mathcal{E}} \left(k_{jt}, l_{jt}, m_{jt} \right) = \sum_{r_k + r_l + r_m \leq r} \gamma'_{r_k, r_l, r_m} k_{jt}^{r_k} l_{jt}^{r_l} m_{jt}^{r_m}, \text{ with } r_k, r_l, r_m \geq 0,$$

- Recover $\hat{\mathcal{E}} = \frac{1}{JT} \sum_{j,t} e^{\hat{\epsilon}_{jt}}$ to recover $\frac{\partial}{\partial m_t} f(k_t, l_t, m_t)$.

A Simple Estimator, cont'd.

- Use coefficient estimates to recover $\mathcal{D}_r$:

$$\mathcal{D}_r\left(k_{jt}, l_{jt}, m_{jt}\right) \equiv \int D_r\left(k_{jt}, l_{jt}, m_{jt}\right) dm_{jt} = \sum_{r_k+r_l+r_m \leq r} \frac{\gamma_{r_k, r_l, r_m}}{r_m+1} k_{jt}^{r_k} l_{jt}^{r_l} m_{jt}^{r_m+1}.$$

- Form sample analog of $\mathcal{Y}$:

$$\hat{\mathcal{Y}}_{jt} \equiv \log\left(\frac{Y_{jt}}{e^{\hat{\epsilon}} e^{\hat{\mathcal{D}}_r\left(k_{jt}, l_{jt}, m_{jt}\right)}}\right)$$

A Simple Estimator, cont'd.

- Recover constant of integration $\mathcal{C}$ and Markovian process h.

$$\mathscr{C}_\tau(k_{jt}, l_{jt}) = \sum_{0<\tau_k+\tau_l\leq\tau} \alpha_{\tau_k,\tau_l} k_{jt}^{\tau_k} l_{jt}^{\tau_l}, \text{ with } \tau_k, \tau_l \geq 0, \tag{20}$$

and

$$h_A(\omega_{jt-1}) = \sum_{0\leq a\leq A} \delta_a \omega_{jt-1}^a, \text{ with } a \leq A \tag{21}$$

- Combine to create the estimating equation

$$\hat{\mathcal{Y}}_{jt} = -\sum_{0<\tau_k+\tau_l\leq\tau} \alpha_{\tau_k,\tau_l} k_{jt}^{\tau_k} l_{jt}^{\tau_l} + \sum_{0\leq a\leq A} \delta_a \left(\hat{\mathcal{Y}}_{jt-1} + \sum_{0<\tau_k+\tau_l\leq\tau} \alpha_{\tau_k,\tau_l} k_{jt-1}^{\tau_k} l_{jt-1}^{\tau_l}\right)^a + \eta_{jt} \tag{23}$$

- Identifying "second-stage" moments:

$$\begin{aligned} E[\eta_{jt} k_{jt}^{\tau_k \tau_l}] &= 0 \\ E[\eta_{jt} \hat{\mathcal{Y}}_{jt-1}^a] &= 0 \end{aligned}$$

A Simple Estimator, cont'd.

- The estimator is therefore a standard just-identified GMM estimator with the following moment conditions:

$$
\begin{aligned}
E\left[\varepsilon_{jt}\frac{\partial \ln D_r\left(k_{jt}, l_{jt}, m_{jt}\right)}{\partial \gamma}\right] &= 0, \\
E\left[\eta_{jt} k_{jt}^{\tau_k} l_{jt}^{\tau_l}\right] &= 0, \\
E\left[\eta_{jt} \mathcal{Y}_{jt-1}^{a}\right] &= 0,
\end{aligned}
$$

- Compute standard errors via block bootstrap.

Is this Correction Economically Meaningful?

- Researchers often have the value of output and inputs rather than physical amounts.
- Usually rationalize that the value added (i.e., the difference between revenue and costs) identifies the underlying gross output production function.
- Can therefore recover the distribution of firm productivity.
- Syverson (JEL 2011) points out that results in literature are robust to the different approaches used to identify the distribution of firm productivity.

  $\rightarrow$ *the underlying variation at the firm-level is so large that mis-measuring it really has not effect on big picture, qualitative results*.
- Question: Is this true? Does the value-added approach (e.g., Ackerberg, Caves, Frazer; ECMA 2015) reveal the "true" distribution of firm productivity?
- Answer by horse race where they recover firm productivity using data from Colombia and Chile:
  1. value added approach via ACF.
  2. gross output approach via GNR.

Table 1: Average Input Elasticities of Output
(Structural Estimates: Value Added vs. Gross Ouput)

	Industry (ISIC Code)											
	Food Products (311)		**Textiles (321)**		**Apparel (322)**		**Wood Products (331)**		**Fabricated Metals (381)**		**All**	
	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)
Colombia												
Labor	0.70	0.22	0.65	0.32	0.83	0.42	0.86	0.44	0.89	0.43	0.78	0.35
	(0.04)	(0.02)	(0.06)	(0.03)	(0.03)	(0.02)	(0.06)	(0.05)	(0.04)	(0.02)	(0.01)	(0.01)
Capital	0.33	0.12	0.36	0.16	0.16	0.05	0.12	0.04	0.25	0.10	0.31	0.14
	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.01)	(0.04)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)
Intermediates	--	0.67	--	0.54	--	0.52	--	0.51	--	0.53	--	0.54
		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.00)
Sum	1.03	1.01	1.01	1.01	0.99	0.99	0.98	0.99	1.14	1.06	1.09	1.04
	(0.03)	(0.01)	(0.04)	(0.02)	(0.02)	(0.01)	(0.07)	(0.04)	(0.02)	(0.01)	(0.01)	(0.00)
Mean(Capital) / Mean(Labor)	0.47	0.55	0.55	0.49	0.19	0.12	0.14	0.08	0.28	0.23	0.39	0.40
	(0.06)	(0.08)	(0.10)	(0.09)	(0.03)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.02)	(0.03)
Chile												
Labor	0.77	0.28	0.93	0.45	0.95	0.45	0.92	0.40	0.96	0.52	0.77	0.38
	(0.02)	(0.01)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)	(0.03)	(0.01)	(0.01)
Capital	0.33	0.11	0.24	0.11	0.20	0.06	0.19	0.07	0.25	0.13	0.37	0.16
	(0.01)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.00)
Intermediates	--	0.67	--	0.54	--	0.56	--	0.59	--	0.50	--	0.55
		(0.00)		(0.01)		(0.01)		(0.01)		(0.01)		(0.00)
Sum	1.10	1.05	1.17	1.10	1.14	1.08	1.11	1.06	1.22	1.15	1.13	1.09
	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)	(0.01)	(0.01)
Mean(Capital) / Mean(Labor)	0.43	0.39	0.26	0.24	0.21	0.14	0.21	0.18	0.26	0.25	0.48	0.43
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)

- Value-added approach (ACF) generates larger elasticities.

Colombia

	Industry (ISIC Code)											
	Food Products (311)		**Textiles (321)**		**Apparel (322)**		**Wood Products (331)**		**Fabricated Metals (381)**		**All**	
	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)	Value Added (ACF)	Gross Output (GNR)
75/25 ratio	2.20	1.33	1.97	1.35	1.66	1.29	1.73	1.30	1.78	1.31	1.95	1.37
	(0.07)	(0.02)	(0.09)	(0.03)	(0.03)	(0.01)	(0.08)	(0.04)	(0.04)	(0.02)	(0.17)	(0.01)
90/10 ratio	5.17	1.77	3.71	1.83	2.87	1.66	3.08	1.80	3.33	1.74	4.01	1.86
	(0.27)	(0.05)	(0.30)	(0.07)	(0.09)	(0.03)	(0.38)	(0.12)	(0.13)	(0.03)	(0.07)	(0.02)
95/5 ratio	11.01	2.24	6.36	2.38	4.36	2.02	4.58	2.24	5.31	2.16	6.86	2.36
	(1.11)	(0.08)	(0.76)	(0.14)	(0.22)	(0.05)	(1.01)	(0.22)	(0.34)	(0.06)	(0.02)	(0.03)
Exporter	3.62	0.14	0.20	0.02	0.16	0.05	0.26	0.15	0.20	0.08	0.51	0.06
	(0.99)	(0.05)	(0.10)	(0.03)	(0.07)	(0.03)	(0.63)	(0.14)	(0.05)	(0.03)	(0.12)	(0.01)
Importer	-0.25	0.04	0.27	0.05	0.29	0.12	0.06	0.05	0.26	0.10	0.20	0.11
	(0.08)	(0.02)	(0.10)	(0.04)	(0.08)	(0.03)	(0.53)	(0.08)	(0.06)	(0.02)	(0.05)	(0.01)
Advertiser	-0.46	-0.03	0.20	0.08	0.13	0.05	0.02	0.04	0.15	0.05	-0.13	0.03
	(0.10)	(0.02)	(0.07)	(0.03)	(0.04)	(0.02)	(0.09)	(0.04)	(0.04)	(0.02)	(0.06)	(0.01)
Wages > Median	0.59	0.09	0.60	0.18	0.41	0.18	0.34	0.15	0.55	0.22	0.63	0.20
	(0.19)	(0.02)	(0.09)	(0.03)	(0.03)	(0.02)	(0.17)	(0.04)	(0.06)	(0.02)	(0.05)	(0.01)
Chile												
75/25 ratio	2.92	1.37	2.56	1.48	2.58	1.43	3.06	1.50	2.45	1.53	3.00	1.55
	(0.05)	(0.01)	(0.07)	(0.02)	(0.07)	(0.02)	(0.08)	(0.02)	(0.06)	(0.02)	(0.03)	(0.01)
90/10 ratio	9.02	1.90	6.77	2.16	6.76	2.11	10.12	2.32	6.27	2.33	9.19	2.39
	(0.30)	(0.02)	(0.30)	(0.05)	(0.33)	(0.05)	(0.60)	(0.05)	(0.27)	(0.05)	(0.15)	(0.02)
95/5 ratio	21.29	2.48	13.56	2.91	14.21	2.77	25.08	3.11	12.52	3.13	20.90	3.31
	(0.99)	(0.05)	(0.84)	(0.09)	(0.77)	(0.09)	(2.05)	(0.11)	(0.78)	(0.10)	(0.47)	(0.04)
Exporter	0.27	0.02	0.07	0.02	0.18	0.09	0.12	0.00	0.03	-0.01	0.20	0.03
	(0.10)	(0.02)	(0.07)	(0.03)	(0.08)	(0.03)	(0.12)	(0.03)	(0.06)	(0.03)	(0.04)	(0.01)
Importer	0.71	0.14	0.22	0.10	0.31	0.14	0.44	0.15	0.30	0.11	0.46	0.15
	(0.11)	(0.02)	(0.05)	(0.02)	(0.05)	(0.02)	(0.10)	(0.03)	(0.05)	(0.02)	(0.03)	(0.01)
Advertiser	0.18	0.04	0.09	0.04	0.15	0.06	0.04	0.03	0.07	0.01	0.14	0.06
	(0.05)	(0.01)	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)	(0.01)	(0.04)	(0.02)	(0.02)	(0.01)
Wages > Median	1.23	0.21	0.47	0.19	0.62	0.22	0.68	0.21	0.56	0.22	0.99	0.30
	(0.09)	(0.01)	(0.06)	(0.02)	(0.06)	(0.02)	(0.08)	(0.02)	(0.06)	(0.02)	(0.04)	(0.01)

- Value-added approach (ACF) implies greater heterogeneity within an industry. i.e., smaller percentile ratios under GNR.
- Value-added approach (ACF) implies greater heterogeneity across industries. i.e., smaller range of percentile ratios across industries under GNR.

Discussion

- Differences between value-added approach and gross output approaches exist even if one doesn't account for transmission bias (see Table 3).

- Not accounting for transmission bias leads to overestimating results of coefficients for more flexible inputs regardless of approach:

  $\rightarrow$ the more flexible an input is, the more it responds to productivity shocks and the higher degree of correlation between the input and the unobserved productivity.

- Estimating productivity via value-added or gross output has quantitatively important implications equivalent to not accounting for transmission bias.

8. Identifying Winners and Losers of Trade Liberalization

De Loecker, Goldberg, Khandelwal, & Pavcnik "Prices, Markups, and Trade Reform" (ECMA 2016)

- Theory indicates that trade reforms can deliver substantial benefits via better resource allocation.
- Theory and empirical literature document potential mechanisms:
  - Changes in aggregate productivity (Melitz 2003).
  - Better inputs (Goldberg, Khandelwal, Pavcnik, & Topalova (2010).
  - Reduce markups Levinsohn (1993).
- Little evidence that trade reforms do in fact put downward pressure on prices.
- Research Objective: Is there empirical evidence that trade reforms impact retail prices?

Empirical Approach

- Develop a general framework to estimate markups and marginal costs. Framework allows for but does not impose imperfect pass-through.
- Use Indian data to estimate quantity-based production functions.
  - Data spans India's 1991 trade liberalization where tariffs fall 62% on average.
  - Data has price and quantity.
  - Avoids output-price bias common with TFPR measures since these confound demand shocks and markups.
- Document two additional biases previously not addressed:
  1. Unobserved allocation of inputs across products within a multi-product firm.
  2. Changes in unobserved input prices.
- Analyze how prices, marginal costs, and markups adjust during India's 1991 trade liberalization.

Data

- Source: Prowess data collected by the Centre for Monitoring the Indian Economy (CMIE).
- Panel which spans the 1991 Indian trade reforms.
- Detailed records at the product-level (≈ 1400) $\Rightarrow$ enables us to distinguish between single and multi-product firms.
- Data include quantity and sales so can also infer price.
- Not a census so not well suited for addressing entry and exit.
- Add tariff rates at six-digit HS level.
  Use Indian Input-Output table to construct input tariffs.

TABLE I

SUMMARY STATISTICS[a]

Sector	Share of Sample Output (1)	All Firms (2)	Single-Product Firms (3)	Products (4)
15 Food products and beverages	9%	302	135	135
17 Textiles, apparel	10%	303	161	78
21 Paper and paper products	3%	77	56	32
24 Chemicals	26%	434	194	483
25 Rubber and plastic	5%	139	85	83
26 Nonmetallic mineral products	7%	110	74	60
27 Basic metals	16%	212	115	101
28 Fabricated metal products	2%	74	48	45
29 Machinery and equipment	7%	160	80	186
31 Electrical machinery and communications	5%	89	52	102
34 Motor vehicles, trailers	9%	71	47	95
Total	100%	1970	1047	1400

[a]Table reports summary statistics for the average year in the sample. Column 1 reports the share of output by sector in the average year. Columns 2 and 3 report the number of firms and number of single-product firms manufacturing products in the average year. Column 4 reports the number of products by sector.

TABLE II

EXAMPLE OF SECTOR, INDUSTRY, AND PRODUCT CLASSIFICATIONS[a]

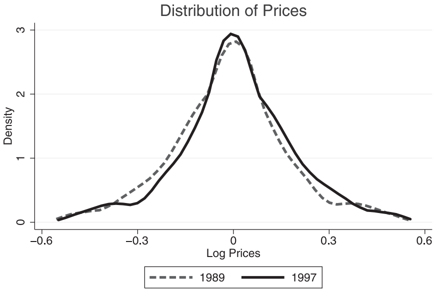
NIC Code		Description
27		Basic metal industries (sector s)
2710		Manufacture of basic iron and steel (industry i)
		Products (j)
	130101010000	Pig iron
	130101020000	Sponge iron
	130101030000	Ferro alloys
	130106040800	Welded steel tubular poles
	130106040900	Steel tubular structural poles
	130106050000	Tube and pipe fittings
	130106100000	Wires and ropes of iron and steel
	130106100300	Stranded wire
2731		Casting of iron and steel (industry i)
		Products (j)
	130106030000	Castings and forgings
	130106030100	Castings
	130106030101	Steel castings
	130106030102	Cast iron castings
	130106030103	Maleable iron castings
	130106030104	S.G. iron castings
	130106030199	Castings, nec

[a]This table is replicated from Goldberg et al. (2010b). For NIC 2710, there are a total of 111 products, but only a subset are listed in the table. For NIC 2731, all products are listed in the table.

Trade Liberalization

- Reduced tariffs significantly (62% $\downarrow$ on average) in August 1991 as part of an IMF structural adjustment program.
- Reforms were unexpected and passed quickly as "shock therapy." There was little debate or analysis in order to avoid political opposition.
- Topalova & Khandelwal (2011) document reforms uncorrelated with firm and/ or industry characteristics (productivity, size, output, growth, capital density).
- The reforms prior to 1997 do not appear to target specific firms or industries (i.e., the were random) so we can plausibly ignore any endogeneity concerns regarding the tariffs.
- Authors therefore estimate production functions of firms which operated from 1989 to 1997.

Trade Reform and Retail Prices



- Figure plots the raw distribution firm-product prices present in 1989 and 1997.
- Retail prices did not change much between 1989 and 1997.

Trade Reform and Retail Prices, cont'd.

	$\ln P_{fjt}$	
	(1)	(2)
$\tau_{it}^{\text{output}}$	0.136**	0.167***
	0.056	0.054
Within R-squared	0.00	0.02
Observations	21,246	21,246
Firm–product FEs	yes	yes
Year FEs	yes	no
Sector–year FEs	no	yes
Overall impact of trade liberalization	−8.4**	−10.4***
	3.4	3.3

[a]The dependent variable is a firm–product's (log) price. Column 1 includes year fixed effects and Column 2 includes sector–year fixed effects. The regressions exclude outliers in the top and bottom 3rd percent of the markup distribution. All regressions

- ... but not very much.
- A 10 percent decline in tariffs reduced retail prices 1.36%.
- Given tariffs fell 62%, retail prices fell on average 8.4%.
- Controlling sector-year FEs yields a similar result.
- Why are retail prices not falling more?

Theoretical Framework

- Production function for firm f producing product j in period t:

$$Q_{fjt} = F_{jt}(\mathbf{V}_{fjt}, \mathbf{K}_{fjt})\Omega_{ft}, \quad (1)$$

- Assumption 1: Production technology is product-specific.
- Assumption 2: $F_{jt}(\cdot)$ is continuous and twice differentiable wrt to at least one flexible, static input (V).
- Assumption 3: Hicks-neutral productivity Ω_{jt} is log-additive and firm-specific.
- Assumption 4: Expenditures on all inputs are attributable to products so can always wrt $W^x_{fjt}X_{fjt} = \tilde{\rho}_{fjt} \sum_j^J W^x_{fjt}X_{fjt}$ where W^x_{fjt} is the input price of input X and $\tilde{\rho}_{fjt}$ is the input share with $\sum \rho_{fjt} = 1$.
- Assumption 5: State variables are

$$s_{ft} = [J_{ft}, K_{f,j=1,t}, ..., , K_{f,j=J,t}, \Omega_{ft}, G_f, r_{fjt}]$$

  where $r \equiv$ pay-off relevant serially-correlated variables (e.g., export status, tariffs).
- Assumption 6: Firms minimize short-run costs taking input prices W^x as given. Excludes monopsony power and quantity discounts.

Cost Minimization

- Assumptions 2, 6 imply firms minimize costs wrt variable inputs.
- Assumptions 4, 6 imply costs are separable across products.

$$\mathcal{L}(\mathbf{V}_{fjt}, \mathbf{K}_{fjt}, \lambda_{fjt}) = \sum_{v=1}^{V} W_{fjt}^{v} V_{fjt}^{v} + \sum_{k=1}^{K} W_{fjt}^{k} K_{fjt}^{k} + \lambda_{fjt}\big[Q_{fjt} - Q_{fjt}(\mathbf{V}_{fjt}, \mathbf{K}_{fjt}, \Omega_{ft})\big]. \tag{2}$$

- FONC wrt to variable input V is then

$$\frac{\partial \mathcal{L}_{fjt}}{\partial V_{fjt}^{v}} = W_{fjt}^{v} - \lambda_{fjt} \frac{\partial Q_{fjt}(\cdot)}{\partial V_{fjt}^{v}} = 0, \tag{3}$$

- Rearranging we define output elasticity wrt input V θ:

$$\frac{\partial Q_{fjt}(\cdot)}{\partial V_{fjt}^{v}} \frac{V_{fjt}^{v}}{Q_{fjt}} = \frac{1}{\lambda_{fjt}} \frac{W_{fjt}^{v} V_{fjt}^{v}}{Q_{fjt}}. \tag{4}$$

Estimating Markups

- Define markup as $\mu = \frac{P}{\lambda}$ then we have

$$\mu_{fjt} = \theta^v_{fjt}\left(\frac{P_{fjt}Q_{fjt}}{W^v_{fit}V^v_{fit}}\right) = \theta^v_{fjt}\left(\alpha^v_{fjt}\right)^{-1}, \quad (5)$$

  where α^v_{fjt} is the share of expenditure on input V allocated to product j in total sales of product j.

- Given an estimate for μ, can infer marginal costs

$$mc_{fjt} = \frac{P_{fjt}}{\mu_{fjt}}. \quad (6)$$

- Need two things to estimate markups μ :
  1. Output elasticity.
  2. Share of input expenditure of total sales.

- Must estimate output elasticity separately for each firm.

- Can't read α off the data so need to impute expenditure allocations across multi-product firms

Estimation

- Apply logs to equation (1:)

$$q_{fjt} = f_j(\mathbf{x}_{fjt}; \boldsymbol{\beta}) + \omega_{ft} + \epsilon_{fjt}. \quad (7)$$

- Again, have simultaneity issue where OLS would deliver biased results.

- Apply proxy variable approach with translog production function.

- Authors point out two new biases:
  From Assumption 4, input quantities x depend on observed deflated input expenditures $\tilde{x}$ as follows:

$$x_{fjt} = \rho_{fjt} + \tilde{x}_{ft} - w^x_{fjt}, \quad (8)$$

  Plugging into (7):

$$q_{fjt} = f_j(\tilde{\mathbf{x}}_{ft}; \boldsymbol{\beta}) + A(\rho_{fjt}, \tilde{\mathbf{x}}_{ft}, \boldsymbol{\beta}) + B(\mathbf{w}_{fjt}, \rho_{fjt}, \tilde{\mathbf{x}}_{ft}, \boldsymbol{\beta}) + \omega_{ft} + \epsilon_{fjt}. \quad (9)$$

  1. $A(\cdot)$ corresponds to unobserved product-level input allocations.
     - Call this "input allocation" bias.
  2. $B(\cdot)$ corresponds to unobserved firm-product-input prices.
     - Call this "input price" bias.

Addressing these Biases

- "Allocation bias" not an issue for single product firms.
- If we assume production functions of single and multi-product firms are the same, can estimate output elasticity using just the single product firms.
- Equation (9) simplifies to:

$$q_{ft} = f(\tilde{\mathbf{x}}_{ft}; \boldsymbol{\beta}) + B(\mathbf{w}_{ft}, \tilde{\mathbf{x}}_{ft}, \boldsymbol{\beta}) + \omega_{ft} + \epsilon_{ft}. \tag{10}$$

- We still need to address unobserved input prices ("Input bias" via $B(\cdot)$) which may change from changes in tariff rates.

Addressing these Biases, cont'd

- Assume input prices are an increasing function of input quality (reasonable supported by data).
- Use variables which proxy for output quality (also assume input and output quality positively correlated) to proxy for input prices.

$$w^x_{ft} = w_t(p_{ft}, \mathbf{ms}_{ft}, \mathbf{D}_f, \mathbf{G}_f, EXP_{ft}), \tag{12}$$

- Substitute for $B(\cdot)$:

$$B(\mathbf{w}_{ft}, \tilde{\mathbf{x}}_{ft}, \boldsymbol{\beta}) = B\big((p_{ft}, \mathbf{ms}_{ft}, \mathbf{D}_f, \mathbf{G}_f, EXP_{ft}) \times \tilde{\mathbf{x}}^c_{ft}; \boldsymbol{\beta}, \boldsymbol{\delta}\big). \tag{13}$$

where $\tilde{x}^c = [1,\ \tilde{x}]$ to account for the fact that $B(\cdot)$ has w as an input as well as interactions of w with deflated expenditures $\tilde{x}$.

Estimation

- First stage:

$$(19) \qquad q_{ft} = \phi_t(\tilde{\mathbf{x}}_{ft}, \mathbf{z}_{ft}) + \epsilon_{ft},$$

where we remind the reader that the vector $\mathbf{z}_{ft}$ includes all variables that affect intermediate input demand, except for the input expenditures and unobserved productivity:

$$\mathbf{z}_{ft} = \{\mathbf{G}_f, p_{ft}, \mathbf{D}_f, \mathbf{ms}_{ft}, EXP_{ft}, \tau_{it}^{\text{input}}, \tau_{it}^{\text{output}}\},$$

and the term $\phi_t(\cdot)$ is equal to $f(\tilde{\mathbf{x}}_{ft}; \boldsymbol{\beta}) + B(\mathbf{w}_{ft}, \tilde{\mathbf{x}}_{ft}, \boldsymbol{\beta}) + \omega_{ft}$ and captures output net of noise ϵ_{ft}.

- Second stage:

$$(20) \qquad \omega_{ft}(\boldsymbol{\beta}, \boldsymbol{\delta}) = \hat{\phi}_{ft} - f(\tilde{\mathbf{x}}_{ft}; \boldsymbol{\beta}) - B\big((p_{ft}, \mathbf{ms}_{ft}, \mathbf{D}_f, \mathbf{G}_f, EXP_{ft}) \times \tilde{\mathbf{x}}_{ft}^c; \boldsymbol{\delta}\big),$$

- Productivity Law of Motion:

$$(18) \qquad \omega_{ft} = g\big(\omega_{ft-1}, \tau_{it-1}^{\text{output}}, \tau_{it-1}^{\text{input}}, EXP_{ft-1}, SP_{ft}\big) + \xi_{ft}.$$

where SP is sample-selection correction to account for firms selecting to become multi-product firms due to changes in productivity (and dropped in this estimation due to focus on single-product firms).

Estimation, cont'd

- Structural errors take advantage of timing assumptions:

$$\xi_{ft}(\boldsymbol{\beta},\boldsymbol{\delta}) = \omega_{ft}(\boldsymbol{\beta},\boldsymbol{\delta}) - E\big(\omega_{ft}(\boldsymbol{\beta},\boldsymbol{\delta})|\omega_{ft-1}(\boldsymbol{\beta},\boldsymbol{\delta}), \tau_{it-1}^{\text{output}}, \tau_{it-1}^{\text{input}}, EXP_{ft-1}, SP_{ft}\big). \tag{21}$$

- Moment conditions:

$$E\big(\xi_{ft}(\boldsymbol{\beta},\boldsymbol{\delta})\mathbf{Y}_{ft}\big) = 0, \tag{22}$$

  where Y contains lagged materials, current capital and labor, lagged output prices, market shares, tariffs + interactions.

- Estimate parameters via GMM.
- Recover input allocations α by solving system of equations.

Input Allocations

- Estimated parameters yield output elasticities θ.
- Recover input allocations α by solving system of equations.

$$\hat{q}_{fjt} = f(\tilde{\mathbf{x}}_{ft}, \hat{\boldsymbol{\beta}}, \hat{w}_{fjt}, \rho_{fjt}) + \omega_{ft},$$

and recover $\{\{\rho_{fjt}\}_{j=1}^{J}, \omega_{ft}\}$ using

$$\hat{q}_{fjt} - f_1(\tilde{\mathbf{x}}_{ft}, \hat{\boldsymbol{\beta}}, \hat{w}_{fjt}) = f_2(\tilde{\mathbf{x}}_{ft}, \hat{w}_{fjt}, \rho_{fjt}) + \omega_{ft}, \tag{23}$$

$$\sum_j \exp(\rho_{fjt}) = 1, \tag{24}$$

Markups and Marginal Costs

- Use estimated parameters to infer markups:

$$\hat{\mu}_{fjt} = \hat{\theta}^{M}_{fjt} \frac{P_{fjt} Q_{fjt}}{\exp(\hat{\rho}_{fjt}) \widetilde{X}^{M}_{ft}}, \tag{30}$$

- Back-out marginal costs:

$$mc_{fjt} = \frac{P_{fjt}}{\mu_{fjt}}. \tag{6}$$

Results: Output Elasticities

Sector	Production Function Estimation (1)	Labor (2)	Materials (3)	Capital (4)	Returns to Scale (5)
15 Food products and beverages	795	0.13	0.71	0.15	0.99
		[0.17]	[0.22]	[0.14]	[0.28]
17 Textiles, apparel	1581	0.11	0.82	0.08	1.01
		[0.02]	[0.04]	[0.08]	[0.06]
21 Paper and paper products	470	0.19	0.78	0.03	1.00
		[0.12]	[0.10]	[0.05]	[0.06]
24 Chemicals	1554	0.17	0.79	0.08	1.03
		[0.08]	[0.07]	[0.06]	[0.08]
25 Rubber and plastic	705	0.15	0.69	–0.02	0.82
		[0.39]	[0.29]	[0.35]	[0.89]
26 Nonmetallic mineral products	633	0.16	0.67	–0.04	0.79
		[0.26]	[0.12]	[0.40]	[0.36]
27 Basic metals	949	0.14	0.77	0.01	0.91
		[0.09]	[0.11]	[0.06]	[0.18]
28 Fabricated metal products	393	0.18	0.75	0.03	0.96
		[0.04]	[0.08]	[0.17]	[0.17]
29 Machinery and equipment	702	0.20	0.76	0.18	1.13
		[0.08]	[0.05]	[0.05]	[0.14]
31 Electrical machinery and communications	761	0.09	0.78	–0.06	0.81
		[0.11]	[0.11]	[0.22]	[0.28]
34 Motor vehicles, trailers	386	0.25	0.63	0.11	1.00
		[0.26]	[0.20]	[0.20]	[0.25]

Results: Markups

TABLE VI

MARKUPS, BY SECTOR[a]

Sector	Markups Mean	Markups Median
15 Food products and beverages	1.78	1.15
17 Textiles, apparel	1.57	1.33
21 Paper and paper products	1.22	1.21
24 Chemicals	2.25	1.36
25 Rubber and plastic	4.52	1.37
26 Nonmetallic mineral products	4.57	2.27
27 Basic metals	2.54	1.20
28 Fabricated metal products	3.70	1.36
29 Machinery and equipment	2.48	1.34
31 Electrical machinery and communications	5.66	1.43
34 Motor vehicles, trailers	4.64	1.39
Average	2.70	1.34

[a] Table displays the mean and median markup by sector for the sample 1989–2003. The table trims observations with markups that are above and below the 3rd and 97th percentiles within each sector.

Results: Trade Liberalization

TABLE IX

PRICES, COSTS, AND MARKUPS AND TARIFFS[a]

	$\ln P_{fjt}$ (1)	$\ln mc_{fjt}$ (2)	$\ln \mu_{fjt}$ (3)
$\tau_{it}^{\text{output}}$	0.156***	0.047	0.109
	0.059	0.084	0.076
τ_{it}^{input}	0.352	1.160**	−0.807‡
	0.302	0.557	0.510
Within *R*-squared	0.02	0.01	0.01
Observations	21,246	21,246	21,246
Firm–product FEs	yes	yes	yes
Sector–year FEs	yes	yes	yes
Overall impact of trade liberalization	−18.1**	−30.7**	12.6
	7.4	13.4	11.9

- Imperfect pass-through (column 1):
  $\rightarrow$ Prices fall 18.1%.
- Marginal costs fall with changes in input tariffs (column 2):
  $\rightarrow$ MC falls 30.7%.
- Markups stable (column 3):
  $\rightarrow$ Markups statistically zero.

Results: Pro-Competitive Effects?

TABLE X

PRO-COMPETITIVE EFFECTS OF OUTPUT TARIFFS[a]

	$\ln \mu_{fjt}$			
	(1)	(2)	(3)	(4)
$\tau_{it}^{\text{output}}$	0.143***	0.150**	0.129**	0.149**
	0.050	0.062	0.052	0.062
$\tau_{it}^{\text{output}} \times \text{Top}_{fp}$			0.314**	0.028
			0.134	0.150
Within R-squared	0.59	0.65	0.59	0.65
Observations	21,246	16,012	21,246	16,012
Second-order polynomial of marginal cost	yes	yes	yes	yes
Firm–product FEs	yes	yes	yes	yes
Sector–year FEs	yes	yes	yes	yes
Instruments	no	yes	no	yes
First-stage F-test	–	8.6	–	8.6

- Look for changes in markups holding marginal costs fixed.
- Reductions in output tariff cause markups to fall (columns 1,2) $\Rightarrow$ evidence of pro-competitive effects.
- Effects are bigger for high markup firms in 1989 (column 3) but this disappears after controlling with lagged mc and tariffs.

Discussion

- Authors estimate marginal costs and markups allowing for but not imposing market power.
- Trade reforms decreased tariffs significantly but consumers only saw a small reduction in retail prices.
- Authors do find evidence of pro-competitive effects but these are minor.
- This suggest that at least in the short run, the effects of trade liberalization are captured by firms.
- Study does not account for:
  1. Increased input quality due to reforms $\Rightarrow$ increased output quality and therefore increased consumer welfare.
  2. Increased innovation due to reforms $\Rightarrow$ new products and firms therefore increased consumer welfare.
- Study also emphasizes short-run effects while theoretical results are long-run comparisons of steady-states.

Fajgelbaum, Grossman, & Helpman "Income Distribution, Product Quality, and International Trade" (JPE 2011)

- Empirical trade flows exhibit systematic patterns of vertical specialization:
  - When rich and poor countries both export in the same category, rich sell goods with higher unit values (e.g., Schott, 2004).
  - When a county imports goods from several sources, higher "quality" goods are imported from disproportionately from higher-income countries (e.g., Hallak, 2006).
  - High income households tend to buy higher quality goods (e.g, Bils & Klenow, 2001).

- Research Question: What are the effects of trade liberalization when countries specialize vertically?

Some Definitions

- There are two ways in which firms can differentiate their product.
- Consider a market with two goods.
- When the prices of the two goods are the same but consumers nonetheless make different purchase decisions, we say the goods are horizontally differentiated.

  e.g., Coke and Pepsi.

- When the prices of the two goods are the same all consumers make the same purchase decision because they agree that one is better than the other, we say the goods are vertically differentiated.

  e.g., high vs. low "quality."

  → We see both types of products because consumers face budget constraints / different willingness-to-pay (think diamonds).

Approach & Mechanism

- Recall Trade Facts:
  - Rich produce high unit-value (price) goods w/n narrow product category.
  - Rich demand high unit-value (price) goods w/n narrow product category.
  - Rich consumers consume higher quality (price) goods.
- Develop a theory to study vertically-differentiated products.

  vs supply-side hypothesis: high quality goods exported by rich b/c these countries have relative technological superiority in producing these goods (e.g., goods are capital-intensive as in Bergstrand, 1990).
- Trade patterns result from differences in demand across Rich and Poor countries.
- Underlying Assumption - As income rises, consumers demand higher-quality goods.

Approach & Mechanism, cont'd

- Each country has a distribution of consumers which differ only in income.
- Rich countries have more high-income consumers and therefore $\exists$ greater demand higher-quality goods.
- Firms enter to provide high-quality goods to meet demand

  $\Rightarrow$ "home-market effect" where exports from these countries tend to to be higher-quality.

Effects of International Trade

- Thus far we've looked at the GE effects of trade liberalization on Rich (US) and Poor (Mexico) countries.
  - Eaton-Kortum (2002) provided a framework to solve for changes in welfare across countries.
  - Waugh (2010) & Fieler (2011) showed how to modify the framework to better match Rich-Poor trade flows.
  - ACR (2011) showed us that welfare gains can be inferred from trade flows.
- Framework allows us to evaluate how trade liberalization affects the poor in a Rich country and the rich in a Poor country.

  Do falling trade costs yield the same impact to a Wall Street banker as a factory worker in Youngstown, Ohio?

Model Outline

- Heterogenous consumers purchase many homogenous goods and one differentiated good subject to their budget constraint.
- Differentiated good vary in their "quality" $\Rightarrow$ vertical differentiation. $\exists$ horizontal-differentiation where consumers have idiosyncratic tastes.
- In differentiated good market discrete choice demand where consumer purchases the good which gives him/her that greatest utility.
- Complementarity btwn quantity of homogenous good and quality of differentiated good.
- Marginal utility of the homogenous good increases with quality of differentiated good $\Rightarrow$ non-homotheticity in demand.
- In equilibrium, rich consumers choose higher-quality goods.
- Supply-side doesn't vary between Rich and Poor countries.

Model Detail

- Preferences:

$$u_j^h = zq + \varepsilon_j^h \quad \text{for } j \in J_q, \tag{1}$$

- Consumer heterogeneity:

$$G_\varepsilon(\boldsymbol{\varepsilon}) = \exp\left[-\sum_{q \in Q}\left(\sum_{j \in J_q} e^{-\varepsilon_j/\theta_q}\right)^{\theta_q}\right],$$

where θ_q is the "dissimilarity" parameter. As $\theta_q \uparrow$, less correlation btwn ϵ_js of the same quality so greater perceived differences between the varieties of the same quality.

Purchase Probabilities

- Consumer optimization. Choose the number of homogenous goods and the differentiated good which yields the highest utility.

$$\max_{z,q_j} \{(y - p_j) \times q_j + \epsilon\}$$

- GEV assumption for ϵ implies analytic solution to the consumer's optimization problem.

- Consumer with income y purchases product q with probability ρ:

$$\rho_j(y) = \rho_{j|q} \cdot \rho_q(y) \quad \text{for } j \in J_q, \tag{2}$$

where

$$\rho_{j|q} = \frac{e^{-p_j q/\theta_q}}{\sum_{l \in J_q} e^{-q p_l/\theta_q}} \tag{3}$$

is the fraction of consumers who buy variety j among those who purchase a differentiated product with quality q and

$$\rho_q(y) = \frac{[\sum_{j \in J_q} e^{(y-p_j)q/\theta_q}]^{\theta_q}}{\sum_{\omega \in Q} [\sum_{j \in J_\omega} e^{(y-p_j)\omega/\theta_\omega}]^{\theta_\omega}} \tag{4}$$

- Assume θ_q is increasing in q.

Non-Homotheticity

- Assume θ_q is increasing in q.
- Market share (purchase prob) varies with income:

$$\frac{1}{\rho_j(y)} \frac{d\rho_j(y)}{dy} = \frac{1}{\rho_q(y)} \frac{d\rho_q(y)}{dy} = q - q_a(y) \quad \text{for } j \in J_q, \tag{5}$$

  where

$$q_a(y) \equiv \sum_{q \in Q} q\rho_q(y)$$

  is the sales-weighted average quality consumed by individuals of income y.

- Consider the case of two quality levels $Q > q_a(y) > L$ then (5) tells us that for all y the fraction of consumers who purchase H rises with income at all income levels.

Prices and Profits

- Firm profits:
$$\pi_j = (p_j - c_j)d_j - f_q$$
where $d_j = N \times \rho_j(y)$.
- Monopolistic competition w/in each quality bin.
- Optimal price is then:
$$p_q = c_q + \frac{\theta_q}{q} \quad \text{for } q \in Q. \tag{6}$$
- Two forces on price:
  1. As $q \uparrow$, marginal utility of homog. good $\uparrow$ which makes consumers more price sensitive.
  2. As $\theta_q \uparrow$, $\exists$ greater differences among products of quality q so more product differentiation and less price-sensitivity.

Prices and Profits, cont'd

- Firm Demand:

$$d_q = \frac{N}{n_q}\mathbb{E}\left[\frac{n_q^{\theta_q}\phi_q(y)}{\sum_{\omega\in Q} n_\omega^{\theta_\omega}\phi_\omega(y)}\right] \quad \text{for } q \in Q, \tag{7}$$

where

$$\phi_q(y) \equiv e^{(y-c_q)\,q-\theta_q}$$

- Firm Profits:

$$\pi_q \equiv \frac{\theta_q}{q}\frac{N}{n_q}\mathbb{E}\left[\frac{n_q^{\theta_q}\phi_q(y)}{\sum_{\omega\in Q} n_\omega^{\theta_\omega}\phi_\omega(y)}\right] - f_q \quad \text{for } q \in Q. \tag{8}$$

- Aggregate Demand: $N = \sum_{q\in Q} n_q d_q$.
- Employment: $\sum_{q\in Q} n_q(d_q c_q + f_q)$.

Autarky Equilibrium

- Free-Entry implies the following break-even volume per firm:

$$x_q = \frac{f_q q}{\theta_q} \quad \text{for } q \in Q. \tag{9}$$

- Aggregate output:

$$\sum_{q \in Q} n_q x_q = N. \tag{10}$$

- Market clearing:

$$x_q = N\mathbb{E}\left[\frac{n_q^{\theta_q - 1}\phi_q(y)}{\sum_{\omega \in Q} n_\omega^{\theta_\omega}\phi_\omega(y)}\right] \quad \text{for } q \in Q. \tag{11}$$

- The (unique) equilibrium is then the solution to the Q system of equations implied by (11).

Comparative Statics

- Consider the case of two quality levels.

PROPOSITION 1. If $Q = \{H, L\}$, there exists a unique autarky equilibrium. In the autarky equilibrium, $n_H > 0$ and $n_L > 0$.

1. As $N \uparrow$ demand grows for all segments but there is more growth in varieties (entry) in high-quality due to assumption 1.

$$\hat{n}_H > \hat{N} > \hat{n}_L > 0$$

2. As $G(y)$ first-order stochastically increases, consumption shifts towards high-quality goods leading to entry of these firms and exit of low quality firms:

$$\hat{n}_L > 0 > \hat{n}_L$$

3. Under mean-preserving spread of G (i.e., income inequality $\uparrow$), result is ambiguous as demand at high (low) income increases for high (low) quality.

Welfare

- McFadden (1978) shows that welfare of consumer with income y increases with

$$v(y) \equiv n_H^{\theta_H}\phi_H(y) + n_L^{\theta_L}\phi_L(y). \quad (12)$$

As market conditions change,

$$\hat{v}(y) = \rho_H(y)\theta_H\hat{n}_H + \rho_L(y)\theta_L\hat{n}_L.$$

which we can rewrite as:

$$\hat{v}(y) = \left[\theta_L\frac{\rho_L(y)}{\rho_L} + \theta_H\frac{\rho_H(y)}{\rho_H}\right]\hat{N} + \rho_H\rho_L\left[\theta_H\frac{\rho_H(y)}{\rho_H} - \theta_L\frac{\rho_L(y)}{\rho_L}\right](\hat{n}_H - \hat{n}_L). \quad (13)$$

- Two effects:

1. Scale Effect: Expansion of scale enables all consumers to benefit (first term).

2. Composition Effect: If a consumer prefers high-quality goods and the market shock results in an increase in high-quality goods, the consumer benefits more than a person who prefers low-quality (second term).

Welfare, cont'd

- Increase in market size benefits all income groups through scale effect while composition effect implies even greater benefit for high-income consumers if $\theta_H > \theta_L$ (Assumption 1).

- An upward shift in income (or increase in equality) creates a shift towards high-income goods so high income consumers benefit. Low income consumers may benefit as well if θ_H and θ_L are very different (otherwise worse-off when θ_H and θ_L are close).

International Trade

- Per unit (not iceberg) trade costs τ_q.
- 100% pass-through so price is:

$$p_q = \underbrace{c_q + \tau_q}_{\tilde{c}_q} + \frac{\theta_q}{q}$$

- Demand:

$$d_q^k = \frac{N^k}{\tilde{n}_q^k}\mathbb{E}^k\left[\frac{(\tilde{n}_q^k)^{\theta_q}\phi_q(y)}{\sum_{\omega \in Q}(\tilde{n}_\omega^k)^{\theta_\omega}\phi_\omega(y)}\right], \quad q = H, L \text{ and } k = \mathcal{R}, \mathcal{P}, \qquad (14)$$

where

$$\tilde{n}_q^k = n_q^k + \lambda_q n_q^l, \quad l \neq k, \quad \lambda_q \equiv e^{-\tau_q q/\theta_q},$$

where "effective competitors" defined by $\lambda \in [0, 1]$.

International Trade, cont'd

- Break-even volume:

$$x_q = d_q^k + \lambda_q d_q^l, \quad k,\ l = \mathcal{R},\ \mathcal{P},\ l \neq k,\ q = H,\ L.$$

- Equilibrium Conditions:

$$N^k \mathbb{E}^k \left[\frac{(\tilde{n}_q^k)^{\theta_q - 1} \phi_q(y)}{\sum_{\omega \in Q} (\tilde{n}_\omega^k)^{\theta_\omega} \phi_\omega(y)} \right] = \frac{1}{1 + \lambda_q} \frac{f_q q}{\theta_q}, \quad q = H,\ L,\ k = \mathcal{R},\ \mathcal{P}. \tag{15}$$

- When trade costs are high, both countries produce all quality levels. When they're low, we get specialization.

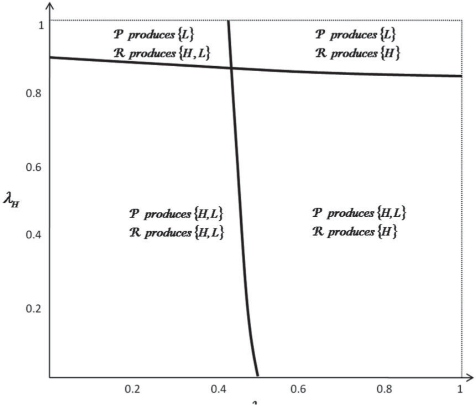
Pattern of Trade (Proposition 2)

When trade costs are sufficiently high, there exists a unique trade equilibrium in which each country pair produces both high and low quality products.

- If $N^R > N^P$ and $G^R(y) = G^P(y) \forall y$, R exports on net high-quality goods but may export or import on net low-quality goods.
- If $N^R = N^P$ and $G^R(y) < G^P(y) \forall y$, R exports on net high-quality goods and imports on net low-quality goods.
- If $N^R = N^P$ and $\rho^R(y) < \rho^P(y) \forall y$ and $G^R(\cdot)$ is a mean-preserving spread of $G^P(\cdot)$, R exports on net high-quality goods and imports on net low-quality goods.

Conclusion: "Home Market Effect" where characteristics of the home market drive specialization of firms.

Pattern of Trade Conditional on Trade Costs



- Pattern of trade when countries are similar in size ($N^R = N^P$) but income distributions differ.
- A sufficient reduction in the cost of trading the high-quality good, with λ_L held fixed at a reasonably low level, generates an equilibrium in which the poor country P produces only low-quality goods whereas the rich country R produces both high- and low-quality goods..
- Opposite also true.

Trade Liberalization

- Consider a reduction in the trade cost of the high quality good ($\tau_H \downarrow$).
- "Effective competitors" increases ($\lambda_H \uparrow$).
- Number of H varieties increase.
- Demand for low-quality falls so there is exit in L segment.
- Analogous result for a reduction in τ_L.

Trade Liberalization - Welfare

- Average country k welfare of those with income y

$$v^k(y) = (\tilde{n}_H^k)^{\theta_H}\phi_H(y) + (\tilde{n}_L^k)^{\theta_L}\phi_L(y) \quad \text{for } k = \mathcal{R}, \mathcal{P}.$$

- Change in welfare due to reductions in trade costs:

$$\begin{aligned} \hat{v}^k(y) = & \left[\theta_L \frac{\rho_L^k(y)}{\rho_L^k} + \theta_H \frac{\rho_H^k(y)}{\rho_H^k}\right]\left[\rho_H^k(\widehat{1+\lambda_H}) + \rho_L^k(\widehat{1+\lambda_L})\right] \\ & + \rho_H^k \rho_L^k \left[\theta_H \frac{\rho_H^k(y)}{\rho_H^k} - \theta_L \frac{\rho_L^k(y)}{\rho_L^k}\right](\hat{\tilde{n}}_H^k - \hat{\tilde{n}}_L^k) \quad \text{for } k = \mathcal{R}, \mathcal{P}, \end{aligned} \tag{17}$$

- Two effects:

1. Cost-savings Effect: all consumers benefit from lower prices (first term).
2. Composition Effect: If a consumer prefers high-quality goods and the reduction in trade costs results in an increase in high-quality goods, the consumer benefits more than a person who prefers low-quality (second term). The opposite may also be true so low income consumers can be hurt by increased trade.

The Distributional Consequences of Falling Trade Costs

- In a trade equilibrium with incomplete specialization, a decline in the trade cost τ_q raises the effective number of brands of quality q and reduces the effective number of brands of quality $q',\ q' \neq q$ in both countries.
- Any reduction in trade costs must benefit the average member of some income group.
- If, as a result of a reduction in trade costs, the effective number of high-quality (low-quality) varieties falls in some country, then the highest-income (lowest-income) groups in that country may lose.

Commercial Policy

- Consider a tariff rebated to consumers in lump-sum fashion
- Markups are fixed so tariffs don't impact terms of trade, just modify entry and exit.
- Demand:

$$d_L^{\mathcal{R}} = \frac{N^{\mathcal{R}}}{n_L} \mathbb{E}^{\mathcal{R}} \left[\frac{(n_L)^{\theta_L} \phi_L(y) e^{(r-t)L}}{(n_L)^{\theta_L} \phi_L(y) e^{(r-t)L} + (n_H)^{\theta_H} \phi_H(y) e^{rH}} \right].$$

The per capita demand for a typical high-quality product in $\mathcal{R}$ is

$$d_H^{\mathcal{R}} = \frac{N^{\mathcal{R}}}{n_H} \mathbb{E}^{\mathcal{R}} \left[\frac{(n_H)^{\theta_H} \phi_H(y) e^{rH}}{(n_L)^{\theta_L} \phi_L(y) e^{(r-t)L} + (n_H)^{\theta_H} \phi_H(y) e^{rH}} \right].$$

- Welfare:

$$v^{\mathcal{R}}(y) = n_H^{\theta_H} \phi_H(y) e^{rH} + n_L^{\theta_L} \phi_L(y) e^{(r-t)L}.$$

Commercial Policy, cont'd

- The impact of a small tariff is

$$\hat{v}^{\mathcal{R}}(y)\big|_{t=0} = \bar{\rho}_H \bar{\rho}_L \left[\theta_H \frac{\rho_H^{\mathcal{R}}(y)}{\bar{\rho}_H} - \theta_L \frac{\rho_L^{\mathcal{R}}(y)}{\bar{\rho}_L}\right](\hat{n}_H - \hat{n}_L) \tag{20}$$

$$+ \rho_H^{\mathcal{R}} \rho_L^{\mathcal{R}} \left[\frac{\rho_H^{\mathcal{R}}(y)}{\rho_H^{\mathcal{R}}} H - \frac{\rho_L^{\mathcal{R}}(y)}{\rho_L^{\mathcal{R}}} L\right] dt,$$

- Two effects:

  1. Composition Effect: If a consumer prefers high-quality goods and the reduction in trade costs results in an increase in high-quality goods, the consumer benefits more than a person who prefers low-quality. The opposite may also be true so low income consumers can be hurt by increased trade (First Term).

  2. The tariff transfers income from those who choose to purchase an imported, low-quality product (i.e., the poor) to those who choose to purchase a domestic, high-quality product (i.e., the rich) – second term.

- If quality differences btwn products are large, a small tariff may benefit all.

Discussion

- Paper shows that differences in income can determine the pattern of trade via demand-side effects alone.
- Moreover, trade liberalization generates distributional consequences w/in a country and may decrease welfare among low income consumers.
- Open Questions:
  1. How important (empirically) are demand-side and supply-side differences?
  2. What is the affect of trade liberalization on the distribution of income?

Pierce & Schott "Trade Liberalization and Mortality: Evidence from U.S. Counties"

- There is a large literature exploring the impact of changing economic conditions on physical and mental health.
  e.g., Case and Deaton (2015)
- Identifying exogenous shocks is difficult though.
- China gains Permanent Normal Trade Relations (PNTR) with the U.S. in October 2000, thereby effectively liberalizing trade between the countries.
- This exposed U.S. counties to more international competition but the effects varied depending upon the dominant industries in each county.
- Research Question: Did trade liberalization with China impact U.S. mortality?

Mechanism

- The impact of trade liberalization on health is ambiguous and depends on which sector an individual is employed and the region in which he/ she lives.
- Trade liberalization introduces more foreign competition (-) but also better inputs (+), lower prices (+), and more consumer goods (+).

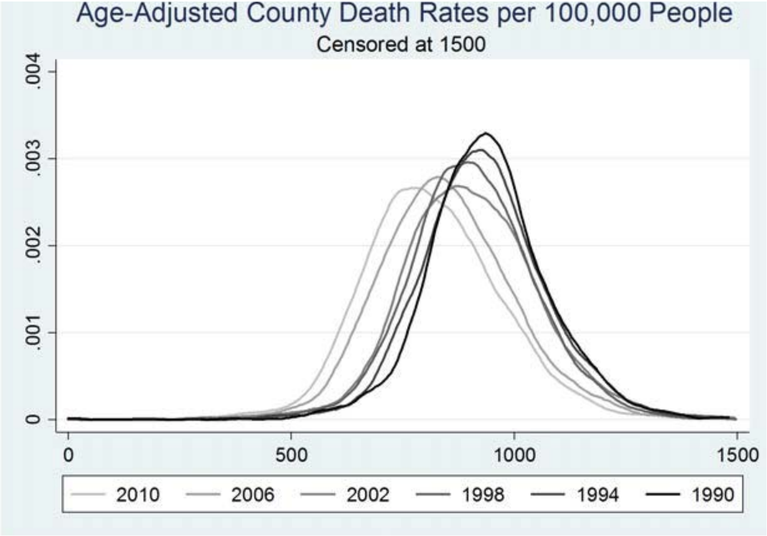
Empirical Approach

- Merge two data sources:
  1. Proprietary microdata on cause of death from the U.S. CDC to compute mortality rates by county, year, cause of death, race, and gender.
  2. Data on county exposure to China by evaluating the composition of workers in industries exposed to the PNTR.
- Apply difference-in-difference identification strategy to see if countries more (less) exposed to China experience larger (or smaller) changes in mortality after the policy is implemented.
- Focus on three type of mortality:
  1. Suicide,
  2. Accidental poisoning including drug overdose, and
  3. Alcohol-related liver disease.

About PNTR Status

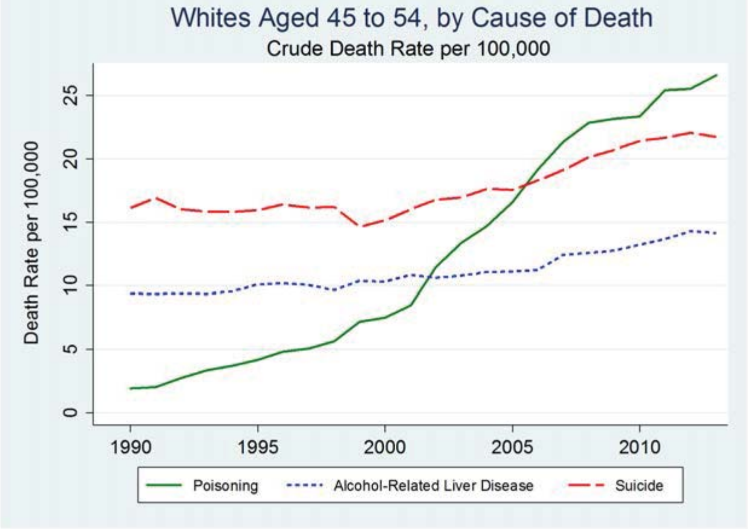
- PNTR was a non-traditional trade liberalization as it did not lower tariffs per se but instead eliminated the threat of tariff increases on U.S. imports from China.
- Before PNTR China's Normal Trade Relations (NTR) status had to be confirmed each year by Congress.
- NTR status gave Chinese goods the same tariffs applied to U.S. imports from other trading partners.
- PNTR therefore reduced risk and incentivized Chinese firms to invest in the U.S. market.
- Important for identification is that the gap between NTR and non-NTR rates varies by industry so the benefit of granting PNTR status for Chinese firms varied by industry.

Mortality Data



1. Leftward shift indicates decreasing mortality rates over time.
2. Wide support indicates large variation across counties, however.

Mortality Data, cont'd



- Similar to Case and Deaton (2015), observe increasing mortality among middle-aged white males due to poisoning (drug overdose).

NTR, PNTR, and the "NTR Gap"

- Define the "NTR Gap" in industry j is defined as

$$\text{NTR Gap}_j = \text{Non-NTR Rate}_j - \text{NTR Rate}_j$$

- NTR Gaps vary widely with a mean and std of 33 and 15 percentage points, respectively.

- Most of the variation is due to the fact many of the Non-NTR rates were set roughly 70 years prior.

- U.S. country exposure to the PNTR is then

$$NTR\,Gap_c = \sum_j \frac{L_{jc}^{1990}}{L_c^{1990}} NTR\,Gap_j. \tag{2}$$

  where L is employment in 1990 and the ratio is therefore the employment share in industry j.

- For industries not subject to tariffs (e.g., services) the NTR gap is set to zero.

Baseline Estimation

- DID specification to examine whether counties with higher NTR gaps (first difference) experience differential changes in mortality after the change in U.S. trade policy (second difference).

$$\begin{aligned} Death\,Rate_{ct} &= \theta Post\,PNTR_t \times NTR\,Gap_c + \\ &\quad \beta \mathbf{X}_{ct} + \gamma Post\,PNTR_t \times \mathbf{X}_c + \\ &\quad \delta_c + \delta_t + \varepsilon_{ct}, \end{aligned} \tag{3}$$

- Interested in the $\theta \equiv$ the interaction of PNTR indicator and NTR gap.
- Control for other policy changes via X_c as well as county (δ_c) and year (δ_t) fixed effects.
- Underlying assumption is that the PNTR is plausibly exogenous.

Results

VARIABLES	Suicide$_{ct}$	Suicide$_{ct}$	Suicide$_{ct}$	Suicide$_{ct}$	Accidental Poisoning$_{ct}$	Accidental Poisoning$_{ct}$	Accidental Poisoning$_{ct}$	Accidental Poisoning$_{ct}$	ARLD$_{ct}$	ARLD$_{ct}$	ARLD$_{ct}$	ARLD$_{ct}$
Post x NTR Gap$_c$	0.076***	0.051***	0.057***	0.051***	0.094***	0.149***	0.025	0.153***	0.003	-0.028*	0.061***	0.028
	0.014	0.017	0.014	0.017	0.034	0.042	0.035	0.039	0.013	0.016	0.019	0.018
NTR$_{ct}$		-0.241		-0.235		0.033		-0.019		-0.552***		-0.349**
		0.194		0.184		0.298		0.237		0.186		0.146
MFA Exposure$_{ct}$		-0.017		-0.011		0.048		0.041		-0.142***		-0.108***
		0.029		0.026		0.072		0.052		0.028		0.018
Post x ΔChinese Tariffs$_c$		-0.093**		-0.027		0.107		0.381***		-0.138***		-0.135***
		0.04		0.035		0.093		0.083		0.039		0.036
Post x ΔChinese Subsidy$_c$		14.298**		8.124**		27.625**		3.781		7.583*		4.115*
		5.98		3.63		13.552		6.968		4.324		2.357
Post x Median HHI in 1990$_c$			-0.01	-0.01			-0.067***	-0.070***			-0.027***	-0.028***
			0.007	0.007			0.016	0.016			0.006	0.006
Post x % No College in 1990$_c$			0.027***	0.026***			0.084***	0.088***			-0.035***	-0.036***
			0.008	0.008			0.018	0.019			0.009	0.009
Post x % Veteran in 1990$_c$			0.207***	0.202***			0.693***	0.692***			0.315***	0.307***
			0.041	0.038			0.078	0.077			0.044	0.043
Observations	74,900	74,900	74,900	74,900	74,900	74,900	74,900	74,900	74,900	74,900	74,900	74,900
R-squared	0.40	0.40	0.41	0.41	0.58	0.58	0.61	0.62	0.51	0.51	0.52	0.52
P-Value DID Term	0.00	0.00	1.00	0.00	0.01	0.00	1.00	0.00	0.83	0.08	1.00	0.12
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Sample Period	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13
FE	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t
Clustering	c	c	c	c	c	c	c	c	c	c	c	c
Weighting	Population	Population	Population	Population	Population	Population	Population	Population	Population	Population	Population	Population
Implied Impact of PNTR	0.63***	0.43***	0.47***	0.42***	0.78***	1.24***	0.21	1.27***	0.02	-0.23*	0.51***	0.23
Std Err	0.11	0.14	0.11	0.14	0.28	0.35	0.29	0.32	0.11	0.13	0.16	0.15
Average Death Rate (2000)	10.51	10.51	10.51	10.51	4.59	4.59	4.59	4.59	4.63	4.63	4.63	4.63
Impact/Average	0.06***	0.041***	0.045***	0.04***	0.171***	0.269***	0.046	0.277***	0.005	-0.051*	0.11***	0.05

Suicides - White Males are Driving Results

	Suicide							
	White		Black		American Indian		Asian or Pac Is	
VARIABLES	Male	Female	Male	Female	Male	Female	Male	Female
Post x NTR Gap_c	0.100***	0.02	-0.051	-0.017	-0.213	-0.164	-0.209	-0.051
	0.032	0.014	0.062	0.02	0.316	0.139	0.186	0.081
NTR_{ct}	-0.281	-0.123	0.15	-0.217	-7.223**	1.547	-2.368	1.241
	0.361	0.15	0.699	0.145	3.544	2.121	1.819	1.124
MFA $Exposure_{ct}$	0.005	0.031	0.009	-0.025	-0.188	0.142	-0.284	0.218
	0.054	0.024	0.064	0.021	0.317	0.176	0.367	0.159
Post x ΔChinese $Tariffs_c$	0.023	-0.04	0.043	-0.035	0.507	-0.024	-1.034**	-0.221
	0.066	0.028	0.125	0.043	0.576	0.258	0.511	0.178
Post x ΔChinese $Subsidy_c$	13.209*	4.02	-0.483	0.983	32.956	-31.426**	50.025*	-6.791
	6.945	2.6	9.897	2.912	46.792	15.692	28.984	12.967
Post x Median HHI in 1990_c	-0.002	-0.018***	0.015	0.014**	-0.139	-0.074	0.041	0.037**
	0.013	0.005	0.02	0.006	0.099	0.048	0.034	0.017
Post x % No College in 1990_c	0.046***	0.006	-0.014	0.001	0.093	0.03	0.026	0.018
	0.014	0.005	0.021	0.006	0.1	0.043	0.042	0.02
Post x % Veteran in 1990_c	0.265***	0.154***	0.023	0.017	-0.295	0.151	-0.009	0.091*
	0.08	0.027	0.059	0.018	0.25	0.111	0.098	0.048
Observations	74,900	74,900	67,082	65,600	70,203	70,316	64,139	68,284
R-squared	0.31	0.17	0.08	0.05	0.14	0.06	0.05	0.05
P-Value DID Term	0.00	0.14	0.41	0.37	0.50	0.24	0.26	0.53
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Sample Period	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13
Fixed Effects	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t
Clustering	c	c	c	c	c	c	c	c
Weighting	Population	Population	Population	Population	Population	Population	Population	Population
Implied Impact of PNTR	0.83***	0.17	-0.42	-0.14	-1.77	-1.36	-1.74	-0.42
Std Err	0.26	0.11	0.51	0.16	2.63	1.16	1.54	0.67
Average Death Rate (2000)	18.3	4.1	9.4	1.5	16.0	3.7	7.6	2.4
Impact/Average	0.045***	0.041	-0.045	-0.094	-0.111	-0.364	-0.228	-0.173

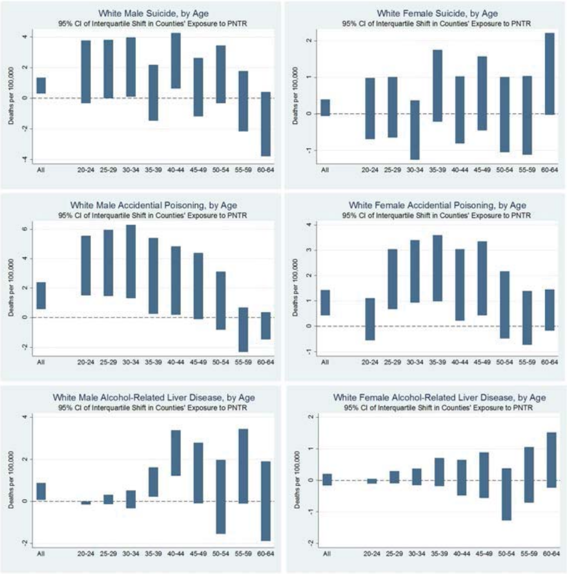
Drug Overdoses Prevalent Among White Men and Women

	Accidental Poisoning							
	White		Black		American Indian		Asian or Pac Is	
VARIABLES	Male	Female	Male	Female	Male	Female	Male	Female
Post x NTR Gap$_c$	0.179***	0.112***	0.061	-0.007	-0.149	-0.078	-0.071	-0.003
	0.056	0.03	0.097	0.046	0.265	0.182	0.058	0.037
NTR$_{ct}$	0.045	0.008	0.521	-0.026	-2.32	-0.991	0.496	0.514
	0.332	0.187	0.93	0.283	1.939	2.204	0.71	0.382
MFA Exposure$_{ct}$	0.105	0.225***	-0.293***	-0.100*	-0.058	0.051	-0.239	0.045
	0.077	0.045	0.102	0.052	0.402	0.286	0.154	0.072
Post x ΔChinese Tariffs$_c$	0.668***	0.338***	-0.035	-0.017	0.563	-0.479	-0.149	-0.099
	0.12	0.063	0.212	0.099	0.541	0.34	0.14	0.077
Post x ΔChinese Subsidy$_c$	2.258	2.322	-5.627	3.22	-45.281	4.635	5.504	1.727
	10.511	6.021	17.061	6.042	34.152	30.698	7.593	4.603
Post x Median HHI in 1990$_c$	-0.032	-0.095***	-0.159***	-0.032*	-0.476***	-0.151**	-0.015	0.007
	0.023	0.011	0.051	0.018	0.082	0.061	0.011	0.008
Post x % No College in 1990$_c$	0.177***	0.043***	-0.102	-0.031	-0.06	-0.085	0.009	0.006
	0.025	0.012	0.068	0.025	0.07	0.069	0.013	0.011
Post x % Veteran in 1990$_c$	0.761***	0.450***	0.676***	0.300***	0.709***	0.757***	0.095**	0.054***
	0.121	0.052	0.193	0.075	0.221	0.143	0.038	0.02
Observations	74,900	74,900	67,082	65,600	70,203	70,316	64,139	68,284
R-squared	0.57	0.48	0.30	0.17	0.12	0.10	0.05	0.04
P-Value DID Term	0.00	0.00	0.53	0.88	0.57	0.67	0.23	0.93
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Sample Period	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13
Fixed Effects	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t
Clustering	c	c	c	c	c	c	c	c
Weighting	Population	Population	Population	Population	Population	Population	Population	Population
Implied Impact of PNTR	1.49***	0.93***	0.5	-0.06	-1.24	-0.64	-0.59	-0.03
Std Err	0.46	0.25	0.81	0.38	2.21	1.51	0.49	0.31
Average Death Rate (2000)	2.5	6.7	6.1	0.4	3.5	9.4	1.0	3.3
Impact/Average	0.586***	0.139***	0.082	-0.159	-0.351	-0.069	-0.57	-0.009

Liver Disease Significant Among Other Groups

	ARLD							
	White		Black		American Indian		Asian or Pac Is	
VARIABLES	Male	Female	Male	Female	Male	Female	Male	Female
Post x NTR Gap_c	0.056**	0.002	-0.01	-0.017	-0.459	-0.608*	0.009	-0.046*
	0.024	0.011	0.092	0.034	0.363	0.311	0.063	0.026
NTR_{ct}	-0.238	-0.056	-1.515**	-0.550**	-4.427	-1.66	0.325	-0.101
	0.211	0.095	0.684	0.269	2.898	2.126	0.846	0.327
MFA $Exposure_{ct}$	-0.134***	-0.057***	-0.051	-0.048	-0.363	-0.571	-0.083	-0.024
	0.029	0.013	0.074	0.035	0.73	0.385	0.166	0.039
Post x ΔChinese $Tariffs_c$	-0.149***	-0.080***	-0.262	-0.107	-0.874	-1.151**	-0.042	-0.141**
	0.05	0.019	0.194	0.069	0.651	0.556	0.166	0.057
Post x ΔChinese $Subsidy_c$	0.649	4.413**	13.464	1.542	94.832**	61.053	1.393	3.265
	3.03	2.188	8.533	4.66	46.022	42.543	9.359	2.779
Post x Median HHI in 1990_c	-0.034***	-0.027***	-0.012	-0.008	-0.216*	-0.121*	0.006	-0.008
	0.008	0.004	0.027	0.012	0.112	0.073	0.015	0.005
Post x % No College in 1990_c	-0.055***	-0.022***	-0.05	-0.021	-0.045	-0.052	-0.018	-0.015**
	0.013	0.004	0.038	0.015	0.105	0.067	0.023	0.006
Post x % Veteran in 1990_c	0.394***	0.126***	0.492***	0.091**	0.098	-0.109	0.142***	0.009
	0.07	0.022	0.11	0.041	0.246	0.211	0.043	0.017
Observations	74,900	74,900	67,082	65,600	70,203	70,316	64,139	68,284
R-squared	0.47	0.27	0.15	0.08	0.18	0.15	0.06	0.05
P-Value DID Term	0.02	0.84	0.92	0.61	0.21	0.05	0.88	0.08
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Sample Period	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13	1990-13
Fixed Effects	c,t	c,t	c,t	c,t	c,t	c,t	c,t	c,t
Clustering	c	c	c	c	c	c	c	c
Weighting	Population	Population	Population	Population	Population	Population	Population	Population
Implied Impact of PNTR	0.47***	0.02	-0.08	-0.14	-3.81	-5.06*	0.08	-0.38*
Std Err	0.20	0.09	0.76	0.28	3.02	2.58	0.52	0.21
Average Death Rate (2000)	7.0	6.9	2.1	2.7	19.9	11.9	2.0	0.6
Impact/Average	0.067***	0.003	-0.038	-0.052	-0.191	-0.425*	0.04	-0.662*

Does Age Matter?



- Figure presents 95% confidence intervals for the coefficient of interest by age group.
- The first bar corresponds to the estimates based on the whole sample for reference.

Summary

- PNTR had significant negative effects on mortality, increasing the likelihood of suicide, drug overdoses, and alcohol-related liver disease.
- Most of these effects are concentrated in 20-44 year old white men. Why?
- Males accounted for 68% of factory workers in 1999.
- Whites accounted for 84.3% of manufactring employment.
- Also likely that within manufacturing, white males are over-represented in management, earning higher wages – and facing larger declines in the event of job separation.

Caliendo, Dvorkin, & Parro "Trade and Labor Market Dynamics: GE Analysis of the China Trade Shock"

- A common assumption of modern trade theory is that labor supply is inelastic and immobile.
- Understanding and quantifying the employment effects of trade shocks has become an important research area.
- Most research focused on reduced-form analysis, however.
- Research Question: What was the general equilibrium effect of increased Chinese imports (i.e., the "China trade shock") on U.S. labor markets?

Empirical Approach

1. Develop a GE dynamic model of trade with spatially-distinct labor markets, each with varying exposure to international trade.
   - Model accounts for a wide variety of potential frictions which impede trade and labor market decisions.
   - Model also account for input-output linkages so some industries may be hurt by Chinese competition while others benefit from Chinese inputs.
   - A researcher can solve the model without knowing trade costs, firm productivities, or labor frictions.
2. Calibrate the model to match data for 22 sectors (e.g., textiles), 38 countries, and 50 U.S. states for 2000 to 2007.
3. Compare baseline model to one in which Chinese import shares remain at their 2000 level.
   - Aggregate effect of China on US employment and welfare.
   - Identify heterogenous effects (employment and welfare) by U.S. states.
   - Identify heterogenous effects (employment and welfare) by sector.

Mechanism

- U.S. firms in industries which compete with Chinese firms (e.g., manufacturing) tend to die so employment in these sectors fall.
- Losses are concentrated in U.S. states which specialized / focused in these industries (e.g., California).
- U.S. firms in industries which use goods produced by Chinese firms (e.g., construction) tend to grow so employment in these sectors increases.
- Gaines are concentrated in U.S. states which specialized / focused in these industries (e.g., New York).

Model

1. N countries and J sectors.
2. Production is Cobb-Douglas with CRS technology with Frecehet distributed productivities indexed by θ^j ala Eaton-Kortum.
3. HHs are either employed or not. If employed receive competitive wage w_t^{nj}.
4. Household period t consumption:

$$C_t^{nj} = \prod_{k=1}^{J} (c_t^{nj,k})^{\alpha^k}, \tag{1}$$

   where $\sum_j \alpha = 1$. Sector 0 is non-employment with $C_t^{n0} = b^n \equiv$ "home production."

5. Assumption 1: utility is $\log(C_t^{nj})$.
6. Assumption 2: Labor reallocation costs $\tau^{nj,ik} \geq 0$ depend on origin (nj), destination (ik), and are time-invariant. They are additive and measured in utility.

Labor Supply

1. HHs observe economic conditions in all countries and sectors.
2. HHs observe their own iid shocks.
3. HHS can choose to relocate after earning period t wage (w_t^{nj}) or home production b^n.

$$\mathrm{v}_t^{nj} = U(C_t^{nj}) + \max_{\{i,k\}_{i=1,k=0}^{N,J}} \left\{ \beta E \left[\mathrm{v}_{t+1}^{ik} \right] - \tau^{nj,ik} + \nu \epsilon_t^{ik} \right\},$$

$$s.t.\ \ C_t^{nj} \equiv \begin{cases} b^n & if\, j = 0, \\ w_t^{nj}/P_t^n & \text{otherwise;} \end{cases}$$

where v_t^{nj} is the lifetime utility of a country n HH employed in sector j in period t, taking into account expected realizations of iid shocks.

4. Assumption 3: The iid shock ϵ is distribution Type 1 Extreme Value with zero mean.

Labor Supply

1. Assumption 3 gives us an analytical solution for expected utility.

$$V_t^{nj} = U(C_t^{nj}) + \nu \log \left(\sum_{i=1}^{N} \sum_{k=0}^{J} \exp\left(\beta V_{t+1}^{ik} - \tau^{nj,ik}\right)^{1/\nu} \right). \tag{2}$$

   where $V_t^{nj} = E[v_t^{nj}]$.

2. Assumption 3 gives us an analytical solution for labor shares.

$$\mu_t^{nj,ik} = \frac{\exp\left(\beta V_{t+1}^{ik} - \tau^{nj,ik}\right)^{1/\nu}}{\sum_{m=1}^{N} \sum_{h=0}^{J} \exp\left(\beta V_{t+1}^{mh} - \tau^{nj,mh}\right)^{1/\nu}}. \tag{3}$$

3. Law of Motion for labor is then

$$L_{t+1}^{nj} = \sum_{i=1}^{N} \sum_{k=0}^{J} \mu_t^{ik,nj} \, L_t^{ik}. \tag{4}$$

Production

1. Intermediate goods.

$$q_t^{nj} = z^{nj} \left(A_t^{nj} \, (h_t^{nj})^{\xi^n} (l_t^{nj})^{1-\xi^n} \right)^{\gamma^{nj}} \prod_{k=1}^{J} (M_t^{nj,nk})^{\gamma^{nj,nk}},$$

   where TFP is time-varying sectoral component A_t^{nj} and iid component z^{nj}.

2. Define:
   - $\gamma^{nj} > 0$ as share of value-added in country n sector j.
   - $\gamma^{nj,nk} > 0$ as share of materials from sector k in production of sector j.
   - ξ is share of "structures" (composite local factor).

3. Unit price of an input bundle is

$$x_t^{nj} = B^{nj} \, \left((r_t^{nj})^{\xi^n} \, (w_t^{nj})^{1-\xi^n} \right)^{\gamma^{nj}} \prod_{k=1}^{J} (P_t^{nk})^{\gamma^{nj,nk}}, \tag{5}$$

   so the cost of an input bundle is $\frac{x_t^{nj}}{z^{nj}(A_t^{nj})^{\gamma^{nj}}}$

4. Iceberg trade costs $\kappa_t^{nj,ij} \geq 1$.

Aggregate and Trade Flows

1. Cost minimization implies firms source from the least costly international source:

$$p_t^{nj}(z^j) = \min_i \left\{ \kappa_t^{nj,ij} \; x_t^{ij} z^{ij} (A_t^{ij})^{\gamma^{ij}} \right\}.$$

2. Probability of sourcing from country i is then

$$\pi_t^{nj,ij} = \frac{(x_t^{ij} \kappa_t^{nj,ij})^{-\theta^j} (A_t^{ij})^{\theta^j \gamma^{ij}}}{\sum_{m=1}^{N} (x_t^{mj} \kappa_t^{nj,mj})^{-\theta^j} (A_t^{mj})^{\theta^j \gamma^{mj}}}. \tag{7}$$

   or equivalently $\pi_t^{nj,ij}$ the total expenditure in market (n, j) on goods j from country i.

Market Clearing

1. Goods:

$$X_t^{nj} = \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{i=1}^{N} \pi_t^{ik,nk} X_t^{ik} + \alpha^j \left(\sum_{k=1}^{J} w_t^{nk} L_t^{nk} + \iota^n \chi_t \right), \tag{8}$$

   where χ is a wedge to account for unbalanced trade.

2. Labor:

$$L_t^{nj} = \frac{\gamma^{nj} \left(1 - \xi^n\right)}{w_t^{nj}} \sum_{i=1}^{N} \pi_t^{ij,nj} X_t^{ij}, \tag{9}$$

3. Structures:

$$H^{nj} = \frac{\gamma^{nj} \xi^n}{r_t^{nj}} \sum_{i=1}^{N} \pi_t^{ij,nj} X_t^{ij}. \tag{10}$$

Equilibrium

1. Define $\Theta \equiv \{\Theta_1, \Theta_2\}$ where $\Theta_1 = (A_t, \kappa_t)$ and $\Theta_2 = (\Upsilon, H, b)$.

2. "Temporary Equilibrium"

   Definition 1 *Given (L_t, Θ_t), a **temporary equilibrium** is a vector of wages $w(L_t, \Theta_t)$ that satisfies the equilibrium conditions of the static subproblem,* (5) *to* (10) *.*

3. "Sequential Competitive Equilibrium"

   $\{L_t, \mu_t, V_t, w(L_t, \Theta_t)\}_{t=0}^{\infty}$ *that solves equilibrium conditions* (2) *to* (4) *and the temporary equilibrium at each t.*

4. "Stationary Equilibrium"

   Definition 3 *A **stationary equilibrium** of the model is a sequential competitive equilibrium such that $\{L_t, \mu_t, V_t, w(L_t, \Theta_t)\}_{t=0}^{\infty}$ are constant for all t.*

Solving the Model

1. Answering the research question requires solving the model to match data (calibration) and removing the "China trade shock" (counterfactual).

2. Solving these equilibria is difficult:

   - We don't observe labor frictions, trade costs, TFP, etc so would need to back them out from the data (i.e., from observed actions of firms, households, and workers).
   - The data is not stationary so solving "Sequential Competitive Equilibrium" requires solving for the transition path between "Stationary Equilibria".

3. Solution is to observe that we can answer our question without solving for most of the parameters or the "fundamentals" (Θ) explicitly.

   - Similar idea as Arkolakis, Costinot, Rodriguez-Clare (2012). Recall ACR predicts welfare changes for a large class of static trade models are:

   $$\hat{W}_j = \hat{\lambda}_{jj}^{\frac{1}{\epsilon}}$$

   - These static results have become known as "exact hat algebra."

"Dynamic Hat Algebra"

- Baseline economy:

  Definition 4 *The* ***baseline economy*** *is the allocation* $\{L_t, \mu_{t-1}, \pi_t, X_t\}_{t=0}^{\infty}$ *corresponding to the sequence of fundamentals* $\{\Theta_t\}_{t=0}^{\infty}$.

- Denote the proportional change $\dot{y}_{t+1} \equiv \{y_{t+1}^1/y_t^1, y_{t+1}^2/y_t^2, ...\}$.

- We can then solve "temporary equilibrium" at $t+1$ of the baseline economy given change in employment $\dot{L}_{t+1}$ and change in fundamentals $\dot{\Theta}_{t+1}$.

- Importantly, we do not require an estimate of Θ_t.

Proposition 1

Proposition 1 *Given the allocation of the temporary equilibrium at t, $\{L_t, \pi_t, X_t\}$, the solution to the* ***temporary equilibrium*** *at $t+1$ for a given change in $\dot{L}_{t+1}$ and $\dot{\Theta}_{t+1}$ does not require information on the level of fundamentals at t, Θ_t. In particular, it is obtained as the solution to the following system of non-linear equations:*

$$\dot{x}^{nj}_{t+1} = (\dot{L}^{nj}_{t+1})^{\gamma^{nj}\xi^n} (\dot{w}^{nj}_{t+1})^{\gamma^{nj}} \prod_{k=1}^{J} (\dot{P}^{nk}_{t+1})^{\gamma^{nj,nk}}, \tag{11}$$

$$\dot{P}^{nj}_{t+1} = \left(\sum_{i=1}^{N} \pi^{nj,ij}_t (\dot{x}^{ij}_{t+1} \dot{\kappa}^{nj,ij}_{t+1})^{-\theta^j} (\dot{A}^{ij}_{t+1})^{\theta^j \gamma^{ij}} \right)^{-1/\theta^j}, \tag{12}$$

$$\pi^{nj,ij}_{t+1} = \pi^{nj,ij}_t \left(\frac{\dot{x}^{ij}_{t+1} \dot{\kappa}^{nj,ij}_{t+1}}{\dot{P}^{nj}_{t+1}} \right)^{-\theta^j} (\dot{A}^{ij}_{t+1})^{\theta^j \gamma^{ij}}, \tag{13}$$

$$X^{nj}_{t+1} = \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{i=1}^{N} \pi^{ik,nk}_{t+1} X^{ik}_{t+1} + \alpha^j \left(\sum_{k=1}^{J} \dot{w}^{nk}_{t+1} \dot{L}^{nk}_{t+1} w^{nk}_t L^{nk}_t + \iota^n \chi_{t+1} \right), \tag{14}$$

$$\dot{w}^{nj}_{t+1} \dot{L}^{nj}_{t+1} w^{nj}_t L^{nj}_t = \gamma^{nj} (1 - \xi^n) \sum_{i=1}^{N} \pi^{ij,nj}_{t+1} X^{ij}_{t+1}, \tag{15}$$

where $\chi_{t+1} = \sum_{i=1}^{N} \sum_{k=1}^{J} \frac{\xi^i}{1-\xi^i} \dot{w}^{ik}_{t+1} \dot{L}^{ik}_{t+1} w^{ik}_t L^{ik}_t$.

Proposition 2

Proposition 2 *Conditional on an initial allocation of the economy,* $\left(L_0, \pi_0, X_0, \mu_{-1}\right)$, *given an anticipated convergent sequence of changes in fundamentals,* $\{\dot{\Theta}_t\}_{t=1}^{\infty}$, *the solution to the sequential equilibrium in time differences does not require information on the level of the fundamentals,* $\{\Theta_t\}_{t=0}^{\infty}$ *and solves the following system of non-linear equations:*

$$\mu_{t+1}^{nj,ik} = \frac{\mu_t^{nj,ik} \left(\dot{u}_{t+2}^{ik}\right)^{\beta/\nu}}{\sum_{m=1}^{N} \sum_{h=0}^{J} \mu_t^{nj,mh} \left(\dot{u}_{t+2}^{mh}\right)^{\beta/\nu}}, \tag{16}$$

$$\dot{u}_{t+1}^{nj} = \dot{\omega}^{nj}(\dot{L}_{t+1}, \dot{\Theta}_{t+1}) \left(\sum_{i=1}^{N} \sum_{k=0}^{J} \mu_t^{nj,ik} \left(\dot{u}_{t+2}^{ik}\right)^{\beta/\nu}\right)^{\nu}, \tag{17}$$

$$L_{t+1}^{nj} = \sum_{i=1}^{N} \sum_{k=0}^{J} \mu_t^{ik,nj} \, L_t^{ik}, \tag{18}$$

for all j, n, i *and* k *at each* t, *where* $\{\dot{\omega}^{nj}(\dot{L}_t, \dot{\Theta}_t)\}_{n=1,j=0,t=1}^{N,J,\infty}$ *is the solution to the temporary equilibrium given* $\{\dot{L}_t, \dot{\Theta}_t\}_{t=1}^{\infty}$.

Solving for Counterfactuals

- We are interested in how the "Sequential Competitive Equilibrium" changes when we alter the fundamentals from Θ to Θ'.
- Assume period $t = 0$ agents make decisions according to Θ while period $t = 1$ agents are surprised and learn entire path of Θ'.
- Define $\hat{y}_{t+1} = \dot{y}'_{t+1}/\dot{y}_{t+1}$ so $\hat{\Theta}_{t+1}$ refers to the CF changes in fundamentals relative to the baseline economy.
- $\hat{\Theta} = 1$ implies the fundamentals change in the same way in the CF as in the baseline.

Proposition 3

Proposition 3 *Given a baseline economy, $\{L_t, \mu_{t-1}, \pi_t, X_t\}_{t=0}^{\infty}$, and a counterfactual convergent sequence of changes in fundamentals (relative to the baseline change), $\{\hat{\Theta}_t\}_{t=1}^{\infty}$, solving for the counterfactual sequential equilibrium $\{L_t', \mu_{t-1}', \pi_t', X_t'\}_{t=1}^{\infty}$ does not require information on the baseline fundamentals ($\{\Theta_{1t}\}_{t=0}^{\infty}, \Theta_2$), and solves the following system of non-linear equations:*

$$\mu_t'^{nj,ik} = \frac{\mu_{t-1}'^{nj,ik} \dot{\mu}_t^{nj,ik} \left(\hat{u}_{t+1}^{ik}\right)^{\beta/\nu}}{\sum_{m=1}^{N} \sum_{h=0}^{J} \mu_{t-1}'^{nj,mh} \dot{\mu}_t^{nj,mh} \left(\hat{u}_{t+1}^{mh}\right)^{\beta/\nu}}, \tag{19}$$

$$\hat{u}_t^{nj} = \hat{\omega}^{nj}(\hat{L}_t, \hat{\Theta}_t) \left(\sum_{i=1}^{N} \sum_{k=0}^{J} \mu_{t-1}'^{nj,ik} \dot{\mu}_t^{nj,ik} \left(\hat{u}_{t+1}^{ik}\right)^{\beta/\nu} \right)^{\nu}, \tag{20}$$

$$L_{t+1}'^{nj} = \sum_{i=1}^{N} \sum_{k=0}^{J} \mu_t'^{ik,nj} \, L_t'^{ik}, \tag{21}$$

for all j, n, i and k at each t, where $\{\hat{\omega}^{nj}(\hat{L}_t, \hat{\Theta}_t)\}_{n=1,j=0,t=1}^{N,J,\infty}$ is the solution to the temporary equilibrium given $\{\hat{L}_t, \hat{\Theta}_t\}_{t=1}^{\infty}$, namely at each t, given $\left(\hat{L}_t, \hat{\Theta}_t\right)$, $\hat{\omega}^{nj}(\hat{L}_t, \hat{\Theta}_t) = \hat{w}_t^{nj}/\hat{P}_t^{n}$ solves,

Proposition 3, cont'd

$$\hat{x}^{nj}_{t+1} = (\hat{L}^{nj}_{t+1})^{\gamma^{nj}\xi^n} (\hat{w}^{nj}_{t+1})^{\gamma^{nj}} \prod_{k=1}^{J} (\hat{P}^{nk}_{t+1})^{\gamma^{nj,nk}}, \tag{22}$$

$$\hat{P}^{nj}_{t+1} = \left(\sum_{i=1}^{N} \pi'^{nj,ij}_{t} \dot{\pi}^{nj,ij}_{t+1} (\hat{x}^{ij}_{t+1} \hat{\kappa}^{nj,ij}_{t+1})^{-\theta^j} (\hat{A}^{ij}_{t+1})^{\theta^j \gamma^{ij}} \right)^{-1/\theta^j}, \tag{23}$$

$$\pi'^{nj,ij}_{t+1} = \pi'^{nj,ij}_{t} \dot{\pi}^{nj,ij}_{t+1} \left(\frac{\hat{x}^{ij}_{t+1} \hat{\kappa}^{nj,ij}_{t+1}}{\hat{P}^{nj}_{t+1}} \right)^{-\theta^j} (\hat{A}^{ij}_{t+1})^{\theta^j \gamma^{ij}}, \tag{24}$$

$$X'^{nj}_{t+1} = \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{i=1}^{N} \pi'^{ik,nk}_{t+1} X'^{ik}_{t+1} + \alpha^j \left(\sum_{k=1}^{J} \hat{w}^{nk}_{t+1} \hat{L}^{nk}_{t+1} w'^{nk}_{t} L'^{nk}_{t} \dot{w}^{nk}_{t+1} \dot{L}^{nk}_{t+1} + \iota^n \chi'_{t+1} \right), \tag{25}$$

$$\hat{w}^{nk}_{t+1} \hat{L}^{nk}_{t+1} = \frac{\gamma^{nj}(1-\xi^n)}{w'^{nk}_{t} L'^{nk}_{t} \dot{w}^{nk}_{t+1} \dot{L}^{nk}_{t+1}} \sum_{i=1}^{N} \pi'^{ij,nj}_{t+1} X'^{ij}_{t+1}, \tag{26}$$

where $\chi'_{t+1} = \sum_{i=1}^{N} \sum_{k=1}^{J} \frac{\xi^i}{1-\xi^i} \hat{w}^{ik}_{t+1} \hat{L}^{ik}_{t+1} w'^{ik}_{t} L'^{ik}_{t} \dot{w}^{ik}_{t} \dot{L}^{ik}_{t}$.

In Words

- By computing the model in relative change over time, we do not need to identify any fundamentals of the model, just the changes.

  i.e., Representative consumers, CRS production, common wage and rental rates generate linear decision rules so only need to keep track of how aggregate variables change.

- We do need to know the original baseline economy since this disciplines the model to match moments of the initial cross-section.

- If the goal is to study the impact of changes in fundamentals relative to constant fundamentals, Proposition 2 tells us we require only the shock and the baseline.

- If the goal is to study the impact of changes in fundamentals relative to variable fundamentals, Proposition 3 tells us we also require changes in the cross-section across time (e.g., $\dot{\mu}$).

Calibrating the Model

- Need initial values (year 2000) for:
  - bilateral trade flows ($\pi_0^{nj,ij}$),
  - value added ($w_0^{nj} L_0^{nj} + r_0^{nj} H_0^{nj}$),
  - distribution of employment (L_0), and
  - initial migration flows across nations and sectors (μ_{-1}).

- Parameters:
  - Share of value-added in output (γ^{nj}),
  - Share of materials from sector k in production of sector j ($\gamma^{nj,nk}$),
  - Share of "structures" in value-added (ξ^n),
  - Final good consumption shares (α^j) and global portfolio (ι^n),
  - Sectoral trade elasticities (θ^j),
  - Migration elasticity ($1/\nu$), and
  - Discount factor (β).

Identifying the China Trade Shock

- We need to introduce a new fundamentals process for an alternative world where China does not enter the WTO.
  1. We solve for the equilibrium with the China Trade Shock via Proposition 3.
  2. In the baseline model Chinese TFP does not change from 2000 (CF).
- I think changes in trade costs via Chinese entry into the WTO is captured in the model via changes in Chinese TFP.
- Have to account for changes in both Chinese imports and TFP.

Identifying the China Trade Shock, cont'd

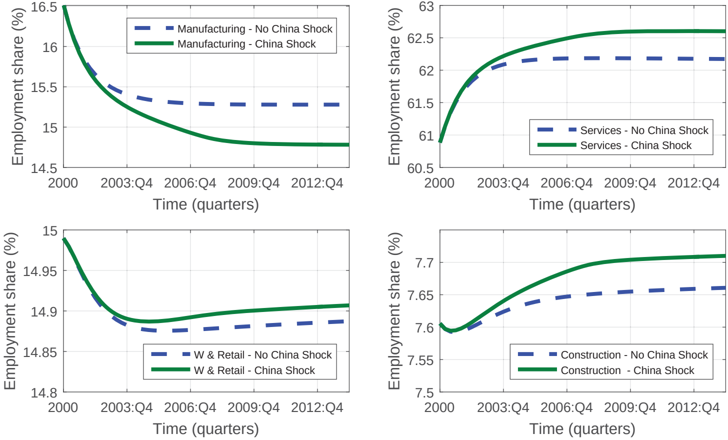
- Changes in US imports of Chinese goods may not be solely driven by an exogenous shock to China (TFP or trade cost).
- If supply driven, change in Chinese imports would likely be similar in the US as other developed countries.
- Estimate the following regression:

$$\Delta M_{USA,j} = a_1 + a_2 \Delta M_{other,j} + u_j,$$

- Given these predicted values, solve for the change in Chinese TFP required for the model to match the US imports of Chinese goods observed in the data.

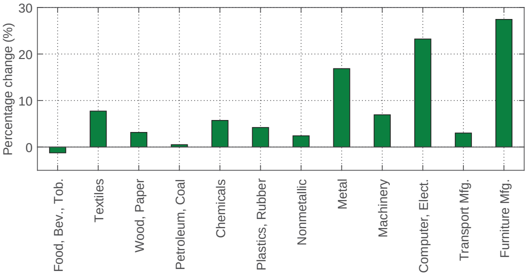
Results - Employment

FIG. 1: The Evolution of Employment Shares



Results - Reductions in Mfg Employment

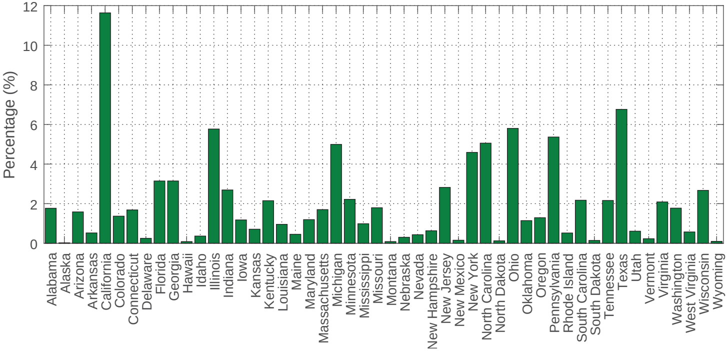
Fig. 2: Manufacturing employment declines (% of total) due to the China trade shock



Note: The figure presents the contribution of each manufacturing industry to the total reduction in the manufacturing employment due to the China Shock.

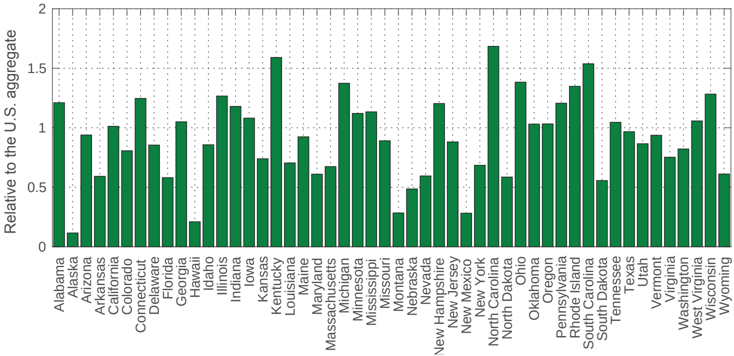
Results - Share of Reductions in Mfg Employment by State

FIG. 3: Regional contribution to U.S. aggregate manufacturing employment decline (%)



Results - Relative to Employment Share

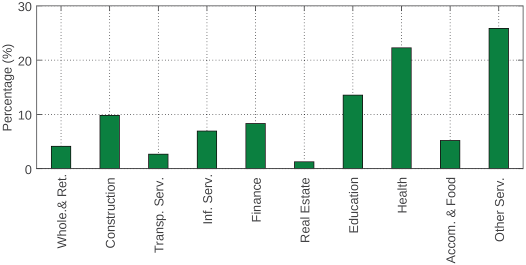
Fig. 4: Regional contribution to U.S. agg. mfg. emp. decline normalized by regional emp. share



- Numbers correspond to local change in mfg employment relative to national change of -0.5%.

Results - Increases in Non Manufacturing Employment

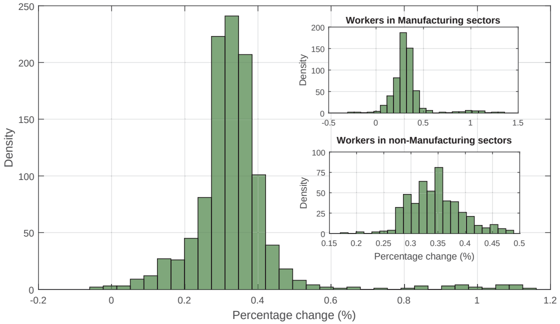
Fig. 5: Non-manufacturing employment increases (% of total) due to the China trade shock



Note: The figure presents the contribution of each non-manufacturing sector to the total increase in the non-manufacturing employment due to the China shock.

Results - Welfare

FIG. 9: Welfare effects of the China Shock across labor markets



- Welfare defined as

$$\hat{W}^{nj} = \sum_{s=1}^{\infty} \beta^s \log \left(\frac{\hat{C}_s^{nj}}{\left(\hat{\mu}_s^{nj,nj}\right)^{\nu}} \right) \tag{28}$$

- Aggregate welfare increases (0.35%).
- Effects are heterogenous:
  - Welfare increases 4.8% for plastics in New Mexico.
  - Welfare decreases 1% for chemicals sector in Wyoming.
- **What does it mean for welfare to be defined over sectors?**

Discussion

- Extensions in the paper:
  1. Adjustment costs.
     i.e., How much of the welfare gains are lost by transition costs?
  2. Effectiveness of trade-displacement policies.
     (they call these "Disability insurance").
  3. Time-varying fundamentals.
  4. Persistent migration decisions.
- Framework could be used to assess many GE effects:
  1. Changes in trade costs or productivity for other countries or regions.
  2. Capital mobility.
  3. Changes in government taxes, subsidies, employment benefits.
  4. Evaluate trade agreements.