Granular Comparative Advantage

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Exports are Granular

- Freund and Pierola (2015): "Export Superstars"

  Across 32 developing countries, the largest exporting firm accounts on average for 17% of total manufacturing exports

- Our focus: French manufacturing

Average export share of the largest firm

Manufacturing	1 industry	7%
— 2-digit	23 sectors	18%
— 3-digit	117 sectors	26%
— 4-digit	316 sectors	37%

Granularity

- Firm-size distribution is:
  1. fat-tailed (Zipf's law)
  2. discrete

  $\left.\begin{array}{l}\text{fat-tailed (Zipf's law)}\\ \text{discrete}\end{array}\right\} \implies$ Granularity

- Canonical example: power law (Pareto) with shape $\theta < 2$
- Intuitions from Gaussian world fail, even for very large N
  - — a single draw can shape $\sum_{i=1}^{N} X_i$ ▸ illustration
  - — average can differ from expectation (failure of LLN)

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- Most common application: **aggregate fluctuations**
  - Gabaix (2011), di Giovanni and Levchenko (2012)

- The role of granularity for **comparative advantage** of countries is a natural question, yet has not been explored
  - Can a few firms shape country-sector specialization?

Trade Models

- Trade models acknowledge fat-tailed-ness but not discreteness
  - emphasis on firms, but each firm is infinitesimal (LLN applies)
  - hence, no role of individual firms in shaping sectoral aggregates

- Exceptions with discrete number of firms
  1. One-sector model of Eaton, Kortum and Sotelo (EKS, 2012)
  2. Literature on competition/markups
     (e.g., AB 2008, EMX 2014, AIK 2014, 2019, Neary 2015)

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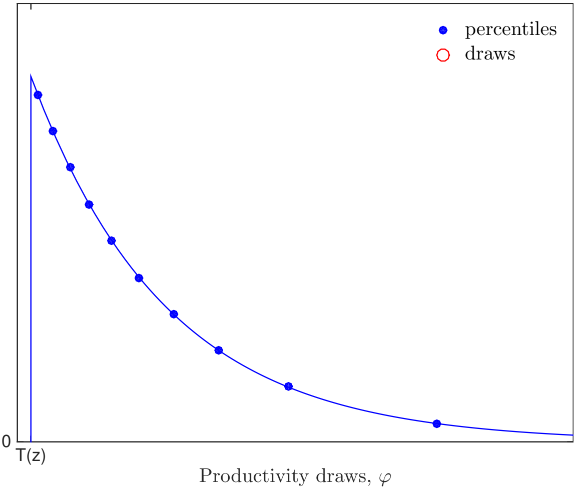
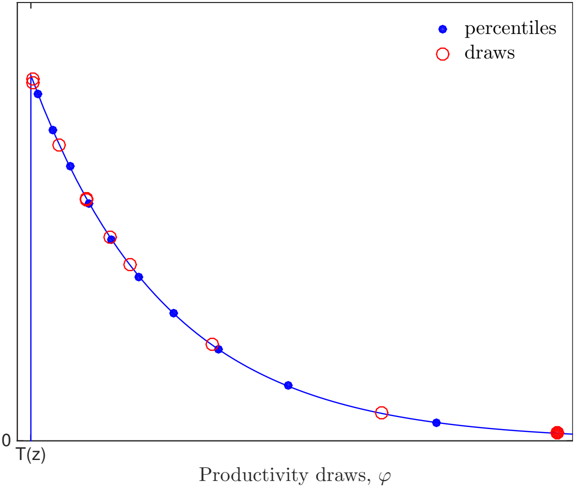
- Our focus: can granularity explain sectoral trade patterns?
  1. sector-level comparative advantage (like DFS)
  2. firm heterogeneity within sectors (like Melitz)
  3. granularity within sectors (like EKS)

  $\longrightarrow$ relax the LLN assumption in a multi-sector Melitz model

  take seriously that a typical French sector has **350 firms** with the largest firm commanding a **20% market share**



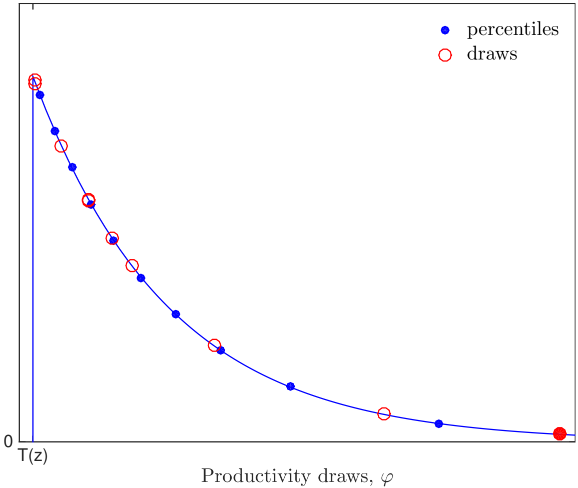
percentiles
draws
0
T(z)
Productivity draws, φ



- **Fundamental** vs **Granular**

Granularity

Our approach



- **Fundamental** vs **Granular**: Why do we care?

This paper

- Roadmap:
  1. Basic framework with granular comparative advantage
  2. GE Estimation Procedure
     - SMM using French firm-level data
  3. Explore implications of the estimated granular model
     - many continuous-world intuitions fail
     - dynamic and policy counterfactuals

This paper

- Roadmap:
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- Highlights of the results from the estimated model:
  1. A parsimonious granular model fits many empirical patterns. Moments of firm-size distribution explain trade patterns
  2. Granularity accounts for 20% of variation in export shares
     — most export-intensive sectors tend to be granular
  3. Granularity can explain much of the mean reversion in CA
     — more granular sectors are more volatile
     — death of a single firm can alter considerably the CA
  4. Policy in a granular economy: mergers and tariffs
     — the role of markups

Modeling Framework

Model Structure

1. Two countries: Home and Foreign
   — inelastically-supplied labor L and L^*

2. Continuum of sectors $z \in [0, 1]$:

$$Q = \exp\left\{ \int_0^1 \alpha_z \log Q_z \, dz \right\}$$

3. Sectors vary in comparative advantage: $\log \frac{T_z}{T_z^*} \sim \mathcal{N}(\mu_T, \sigma_T)$

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4. Within a sector, a finite number of firms (varieties) K_z:

$$Q_z = \left[\sum_{i=1}^{K_z} q_{z,i}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

5. Each sector has an EKS market structure

EKS Sectors

- Productivity draws in a given sector z:
  - — Number of (shadow) entrants: $\mathrm{Poisson}(M_z)$
  - — Entrants' productivity draws: $\mathrm{Pareto}(\theta; \underline{\varphi}_z)$

- Denote N_φ number of firms with productivity $\geq \varphi$

$$N_\varphi \sim \mathrm{Poisson}\big(T_z \cdot \varphi^{-\theta}\big), \qquad T_z \equiv M_z \underline{\varphi}_z^\theta$$

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- Fixed cost of production and exports: F in local labor

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- Oligopolistic (Bertrand) competition and variable markups
  - Atkeson-Burstein (2008): $\{c_i\} \longmapsto \{s_i, \mu_i, p_i\}_{i=1}^{K_z}$ show

Market Entry and GE

- Assumption: sequential entry in increasing order of unit cost

$$c_1 < c_2 < \ldots < c_K < \ldots, \quad \text{where} \quad c_i = \left[\begin{array}{rl} w/\varphi_i, & \text{if Home,} \\ \tau w^*/\varphi_i^*, & \text{if Foreign} \end{array} \right.$$

   $\rightarrow$ unique equilibrium

- Profits: $\Pi_i = \frac{s_i}{\varepsilon(s_i)} \alpha_z Y - wF$

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- Entry: $\Pi_K^K \geq 0$ and $\Pi_{K+1}^{K+1} < 0 \longmapsto$ determines K_z
- General equilibrium:
  - GE vector $\mathbf{X} = (Y, Y^*, w, w^*)$
  - Within-sector allocations $\mathbf{Z} = \left\{ K_z, \{s_{z,i}\}_{i=1}^{K_z} \right\}_{z \in [0,1]}$
  - Labor market clearing and trade balance (linear in $\mathbf{X}$)
  - Fast iterative algorithm

Estimation and Model Fit

Estimation procedure

- Data: French firm-level data (BRN) and Trade data
  - Firm-level domestic sales and export sales
  - Aggregate import data (Comtrade)
  - 119 4-digit manufacturing sectors
- Parametrize sector-level comparative advantage:
  - $T(z)/T^*(z) \sim \log \mathcal{N}(\mu_T, \sigma_T)$ (and robustness with Laplace)
  - Based on empirical distribution shown in Hanson et al. (2015)
- Stage 1: calibrate Cobb-Douglas shares $\{\alpha_z\}$ and $w/w*$
  - CD shares read from domestic sales + imports, by sector
  - $w/w* = 1.13$, trade-weighted wage of France's trade partners
  - Normalizations: $w = 1$ and $L = 100$
- Stage 2: SMM procedure to estimate $\{\sigma, \theta, \tau, F, \mu_T, \sigma_T\}$, while $(Y, Y^*, L^*/L)$ are pinned down by GE

Estimated Parameters

Parameter	Estimate	Std. error	Auxiliary variables	
σ	5	—	$\kappa = \frac{\theta}{\sigma - 1}$	1.077
θ	4.307	0.246		
τ	1.341	0.061	w/w^*	1.130
F ($\times 10^5$)	0.946	0.252	L^*/L	1.724
μ_T	0.137	0.193	Y^*/Y	1.526
σ_T	1.422	0.232	Π/Y	0.211

Moment Fit

	Moments			Data, $\hat{\mathbf{m}}$	Model, $\bar{\mathcal{M}}(\hat{\Theta})$	Loss (%)
1.	Log number of firms,	mean	$\log \tilde{M}_z$	5.631	5.624	0.1
2.		— st. dev.		1.451	1.222	7.9
3.	Top-firm market share,	mean	$\tilde{s}_{z,1}$	0.197	0.206	3.5
4.		— st. dev.		0.178	0.149	3.8
5.	Top-3 market share,	mean	$\sum_{j=1}^{3} \tilde{s}_{z,j}$	0.356	0.343	2.0
6.		— st. dev.		0.241	0.175	11.5
7.	Imports/dom. sales,	mean	$\tilde{\Lambda}_z$	0.365	0.351	2.2
8.		— st. dev.		0.204	0.268	14.8
9.	Exports/dom. sales,	mean	$\tilde{\Lambda}_z^{*\prime}$	0.328	0.350	6.0
10.		— st. dev.		0.286	0.346	6.5
11.	Fraction of sectors with exports>dom. sales		$\mathbb{P}\left\{ \begin{smallmatrix} \tilde{X}_z > \\ \tilde{Y}_z - \tilde{X}_z^* \end{smallmatrix} \right\}$	0.185	0.092	37.9
Regression coefficients[†]						
12.	export share on top-firm share		$\hat{b}_1$	0.215 (0.156)	0.243 (0.104)	2.6
13.	export share on top-3 share		$\hat{b}_3$	0.254 (0.108)	0.232 (0.090)	1.1
14.	import share on top-firm share		$\hat{b}_1^*$	−0.016 (0.097)	−0.020 (0.079)	0.0
15.	export share on top-3 share		$\hat{b}_3^*$	0.002 (0.074)	−0.005 (0.069)	0.1

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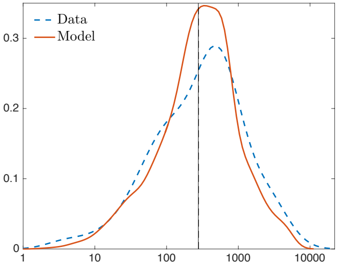
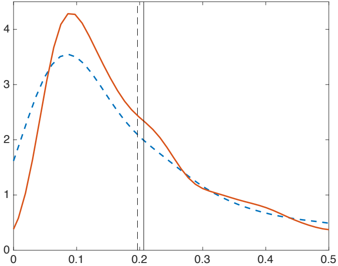
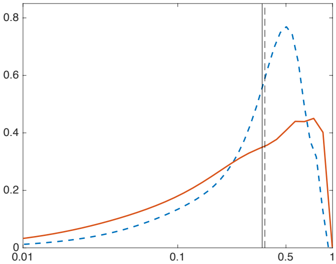
(a) Number of French firms



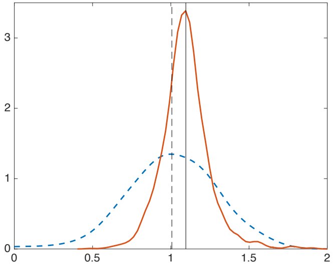
(b) Top market share



(c) Domestic import share



(d) Pareto shape of sales



Non-targeted Moments

- Correlation between top market share and number of firms:

$$\tilde{s}_{z,1} = const + \underset{\substack{\text{Data:}\; -0.094 \\ (0.008) \\ \text{Model:}\; -0.064 \\ (0.007)}}{\gamma_M} \cdot \log \tilde{M}_z + \underset{\substack{0.018 \\ (0.008) \\ 0.025 \\ (0.006)}}{\gamma_Y} \cdot \log \tilde{Y}_z + \epsilon_z^s$$

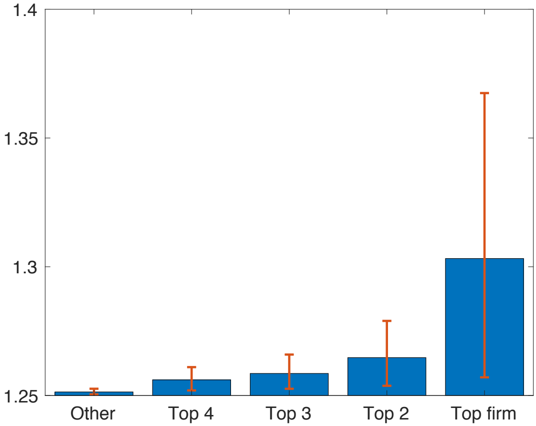
	γ_M	γ_Y
Data:	-0.094 (0.008)	0.018 (0.008)
Model:	-0.064 (0.007)	0.025 (0.006)

- Extensive margin of sales:

$$\log \tilde{M}_z = c_d + \chi_d \cdot \log(\tilde{Y}_z - \tilde{X}_z^*) + \epsilon_z^d$$

	χ_d
Data:	0.563 (0.082)
Model:	0.861 (0.011)

Equilibrium markups



- Oligopolistic (Bertrand) markups: averages (blue bars) and 10–90% range (red intervals) across industry
- Monopolistic competition markup: $\frac{\sigma}{\sigma-1} = 1.25$ is lower bound for all oligopolistic markups

Quantifying Granular Trade

Properties of the Granular Model

- Foreign share:

$$\Lambda_z \equiv \frac{X_z^*}{\alpha_z Y} = \sum\nolimits_{i=1}^{K_z} (1 - \iota_{z,i}) s_{z,i}$$

- Expected foreign share:

$$\Phi_z = \mathbb{E}\left\{ \Lambda_z \,\middle|\, \tfrac{T_z}{T_z^*} \right\} = \frac{1}{1 + (\tau\omega)^\theta \cdot \frac{T_z}{T_z^*}}$$

- Granular residual:

$$\Gamma_z \equiv \Lambda_z - \Phi_z \quad : \qquad \mathbb{E}_T\{\Gamma_z\} = \mathbb{E}_T\{\Lambda_z - \Phi_z\} = 0$$

- Aggregate exports:

$$X^* = Y \int_0^1 \alpha_z \Lambda_z \mathrm{d}z = \Phi Y, \qquad \Phi \equiv \int_0^1 \alpha_z \Phi_z \mathrm{d}z$$

Decomposition of Trade Flows

- Variance decomposition of $X_z = \Lambda_z^* \alpha_z Y^*$ with $\Lambda_z^* = \Phi_z^* + \Gamma_z^*$:

$$\mathrm{var}(\Lambda_z^*) = \mathrm{var}(\Phi_z^*) + \mathrm{var}(\Gamma_z^*),$$

$$\mathrm{var}(\log X_z) \approx \mathrm{var}(\log \alpha_z) + \mathrm{var}(\log \Lambda_z^*)$$

Table: Variance decomposition of trade flows

		Common θ		Sector-specific θ_z		
		(1)	(2)	(3)	(4)	(5)
Granular contribution	$\frac{\mathrm{var}(\Gamma_z^*)}{\mathrm{var}(\Lambda_z^*)}$	17.0%	22.3%	26.0%	28.4%	20.3%
Export share contribution	$\frac{\mathrm{var}(\log \Lambda_z^*)}{\mathrm{var}(\log X_z)}$	57.2%	59.2%	62.5%	63.9%	59.0%
Pareto shape parameter	$\kappa_z = \frac{\theta_z}{\sigma - 1}$	1.08	1.00	**1.02**	0.96	1.15
Estimated Pareto shape	$\hat{\kappa}_z$	1.10	**1.02**	1.07	**1.02**	1.21
Top-firm market share	$s_{z,1}$	**0.21**	0.25	0.26	0.29	**0.21**

show fit

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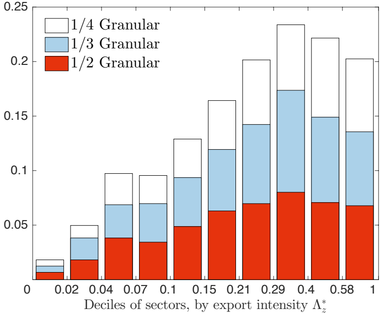
show fit

Extensions: (i) $T_z/T_z^* \sim \mathit{Laplace}$ (two-sided Pareto)
(ii) $\log \varphi_{z,i} \sim \mathcal{N}(\mu, \theta)$

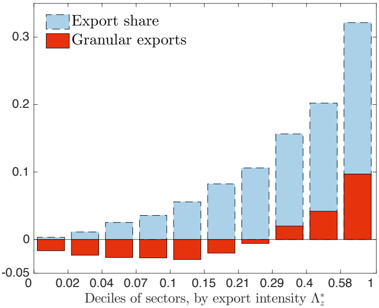
Export Intensity and Granularity

- Granularity does not create additional trade on average
- Yet, granularity creates skewness across sectors in exports
  - most export-intensive sectors are likely of granular origin

(a) Fraction of granular sectors



(b) Granular contribution to trade



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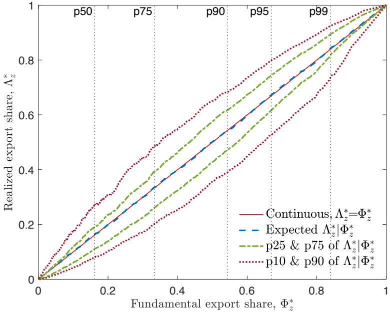
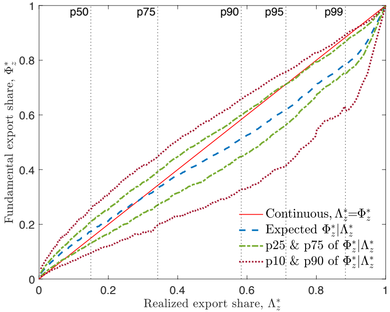
(a) Distribution of $\Lambda_z^* \mid \Phi_z^*$



(b) Distribution of $\Phi_z^* \mid \Lambda_z^*$



Properties of Granular Exports

- $\Gamma_z^* = \Lambda_z^* - \Phi_z^*$ are orthogonal with Φ_z^*, $\log(\alpha_z Y^*)$ and $\log \tilde{M}_z$
- Best predictor of Γ_z^* is $\tilde{s}_{z,1}$, the relative size of the largest firm

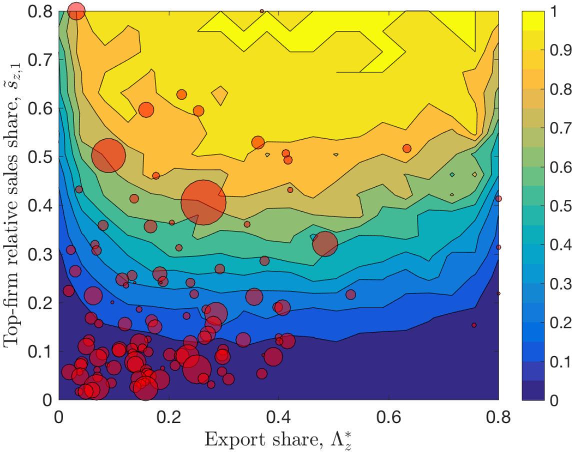
Table: Projections of granular exports Γ_z^*

	(1)	(2)	(3)	(4)	(5)	(6)
$\tilde{s}_{z,1}$		0.335	0.373	0.379	0.357	0.354
$\tilde{s}_{z,1}^*$					-0.254	-0.268
$\log \tilde{M}_z$	-0.008		0.012	0.016		-0.011
$\log(\alpha_z Y)$				-0.005		0.013
Φ_z^*				0.004		0.073
R^2	0.013	0.353	0.375	0.376	0.520	0.539

Identifying Granular Sectors

- Which sectors are granular? Neither Φ_z^*, nor Γ_z^* are observable

$$\mathbb{P}\{\Gamma_z^* \geq \vartheta\Lambda_z^* \,|\, \Lambda_z^*, \mathbf{r}_z\} = \frac{\int_{\Lambda_z^* - \Phi^* \geq \vartheta\Lambda_z^*} g\left(\Phi_z^*, \Lambda_z^*, \mathbf{r}_z\right) \mathrm{d}\Phi_z^*}{\int_0^1 g\left(\Phi_z^*, \Lambda_z^*, \mathbf{r}_z\right) \mathrm{d}\Phi_z^*},$$



Dynamics of Comparative Advantage

Dynamic Model

- Use the granular model with firm dynamics to study the implied time-series properties of aggregate trade
  - Shadow pull of firms in each sector with productivities $\{\varphi_{it}\}$
  - Productivity of the firms follows a random growth process:
    $$\log \varphi_{it} = \mu + \log \varphi_{i,t-1} + \nu\varepsilon_{it}, \quad \varepsilon_{it} \sim iid\mathcal{N}(0,1)$$
    with reflection from the lower bound $\underline{\varphi}$ and $\mu = -\theta\nu^2/2$
  - Each period: static entry game and price setting equilibrium
- Calibrate idiosyncratic firm dynamics (volatility of shocks ν) using the dynamic properties of market shares

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- Extension with aggregate shocks: $\varepsilon_{it} = \sqrt{\rho} \cdot v_t + \sqrt{1-\rho} \cdot u_{it}$

Firm Dynamics and CA

- Empirical evidence in Hanson, Lind and Muendler (2015):
  1. Hyperspecialization of exports
  2. High Turnover of export-intensive sectors

Moment	Data		Model
	HLM	France	
SR persistence $\mathrm{std}(\Delta\tilde{s}_{z,i,t+1})$	—	0.0018	0.0017
LR persistence $\mathrm{corr}(\tilde{s}_{z,i,t+10}, \tilde{s}_{z,i,t})$	—	0.86	0.83
Top-1% sectors export share	21%	17%	18%
Top-3% sectors export share	43%	30%	33%
Turnover I: remain in top-5% after 20 years	52%	—	71%
Turnover II: remain in top-5% after 10 years	—	80%	79%

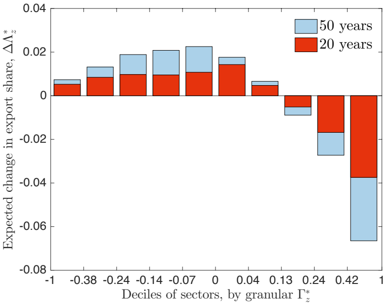
- Idiosyncratic firm productivity dynamics explains the majority of turnover of top exporting sectors over time

show more

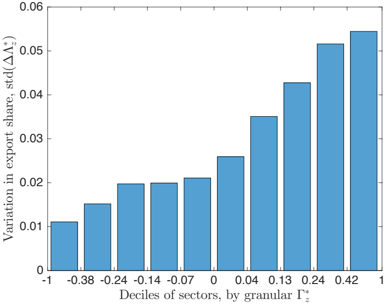
Mean Reversion in CA

- Idiosyncratic firm dynamics in a granular model predicts mean reversion in comparative advantage
- In addition, granular sectors are more volatile

(a) Mean reversion in Λ_z^*

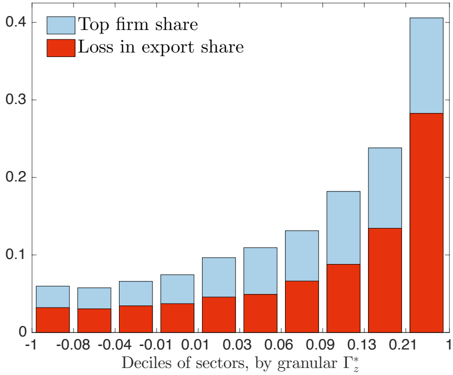


(b) Volatility of $\Delta\Lambda_z^*$



Death of a Large Firm

- Death (sequence of negative productivity shocks) of a single firm can substantially affect sectoral comparative advantage
- In the most granular sectors, death of a single firm can push the sector from top-5% of CA into comparative disadvantage



show more

Granularity and reallocation

- Sectoral labor allocation:

$$\frac{L_z}{L} \approx \alpha_z + \frac{\theta}{\sigma\kappa - 1}\frac{NX_z}{Y}$$

- Interaction between trade openness and granularity results in sectoral reallocation and aggregate volatility

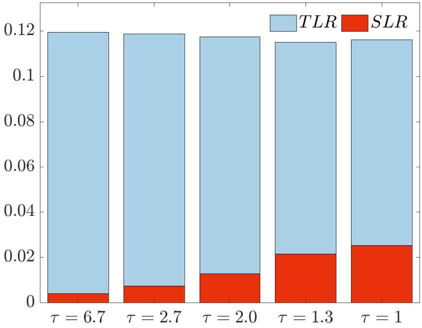


Figure: Total and Sectoral Labor Reallocation (fraction of total L)

Empirical Analysis

Granularity and Exports

Cross section and Dynamic panel

$\log X_z$	Cross-section, 2005 (1)	(2)	Panel, 1997–2008 (3)	(4)	Dynamics (5)	(6)	(7)
$\sum_{i=1}^{3} \tilde{s}_{z,i}$	0.802^{***} (0.290)	0.833^{**} (0.293)	0.846^{***} (0.302)	0.860^{**} (0.302)	0.418^{***} (0.129)	0.512^{***} (0.133)	0.511^{***} (0.134)
$\log D_z$	0.895^{***} (0.050)	0.933^{***} (0.051)	0.909^{***} (0.051)	0.951^{***} (0.052)			
R^2	0.512	0.652	0.520	0.656	0.954	0.012	0.017
R^2_{adj}	0.509	0.623	0.518	0.652	0.949	0.009	0.007
N	316	316	3,409	3,409	3,409	3,091	3,091
N clusters			316	316			
Fixed effects:							
2-digit		✓		✓			✓
Sector					✓		
Year			✓	✓	✓		

Predictive Regressions

Mean reversion in exports

$\Delta_{10} \log X_z$	OLS (1)	(2)	(3)	IV (4)
$\log X_z$	-0.116^{***} (0.040)		-0.092^{**} (0.040)	-0.600^{***} (0.215)
$\sum_{i=1}^{3} \tilde{s}_{z,i}$		-0.660^{***} (0.199)	-0.559^{***} (0.203)	
$\log D_z$	0.101^{**} (0.049)	-0.057 (0.036)	0.035 (0.054)	0.542^{***} (0.200)
R^2	0.146	0.153	0.168	
R^2_{adj}	0.075	0.083	0.096	
N	316	316	316	316
2-digit FE	✓	✓	✓	✓

Policy Counterfactuals

Policy counterfactuals

1. Misallocation and trade policy
   - policies that hinder growth of granular firms
   - why trade barriers often target individual foreign firms?
2. Merger analysis

Policy counterfactuals

1. Misallocation and trade policy
   - policies that hinder growth of granular firms
   - why trade barriers often target individual foreign firms?

2. Merger analysis

- Welfare analysis of a policy:

$$\hat{\mathbb{W}} \equiv \mathrm{d}\log\frac{Y}{P}$$
$$= \frac{wL}{Y}\mathrm{d}\log w + \frac{\mathrm{d}\,TR}{Y} + \int_0^1 \alpha_z \frac{\mathrm{d}\Pi_z}{\alpha_z Y}\mathrm{d}z - \int_0^1 \alpha_z \mathrm{d}\log P_z \mathrm{d}z$$

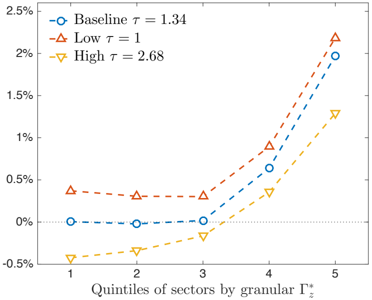
and across sectors $\hat{\mathbb{W}} = \int_0^1 \alpha_z \hat{W}_z \mathrm{d}z$

- In partial equilibrium: $\hat{W}_z = \frac{\mathrm{d}\,TR_z + \mathrm{d}\Pi_z}{\alpha_z Y} - \mathrm{d}\log P_z$
- In general equilibrium: spillovers to other sectors via (w, Y)

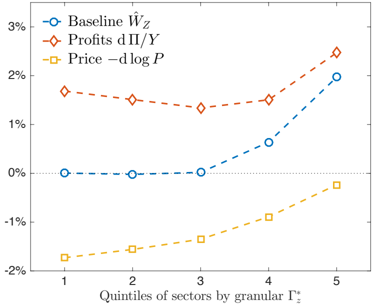
Merger

- Merger is more beneficial:
  1. The larger is the productivity spillover $\varrho \uparrow$
     $\varphi'_{z,2} = \varrho\varphi_{z,1} + (1-\varrho)\varphi_{z,2}$. Baseline $\varrho = 0.5$. For low $\varrho = 0.1$ click
  2. The more open is the economy $\tau \downarrow$
  3. The more granular is the sector $\Gamma^*_z \uparrow$

(a) Welfare effect of a merger, $\hat{W}_Z$



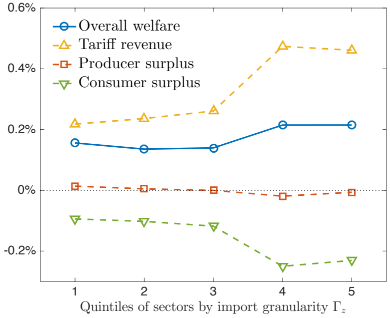
(b) Decomposition of $\hat{W}_Z$, $\tau = 1.34$



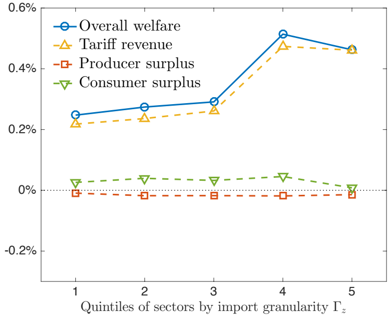
Import Tariff

- Tariff on the top importer $\varsigma_{z,1}$ vs a uniform import tariff $\bar{\varsigma}_z$
  - yielding the same tariff revenue
  - $\varsigma_{z,1} \succ \bar{\varsigma}_z$, particularly in the foreign granular industries ($\Gamma_z \uparrow$)

(a) Uniform tariff



(b) Granular tariff



Conclusion

Conclusion

- The world is granular! *(at least, at the sectoral level)*

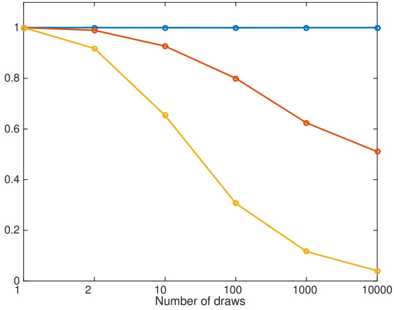
  We better develop tools and intuitions to deal with it

- Applications:
  1. Innovation, growth and development
  2. Misallocation
  3. Industrial policy
  4. Cities and agglomeration

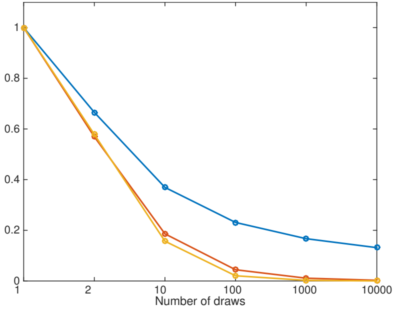
APPENDIX

- The role of top draw, as the number of draws N increases

$$\operatorname{corr}\left(\max_i X_i, \sum_i X_i\right)$$



$$\frac{\max_i X_i}{\sum_i X_i}$$



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Sectoral equilibrium

- Sectoral equilibrium system:

$$p_i = \mu_i c_i,$$

$$\mu_i = \frac{\varepsilon_i}{\varepsilon_i - 1} \qquad \text{where} \quad \varepsilon_i = \sigma(1 - s_i) + s_i,$$

$$s_i = \left(\frac{p_i}{P}\right)^{1-\sigma} \qquad \text{where} \quad P = \left(\sum_{i=1}^{K} p_i^{1-\sigma}\right)^{1/(1-\sigma)}.$$

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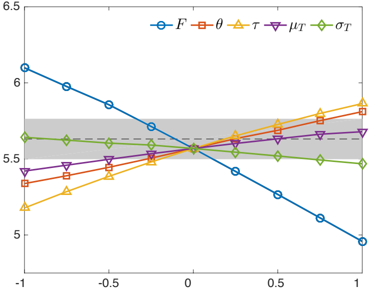
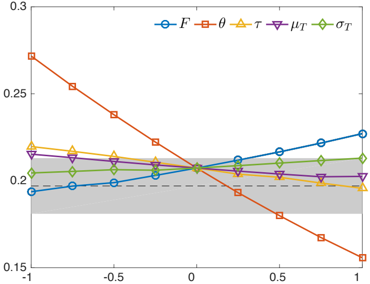
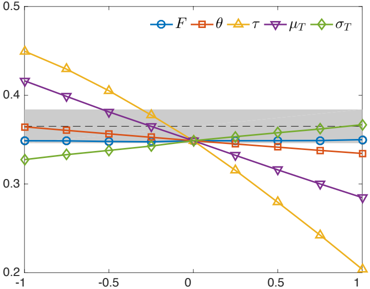
(a) Number of French firms



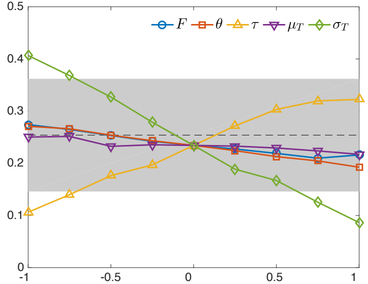
(b) Top French firm share



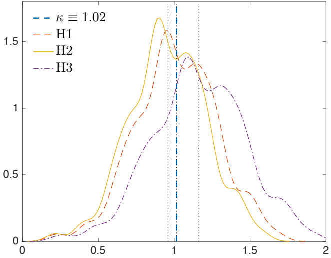
(c) Domestic import share



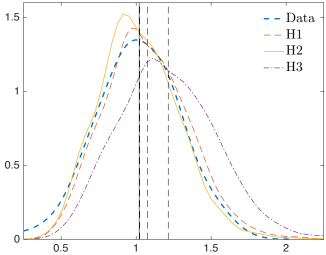
(d) Export projection coefficient



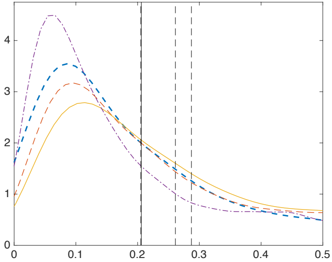
(a) Pareto shape, $\kappa_z = \frac{\theta_z}{\sigma - 1}$



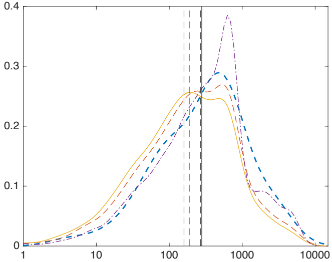
(b) Estimated Pareto, $\hat{\kappa}_z$



(c) Top-firm sales share, $\tilde{s}_{z,1}$



(d) Number of firms, $\tilde{M}_z$



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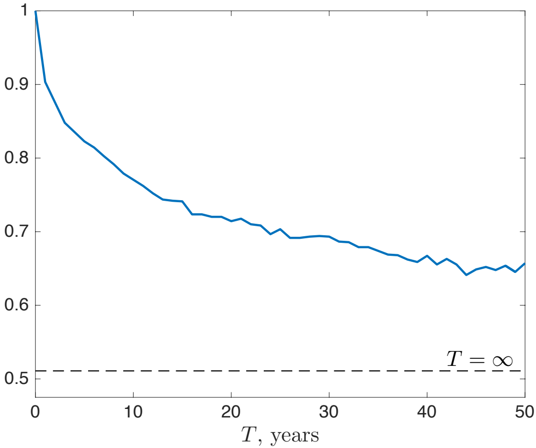
Probability a sector remains among top-5% of export-intensive sectors



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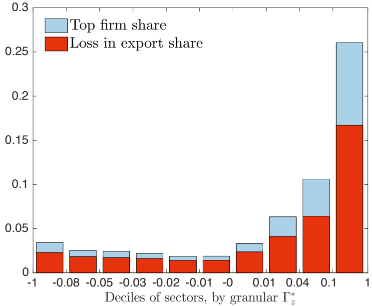
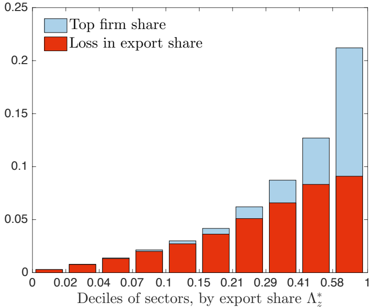
Trade effects of individual firm exit

(a) All sectors, deciles of Γ_z^*



(b) All sectors, deciles of Λ_z^*



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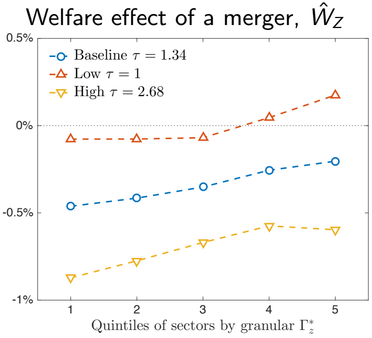
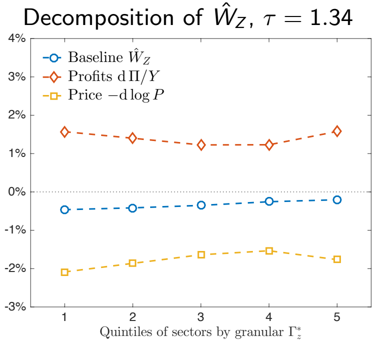
Merger

Low spillover $\varrho = 0.1$





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