The Impact of Trade on Organization and Productivity

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Introduction

- Firms are heterogeneous in a variety of dimensions
  - But little is known about where this heterogeneity comes from
- Some of the observed heterogeneity is the result of organizational differences (Number and knowledge of employees)
- Does this matter?
  - Yes, if we are looking at within-firm outcomes
    - ★ e.g. productivity, skill composition, wages, layers of management
  - Yes, because these within-firm effects can have aggregate consequences
- Here we aim to understand the impact of trade on within-firm outcomes as well as across firms
  - Not only focus on who does what but also how do they do it

How we do it?

- We introduce organization in a heterogeneous firm equilibrium framework with differentiated products
  - Exogenous demand heterogeneity rather than heterogeneity in productivity as in Melitz (2003)
- We use the model of organization in Garicano (2000)
- Much closer to the empirical literature and ready for calibration or structural estimation

Technology

- An entrepreneur pays a fixed entry cost f^E in units of labor to design her product
  - It obtains a demand draw α from $G(\cdot)$ (later $G(\alpha) = 1 - \alpha^{-\gamma}$)
  - α determines the level of demand of the firm
- If entrepreneur decides to produce she pays a fixed cost f in units of labour
  - Needs to build an organization

Technology

- Production requires labor and knowledge
- Agents employed in a firm act as production workers or managers
- Workers:
  - Each worker uses her unit of time to generate a production possibility that can yield A units of output
  - For output to be realized the worker needs to solve a problem
  - Problems are drawn from $F(z) = 1 - e^{-\lambda z}$
    - ★ $\lambda > 0$ regulates how common are the problems faced in production
  - Workers learn how to solve an interval of knowledge $\left[0, z_L^0\right]$
    - ★ If the problem they face is in this interval production is realized
    - ★ Otherwise they could ask a manager one layer above

Technology

- Managers
  - Specialize in solving problems
  - Spend h units of time with each problem that gets to her
    - ★ So each manager can deal with $1/h$ problems
  - A manager of layer 1 tries to solve the problems workers could not solve
    - ★ So problems that require knowledge larger than z_L^0
    - ★ Learns how to solve problems in the interval $\left[z_L^0, z_L^0 + z_L^1\right]$
    - ★ So the firm needs $n_L^1 = hn_L^0\left(1 - F\left(z_L^0\right)\right)$ of these managers
    - ★ Unsolved problems can be sent to a manager one layer above
  - In general, managers in layer l learn $\left[Z_L^{l-1}, Z_L^l\right]$ and there are $n_L^l = hn_L^0(1 - F(Z_L^{l-1}))$ of them, where $Z_L^l = \sum_{\ell=0}^{l} z_L^\ell$

Cost Minimization

- Consider a firm that produces a quantity q. The variable cost function is given by

$$C(q; w) = \min_{L \geq 0} \{C_L(q; w)\}$$

where $C_L(q; w)$ is the minimum cost of producing q with an organization with $L+1$ layers, namely,

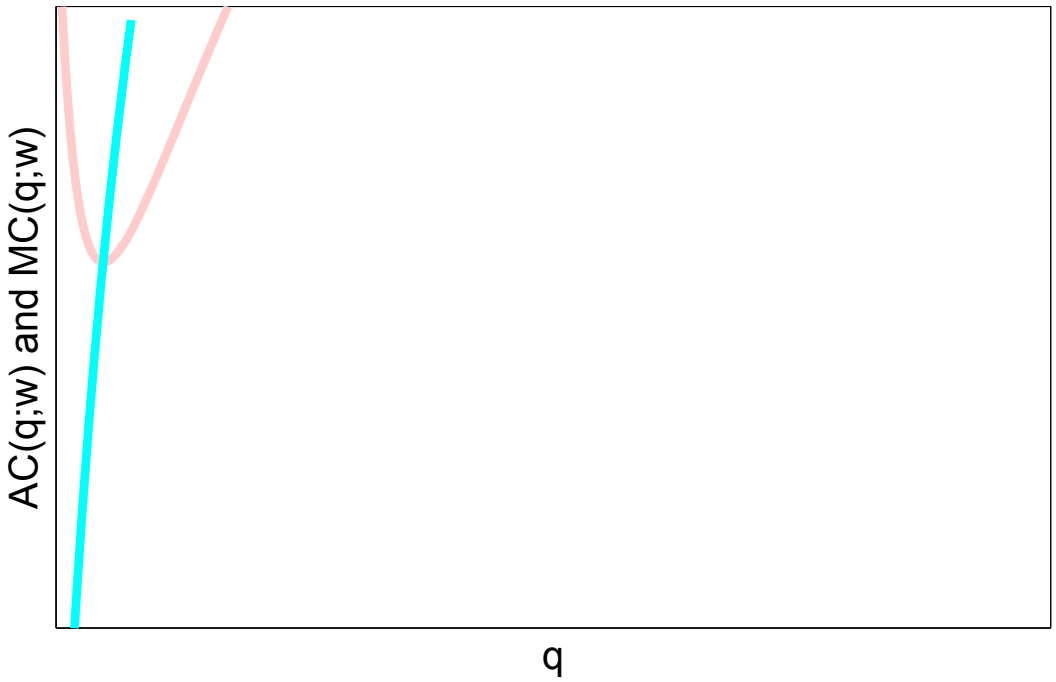
$$C_L(q; w) = \min_{\{n_L^l, z_L^l\}_{l=0}^L \geq 0} \sum_{l=0}^L n_L^l w \left(c z_L^l + 1\right)$$

subject to

$$\begin{aligned} q &\leq F(Z_L^L) A n_L^0, \\ n_L^l &= h n_L^0 (1 - F(Z_L^{l-1})) \text{ for } L \geq l > 0, \\ n_L^L &= 1 \end{aligned}$$

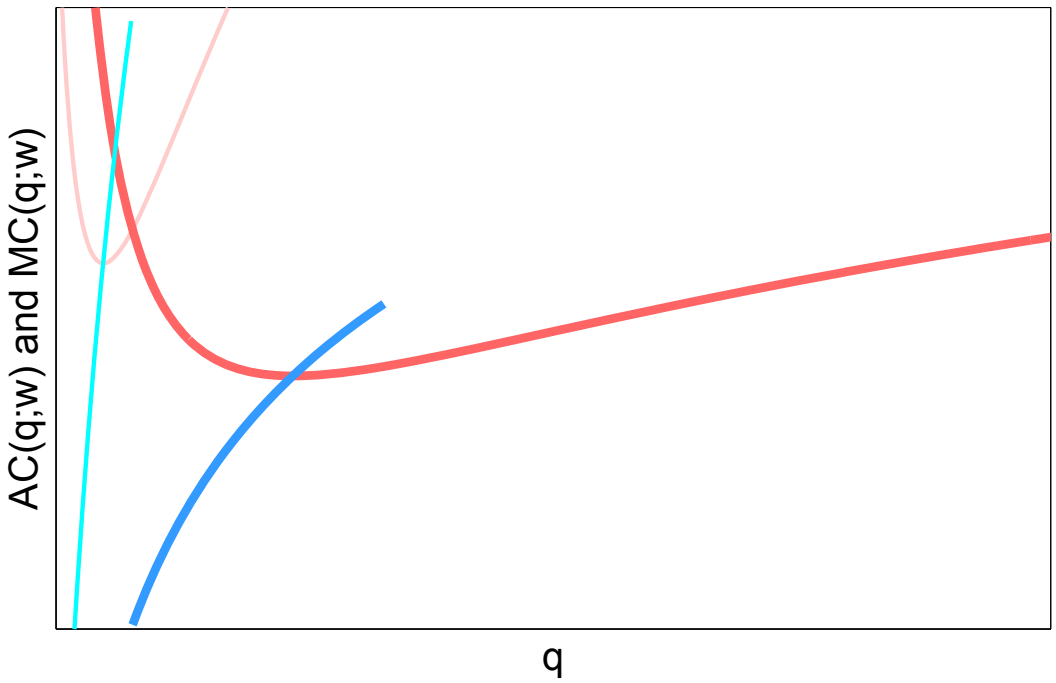
▸ z > 0

Marginal and Average Costs



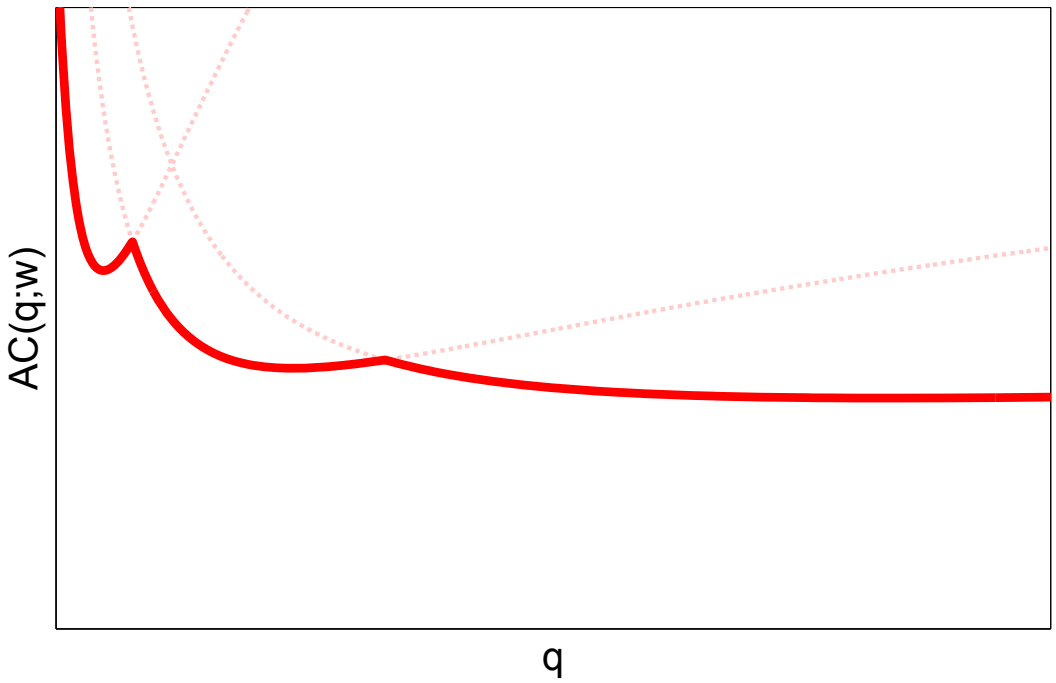
Propositions 1 to **6** characterize the cost function

Marginal and Average Costs



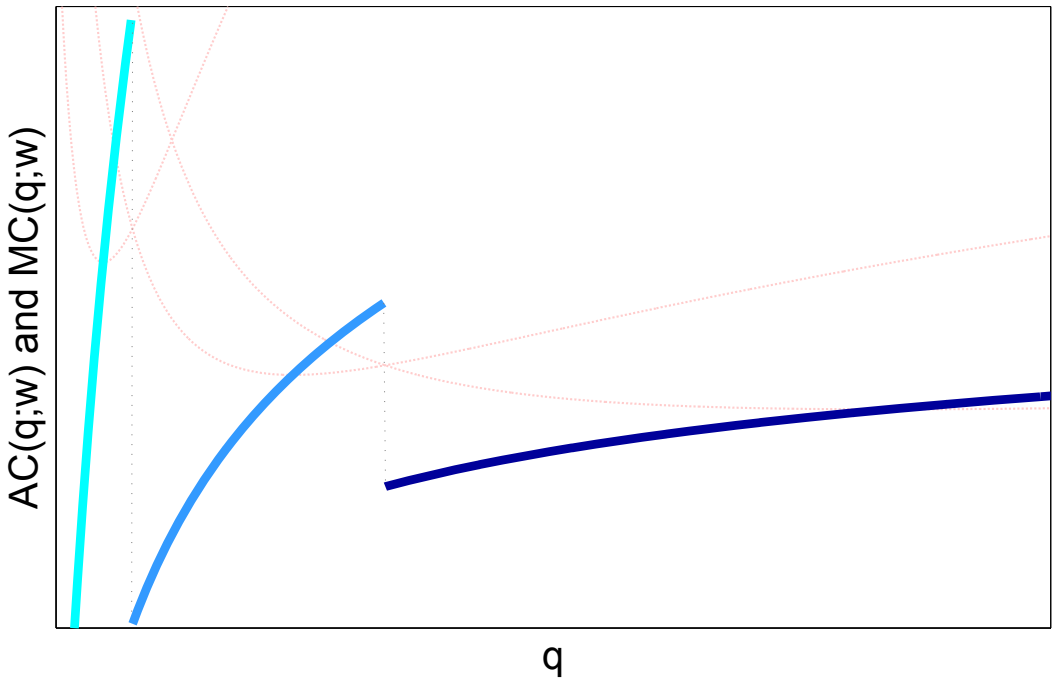
Propositions 1 to **6** characterize the cost function

Average Costs: The Lower Envelope



Propositions 1 to **6** characterize the cost function

Marginal Costs



Propositions 1 to **6** characterize the cost function

Profit Maximization

- Given CES preferences demand is given by $p(\alpha) = q(\alpha)^{-\frac{1}{\sigma}} (\alpha R)^{\frac{1}{\sigma}}$ where R is total revenue and $P = 1$
- The problem of an entrepreneur with draw α is

$$\pi(\alpha) \equiv \max_{q(\alpha) \geq 0} p(\alpha) q(\alpha) - C(q(\alpha); w) - wf$$

- Hence,

$$p(\alpha) = \frac{\sigma}{\sigma - 1} MC(q(\alpha); w)$$

and

$$q(\alpha) = \alpha R \left(\frac{\sigma}{\sigma - 1} MC(q(\alpha); w) \right)^{-\sigma}$$

- $MC(q(\alpha); w)$ increasing in $q(\alpha)$ and jumps down with new layer
  - **Proposition 8**: $q(\alpha)$ and $p(\alpha)$ increase in α given L and jump (up for $q(\alpha)$ and down for $p(\alpha)$) across L's

▸ Profits

Open Economy

- Two countries: Domestic (D) and Foreign (F) with populations $\tilde{N}_i$
  - Same preferences so a draw α applies to both markets
  - Fixed cost of production given by f_{ii}, and fixed cost to export of f_{ij}
  - $x_{ij}(\alpha)$ is the demand of an agent in country j for goods α produced in country i, $q_{ij}(\alpha)$ the quantity produced, and $p_{ij}(\alpha)$ is the price
  - We normalize $P_D = 1$
- Trade is costly. Iceberg trade cost are given by $\tau_{ij} > 1$, for $i \neq j$

Prices and Quantities in the Open Economy

- Quantities produced for each market are then

$$q_{ii}(\alpha) = \alpha R_i P_i^{\sigma-1} \left(\frac{\sigma}{\sigma - 1} MC\left(q_i(\alpha); w_i\right) \right)^{-\sigma}$$

and

$$q_{ij}(\alpha) = \alpha R_j \left(\frac{P_j}{\tau_{ij}} \right)^{\sigma-1} \left(\frac{\sigma}{\sigma - 1} MC\left(q_i(\alpha); w_i\right) \right)^{-\sigma}$$

  - Note that domestic quantity now depends on total production, $q_i(\alpha)$
  - So exporting changes domestic production through within-firm reorganization
  - In contrast to standard model all firms might export even if $f_{ij} > f_{ii}$

- Price in each market is given by

$$p_{ij}(\alpha) = \tau_{ij} p_{ii}(\alpha) = \tau_{ij} \frac{\sigma}{\sigma - 1} MC\left(q_i(\alpha); w_i\right)$$

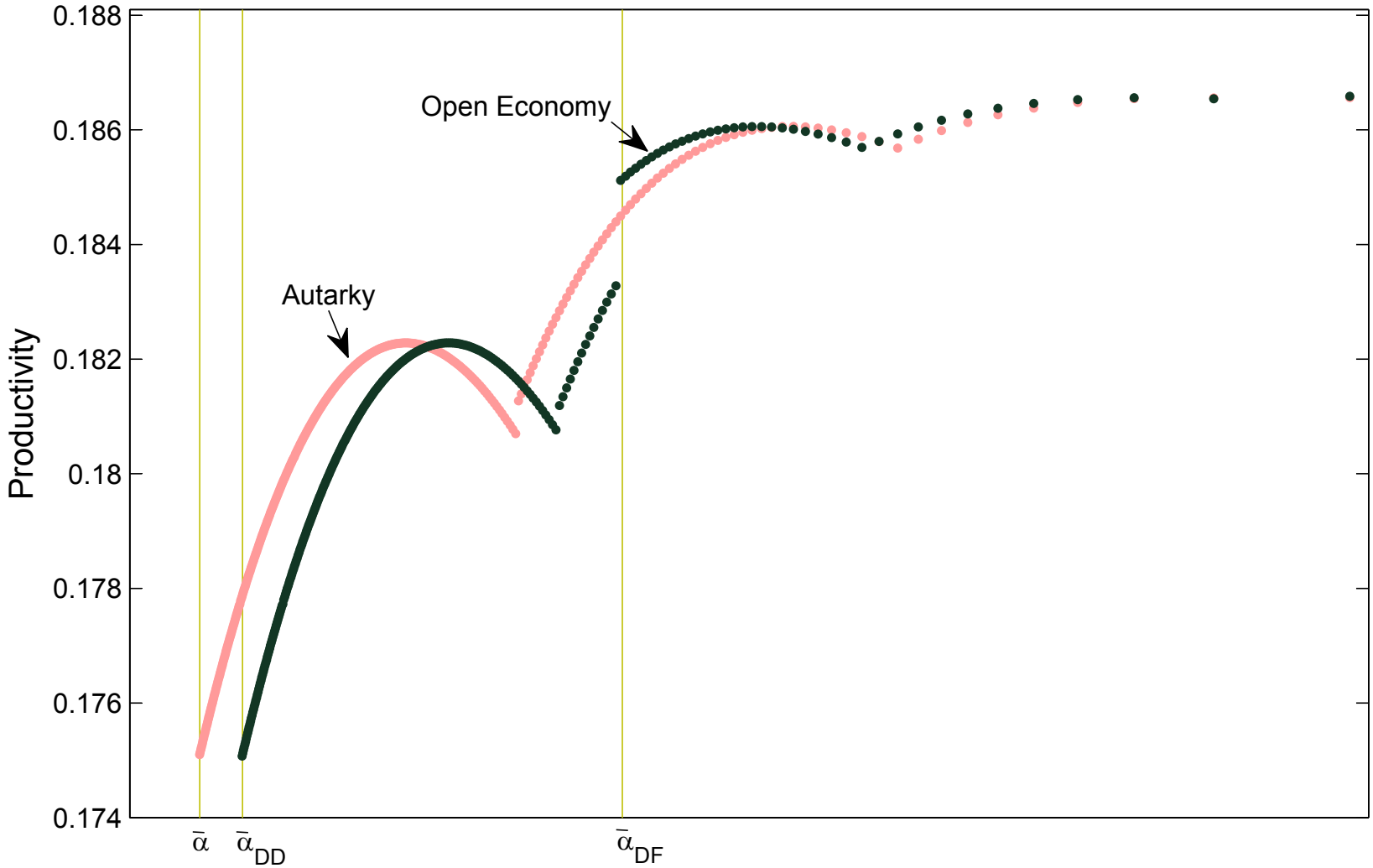
Calibration

- Consider a world with two symmetric countries like the U.S. in 2002
- Need values for f_i^E, f_{ii}, f_{ij}, h, c/λ, γ, σ, A, $\tilde{N}_i$, δ, τ_{ij}
- We set $\sigma = 3.8$ (Bernard, et al., 2003), $\tau = 1.3$, $\delta = 10\%$ (Ghironi and Melitz, 2005), and normalize $f_{ii} = 1.1$
- $\tilde{N}_i$ is the total number of employees in the manufacturing sector and proportional educational sector
- We calibrate the values of f_i^E, f_{ij}, h, c/λ, A and γ to match:

Moments	Data	Model
Share of firms that export	18.0	17.53
Average size of firms	45.2	45.44
Share of education employees	11.8	11.85
Share of expenditure on domestic goods	78.9	74.94
Total expenditure	5.1	5.10
Pareto coefficient	-1.095	-1.094

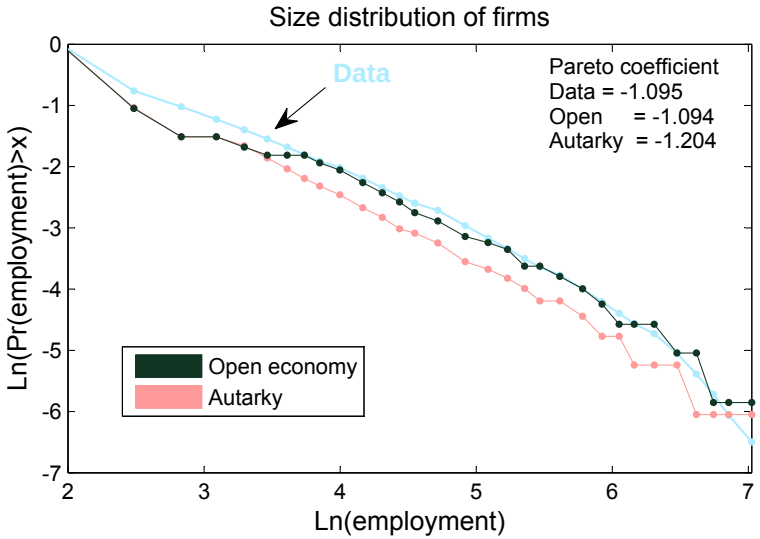
▸ Parameter Values ▸ Data

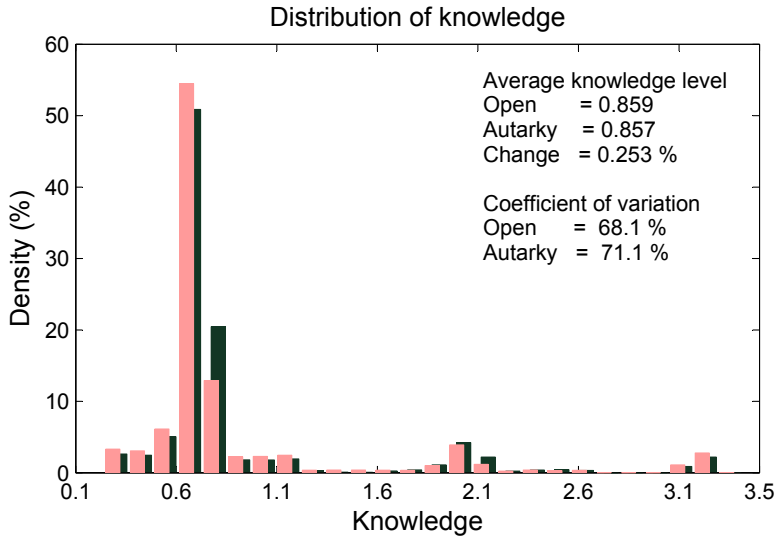
Productivity

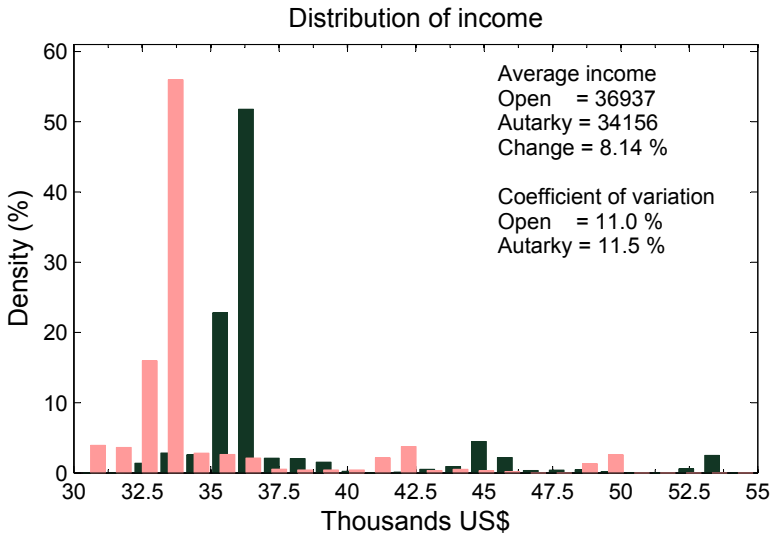


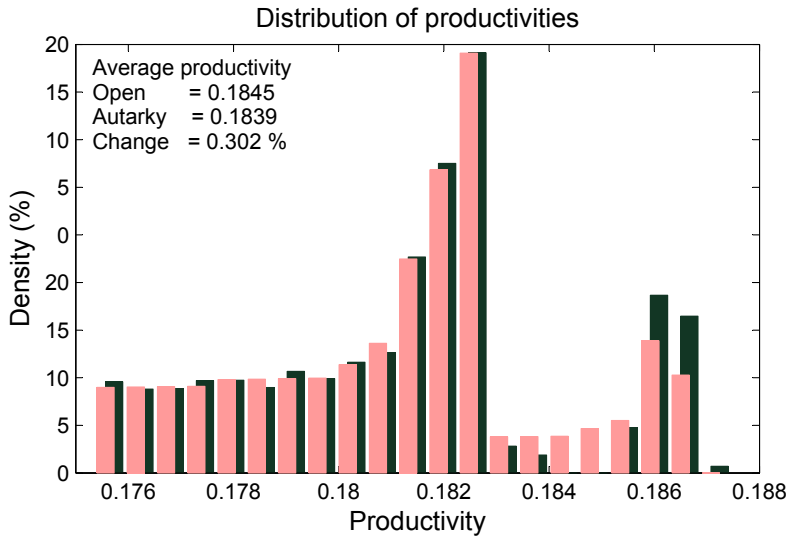
▸ Distributions

Distributions of Size, Knowledge, Income, and Productivity



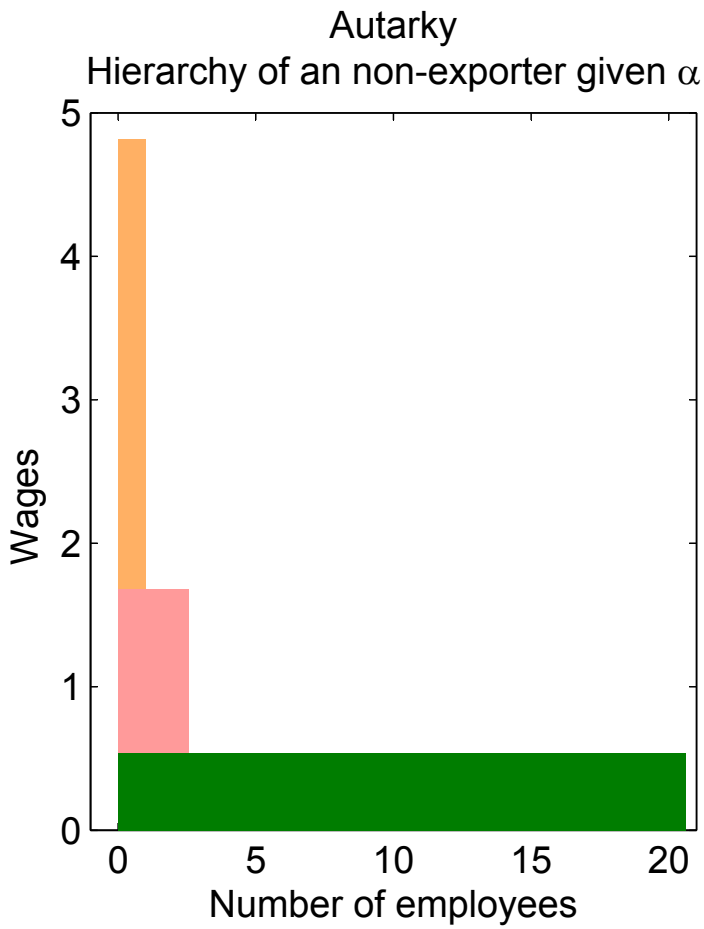


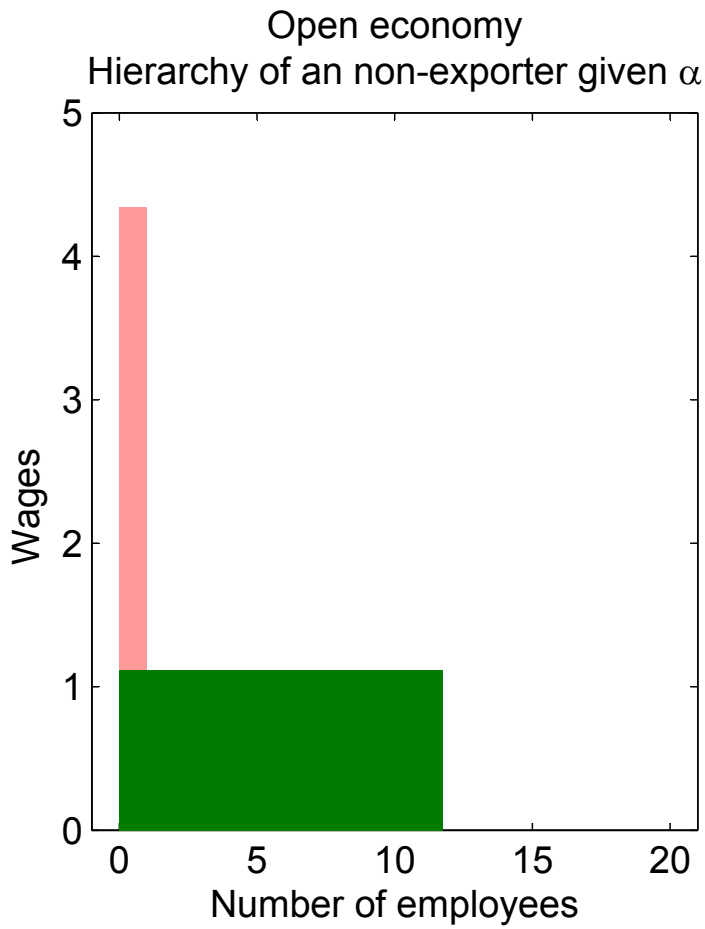




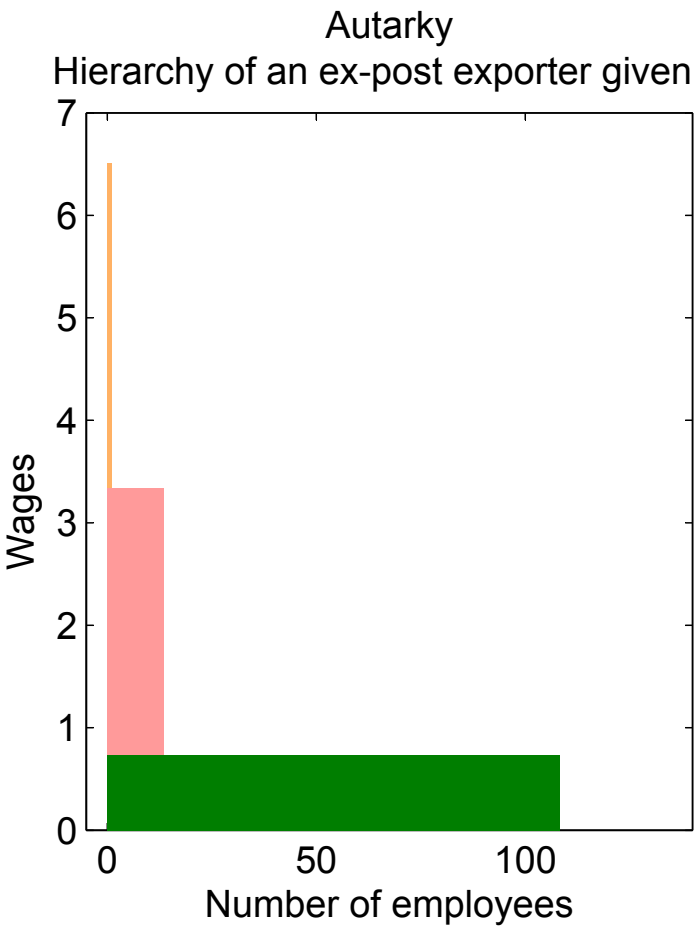
▸ Free Trade

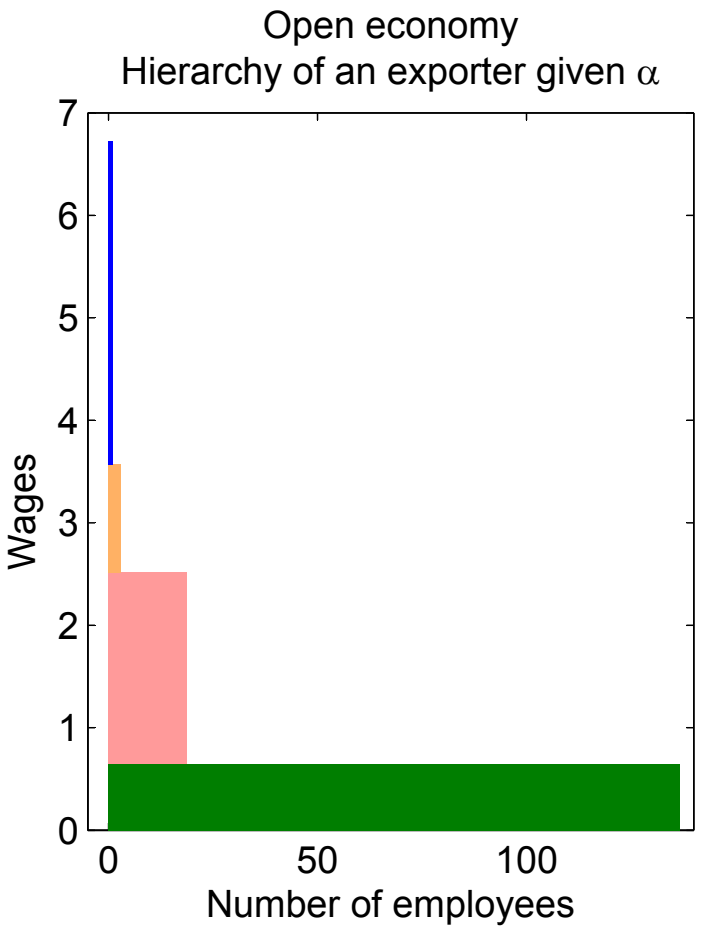
Impact of Trade on Internal Organization: Non-exporters





Impact of Trade on Internal Organization: Exporters

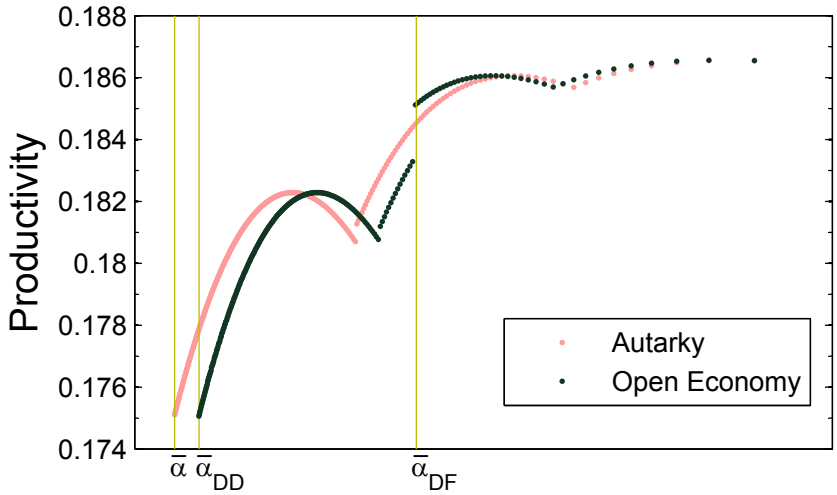


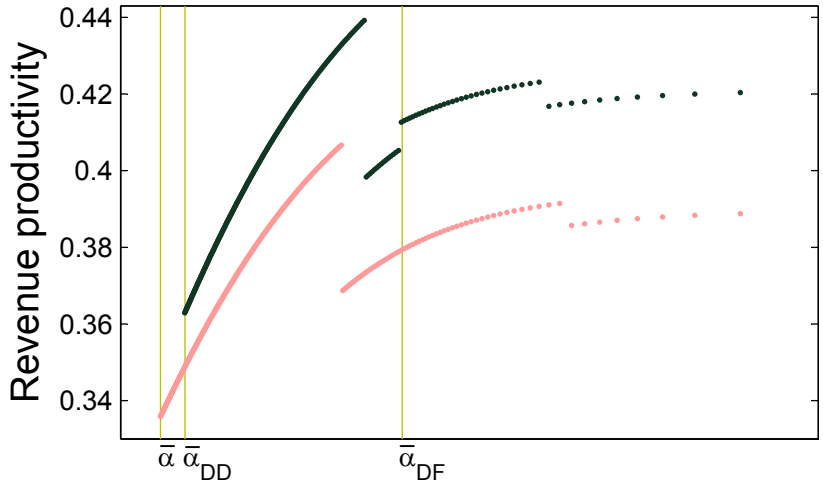


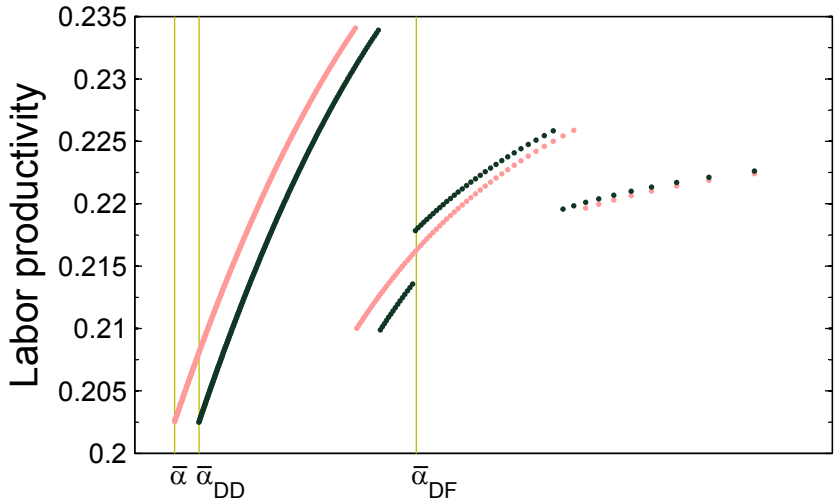
Other Measures of Productivity

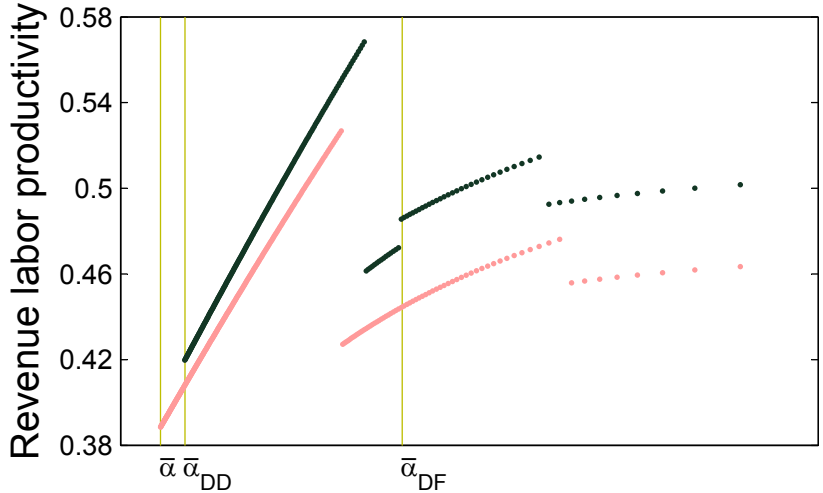
- We measure productivity by $q(\alpha) / C(\alpha; 1)$
- In many cases this is hard to do empirically, since neither the cost function nor prices are available
- So other measures are used in practice:
  - Revenue productivity: $r(\alpha) / C(\alpha; 1) = p(\alpha) q(\alpha) / C(\alpha; 1)$
  - Labor productivity: $q(\alpha) / n(\alpha)$ where $n(\alpha)$ is the total number of employees in the firm
    - ★ Does not include education or fixed costs
  - Revenue labor productivity: $r(\alpha) / n(\alpha)$
- These measures use progressively more easily available data

Other Measures of Productivity









▸ Table ▸ P Dist. ▸ LP Dist.

Conclusions

- We propose a theory where production requires organization
  - Choosing the number of distinct functions, the number of employees in each of them, as well as their skill
- Then, heterogeneity in demand leads to heterogeneity in productivity and other within-firm characteristics
  - Organization allows the firm to economize on knowledge thereby increasing its productivity
  - Organizational choices are discrete: The number of functions or layers
- Theory allows us to study a rich set of within firm implication on trade
  - In particular on within-firm wages, skill composition and productivity
  - The model can be calibrated or structurally estimated
  - Findings are consistent with the empirical literature

What next?

- Empirical studies guided by Caliendo and Rossi-Hansberg (2012)
- Do firms change wages, spans of control, and number of employees consistent with the theory?
  - *"The Anatomy of French Production Hierarchies"*, joint with Monte, and Rossi-Hansberg
- How large are the productivity effects of organizational changes?
  - *"Productivity and Organization in Portuguese Firms"*, joint with Mion, Opromolla, and Rossi-Hansberg

Positive Knowledge

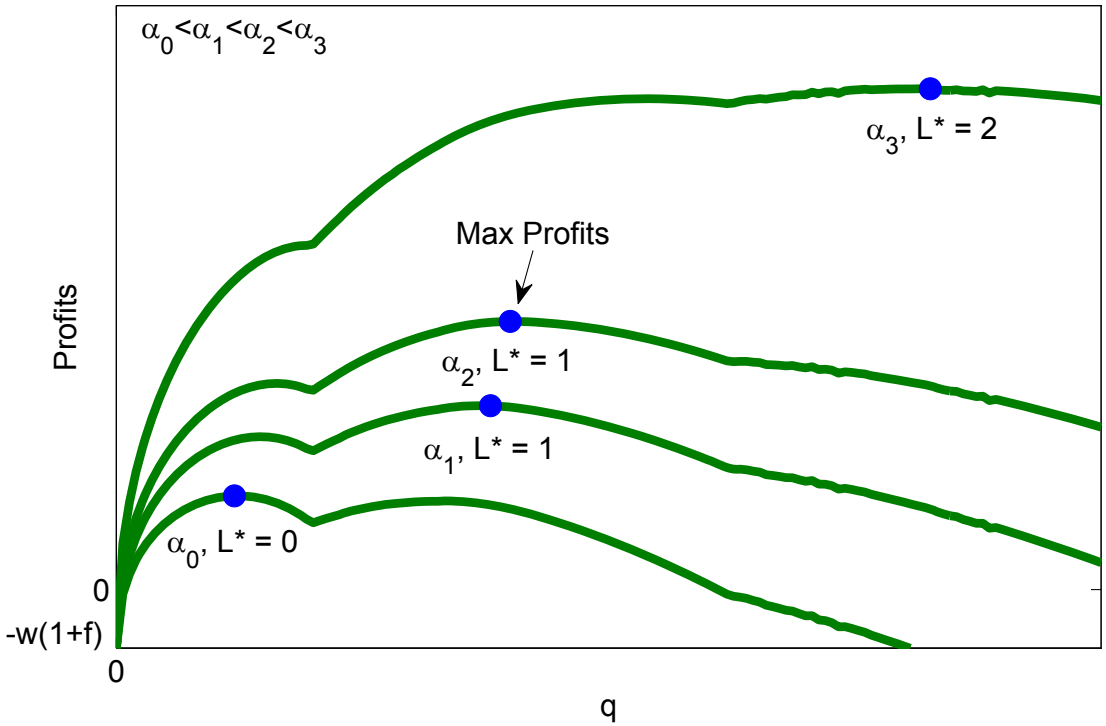
- In order to guarantee that $z_L^l(q) \geq 0$ for all q, l and L we need to impose a parameter restriction
  - If L is optimally chosen, $z_L^l(q) > 0$ for $l \neq \{0, L\}$ since there is no benefit of having that management layer
  - Still, without Assumption 1, it could be that $z_L^0(q) = 0$ for $L \geq 1$ and $z_L^L(q) = 0$ for $L \geq 2$, but $z_L^L(q) > 0$ if $z_L^0(q) > 0$
    - ★ In this case, results still apply but more cumbersome notation

Assumption 1 *The parameters* λ, c, *and* h *are such that* $\frac{c}{\lambda} \leq \frac{h}{1-h}$

Proposition 1 *Under Assumption 1, for all* $L \neq 1$ *and any output level* q, *the knowledge of agents at all layers is positive (*$z_L^l \geq 0$ *never binds)*

▸ Back

Profits



Proposition 9 *Given L, the profit function is strictly concave in q. Furthermore, $\pi(\alpha)$ is increasing and continuous in α*

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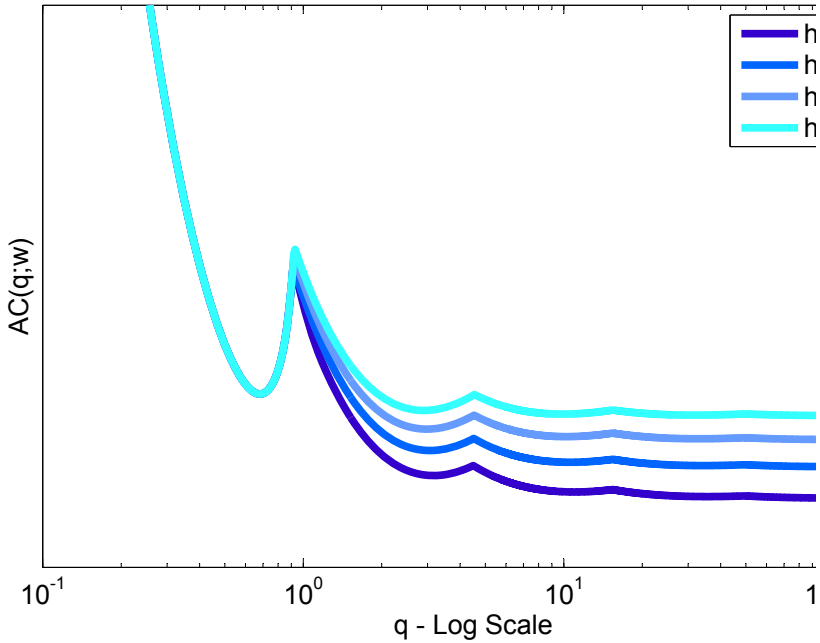
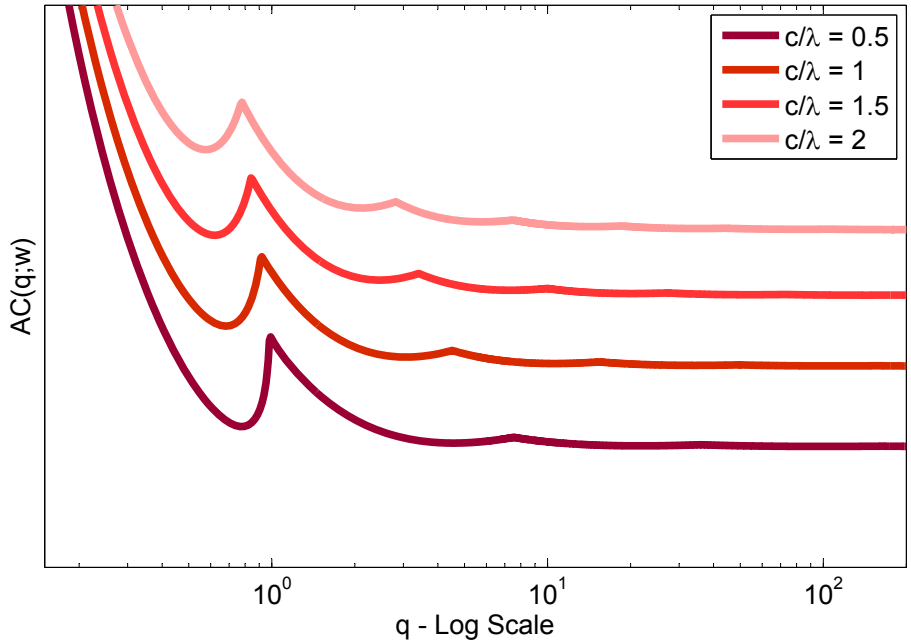
Effect of Communication and Learning Cost on AC(q;w)





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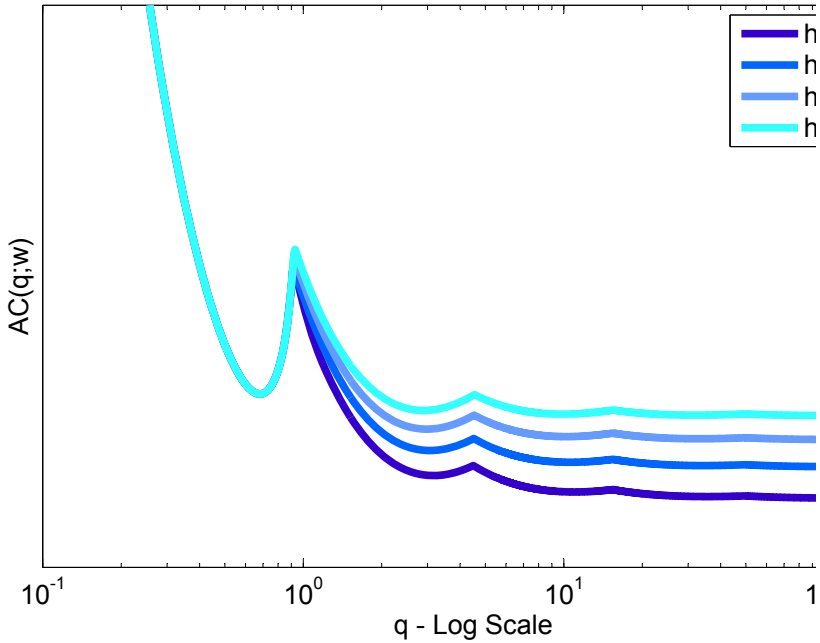

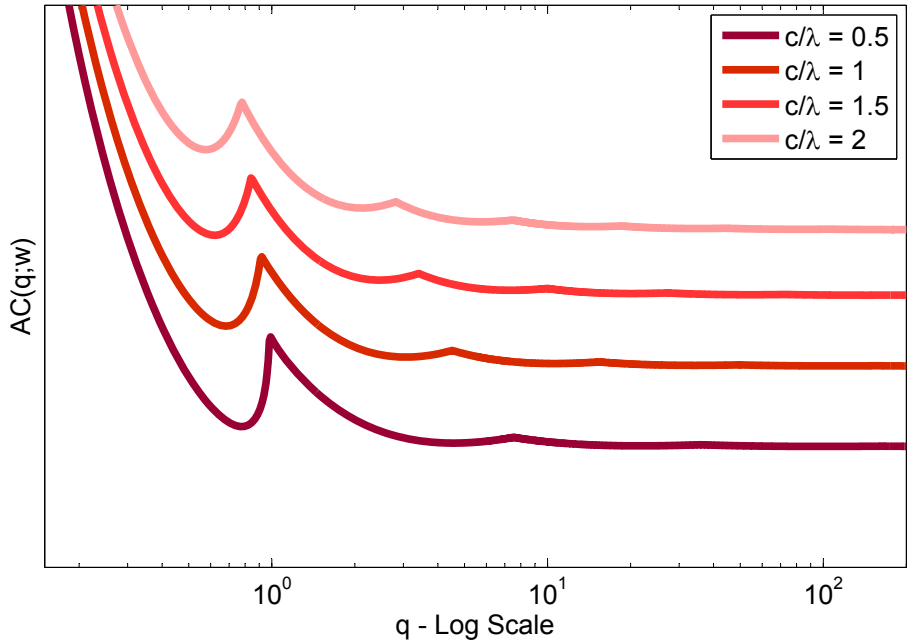

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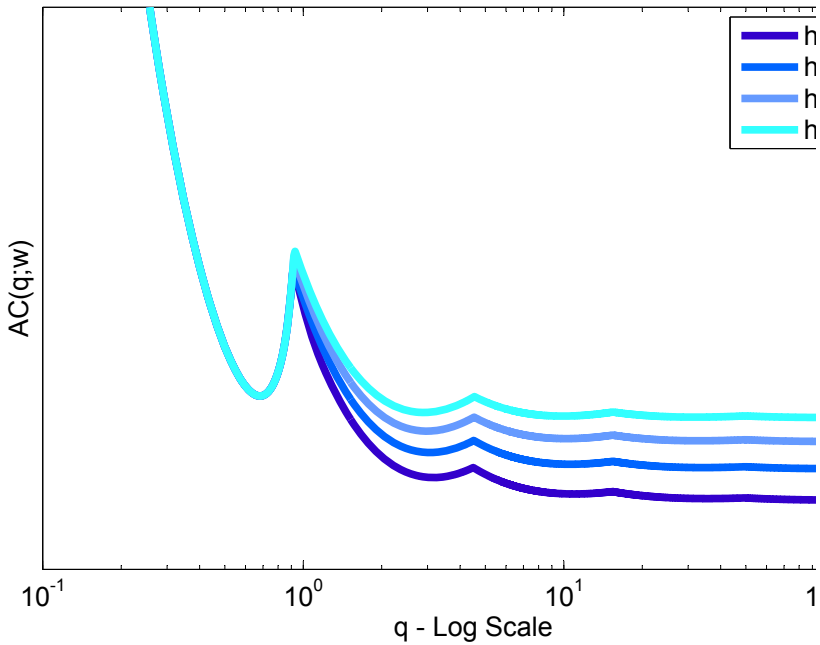

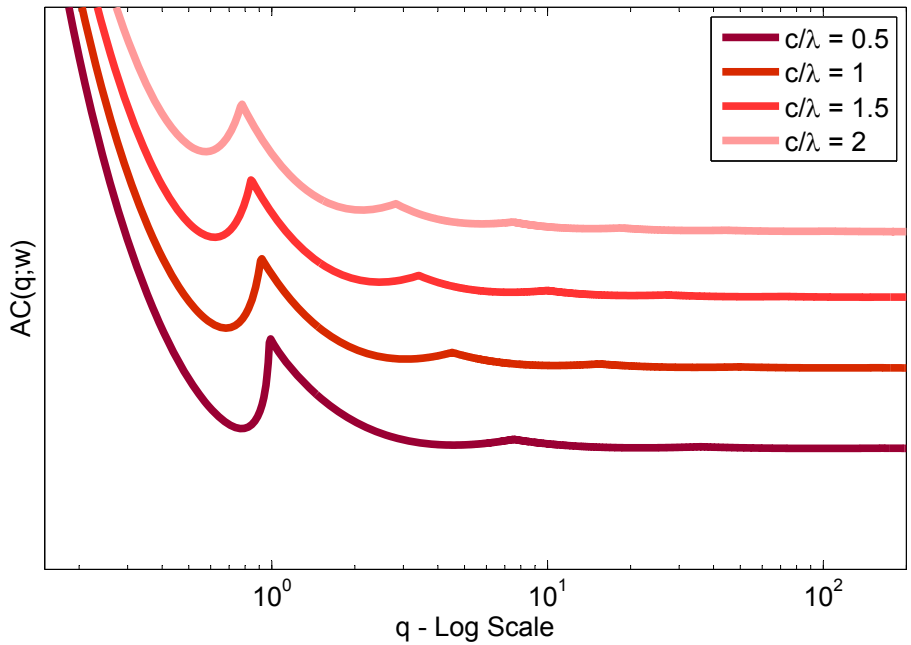

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Parameter Values

Calibrated Parameter values

Parameters	A	f^E	f_{ij}	γ	c/λ	h
Values	0.26	35.1	5.4	0.9	0.225	0.26

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Productivity Gains Relative to Autarky

	Productivity			Revenue productivity		
Weight	1	$n(\alpha)$	$q(\alpha)$	1	$n(\alpha)$	$q(\alpha)$
All firms	0.03%	0.30%	0.22%	8.16%	8.63%	8.47%
Exporters	0.10%	0.04%	0.05%	8.33%	8.22%	8.22%
Non-exporters	-0.08%	-0.18%	-0.21%	7.95%	7.87%	7.89%
Marginal firm		1.00%			1.82%	

	Labor productivity			Revenue labor productivity		
Weight	1	$n(\alpha)$	$q(\alpha)$	1	$n(\alpha)$	$q(\alpha)$
All firms	0.08%	0.35%	0.28%	8.21%	8.65%	8.53%
Exporters	0.33%	0.13%	0.13%	8.63%	8.30%	8.29%
Non-exporters	-0.03%	0.02%	0.08%	8.00%	8.10%	8.21%
Marginal firm		2.00%			2.83%	

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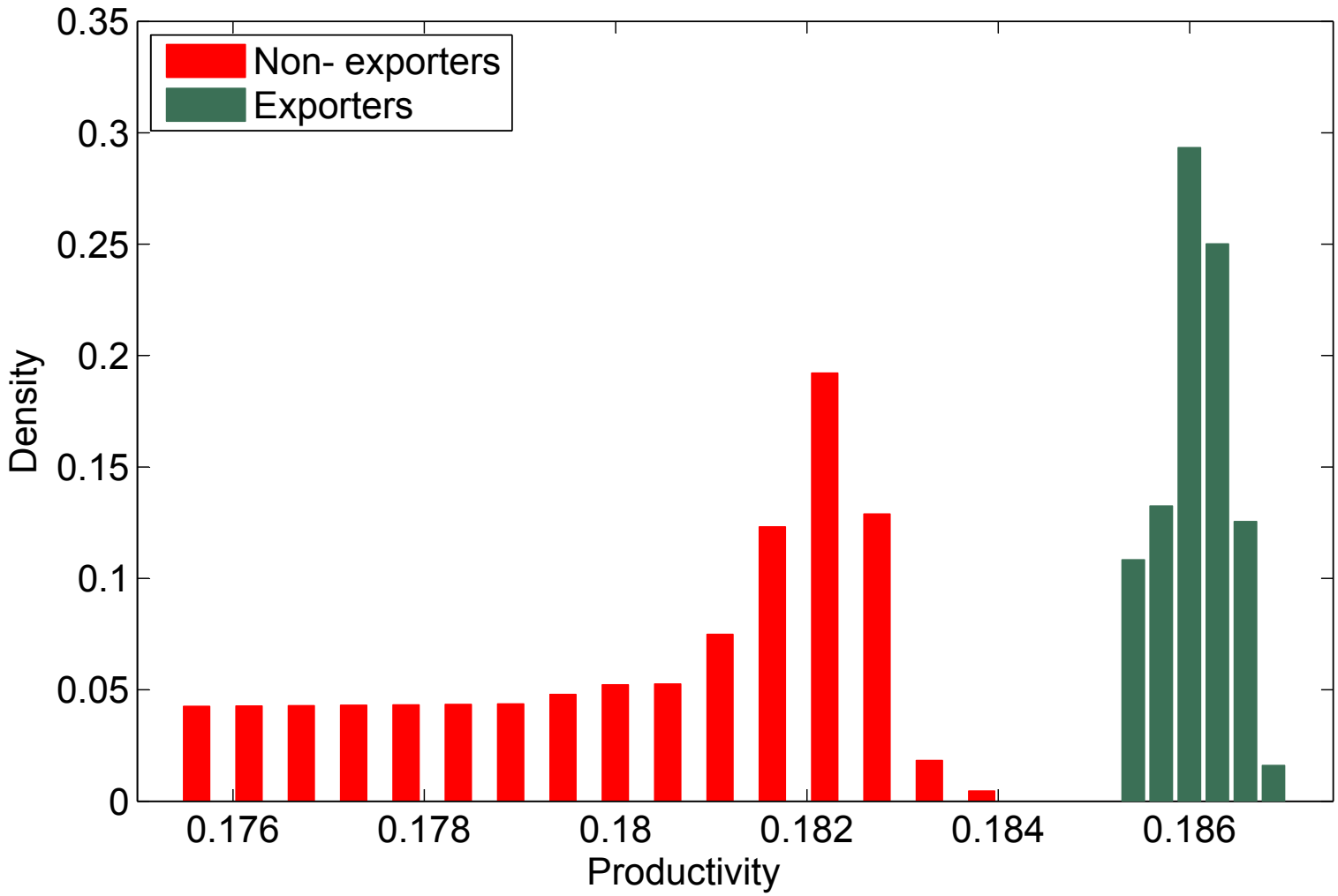
Productivity of Exporters and Non-exporters



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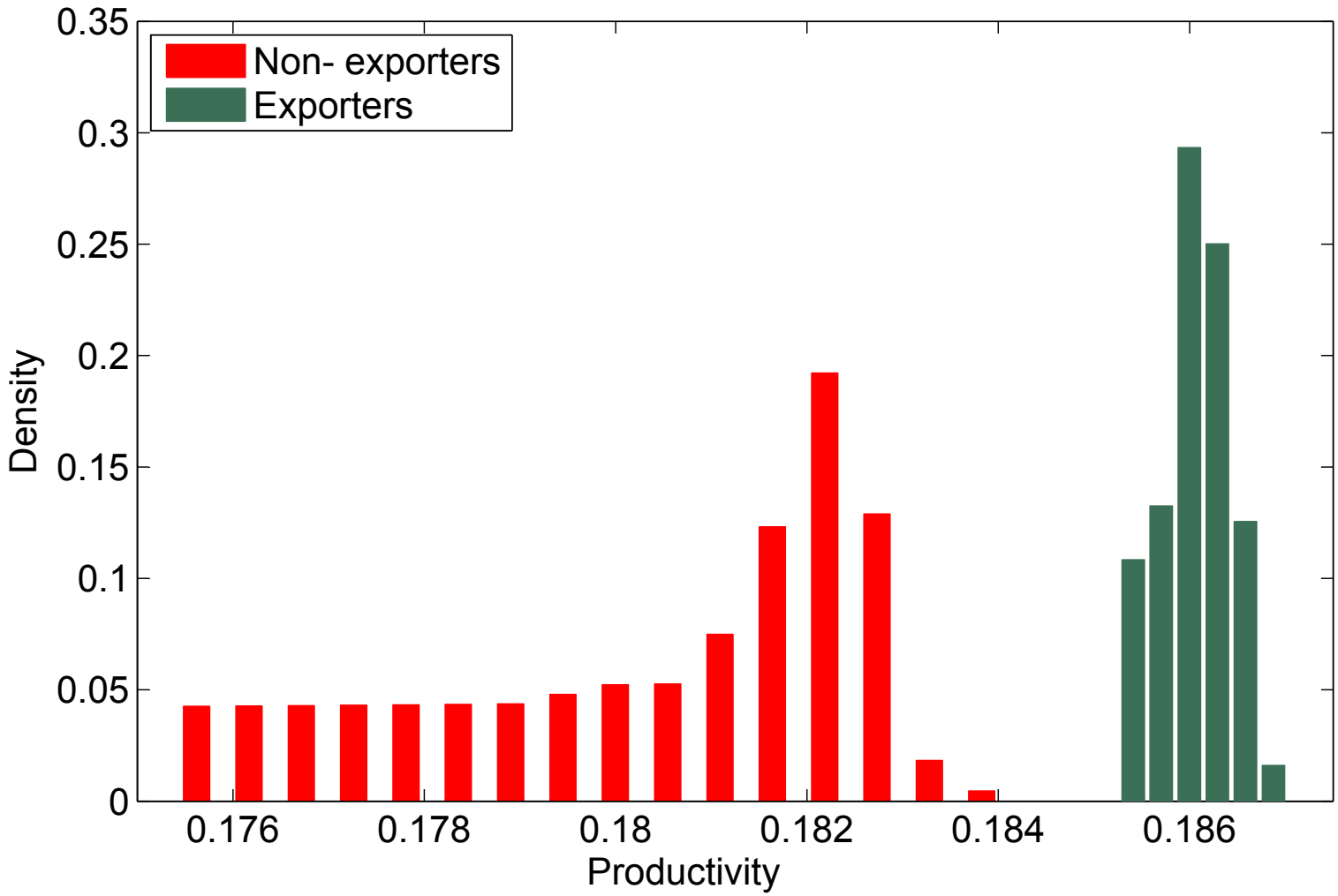
Productivity of Exporters and Non-exporters



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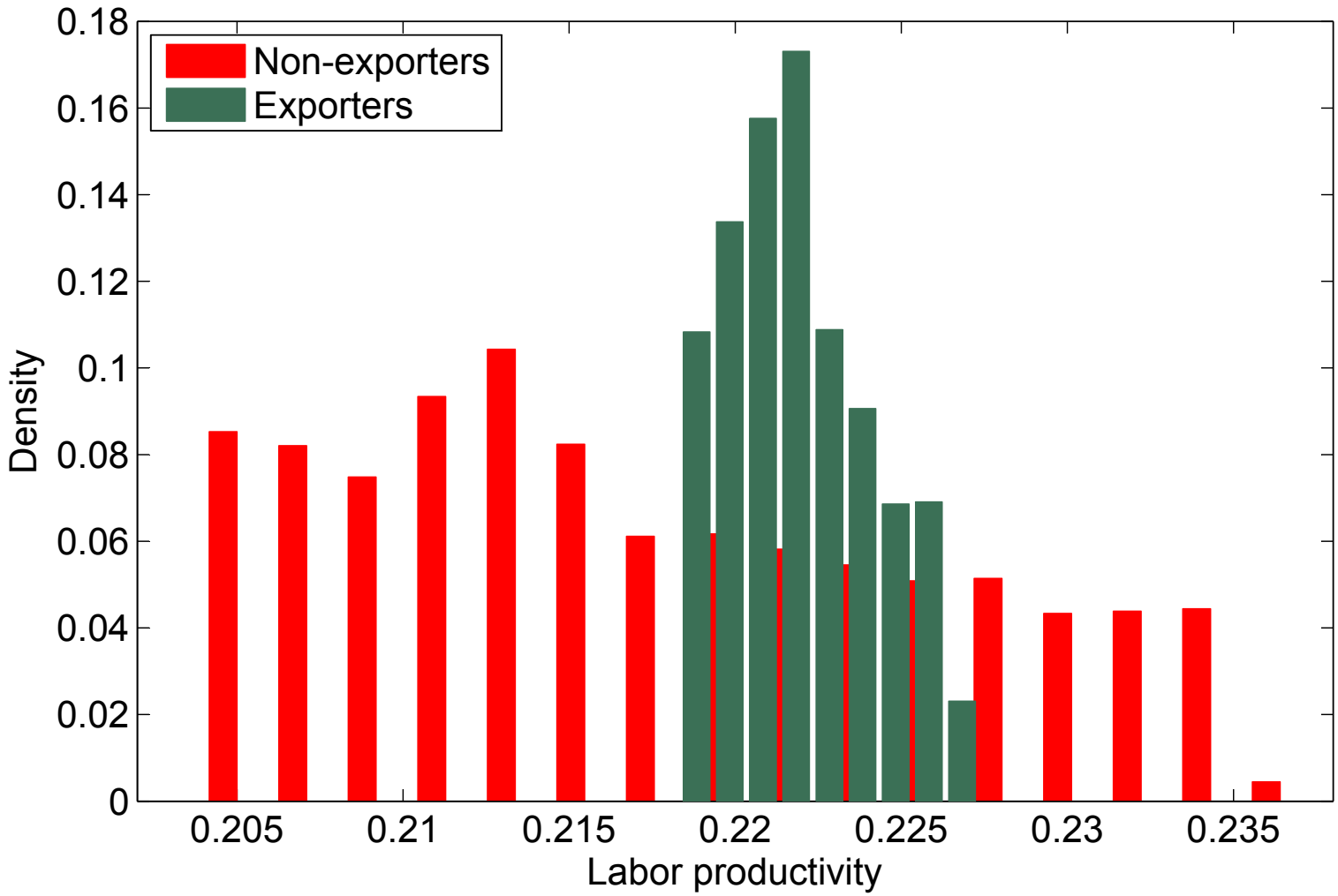
Labor Productivity of Exporters and Non-exporters



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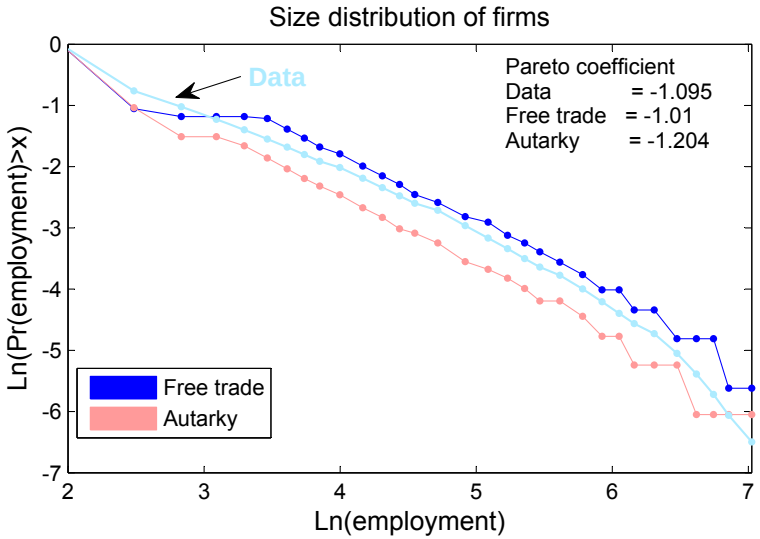
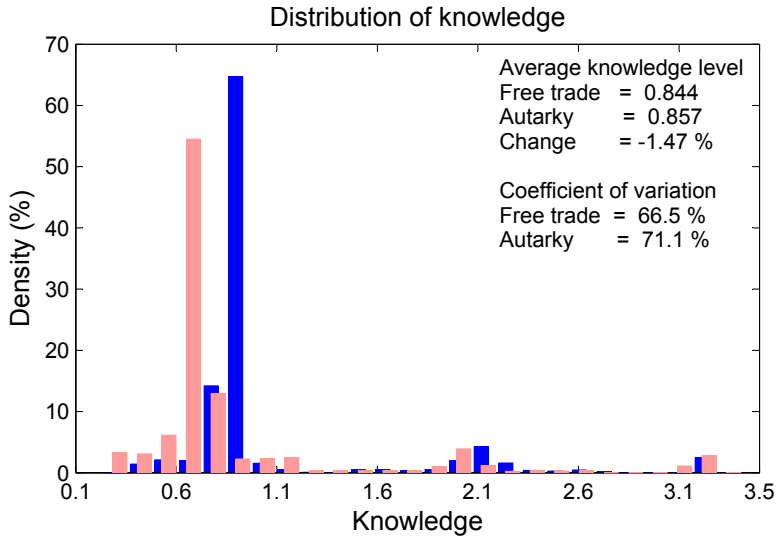
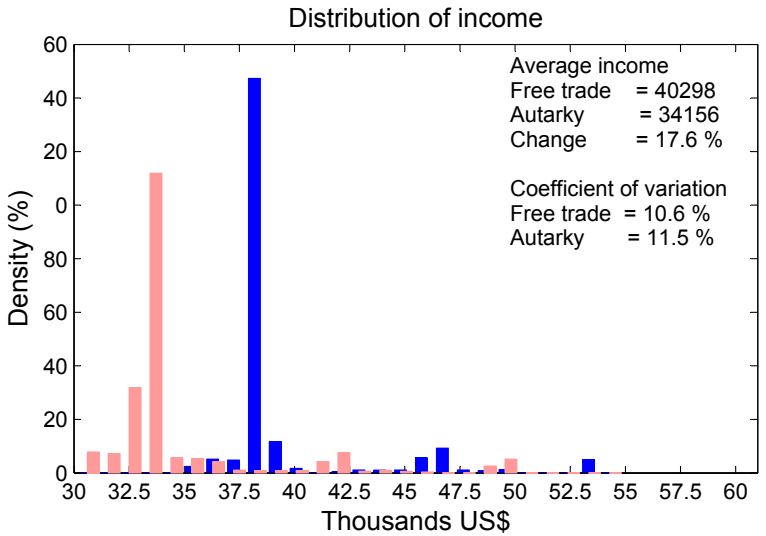
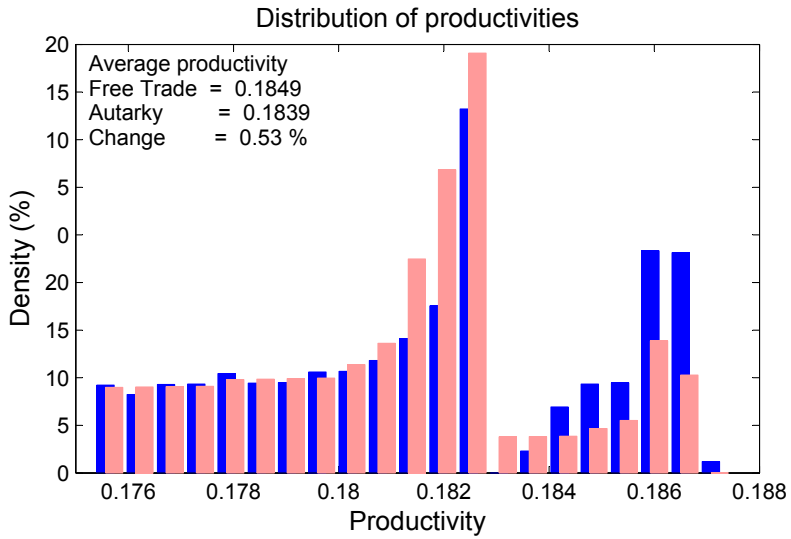
Changes in Distributions from Autarky to Free Trade









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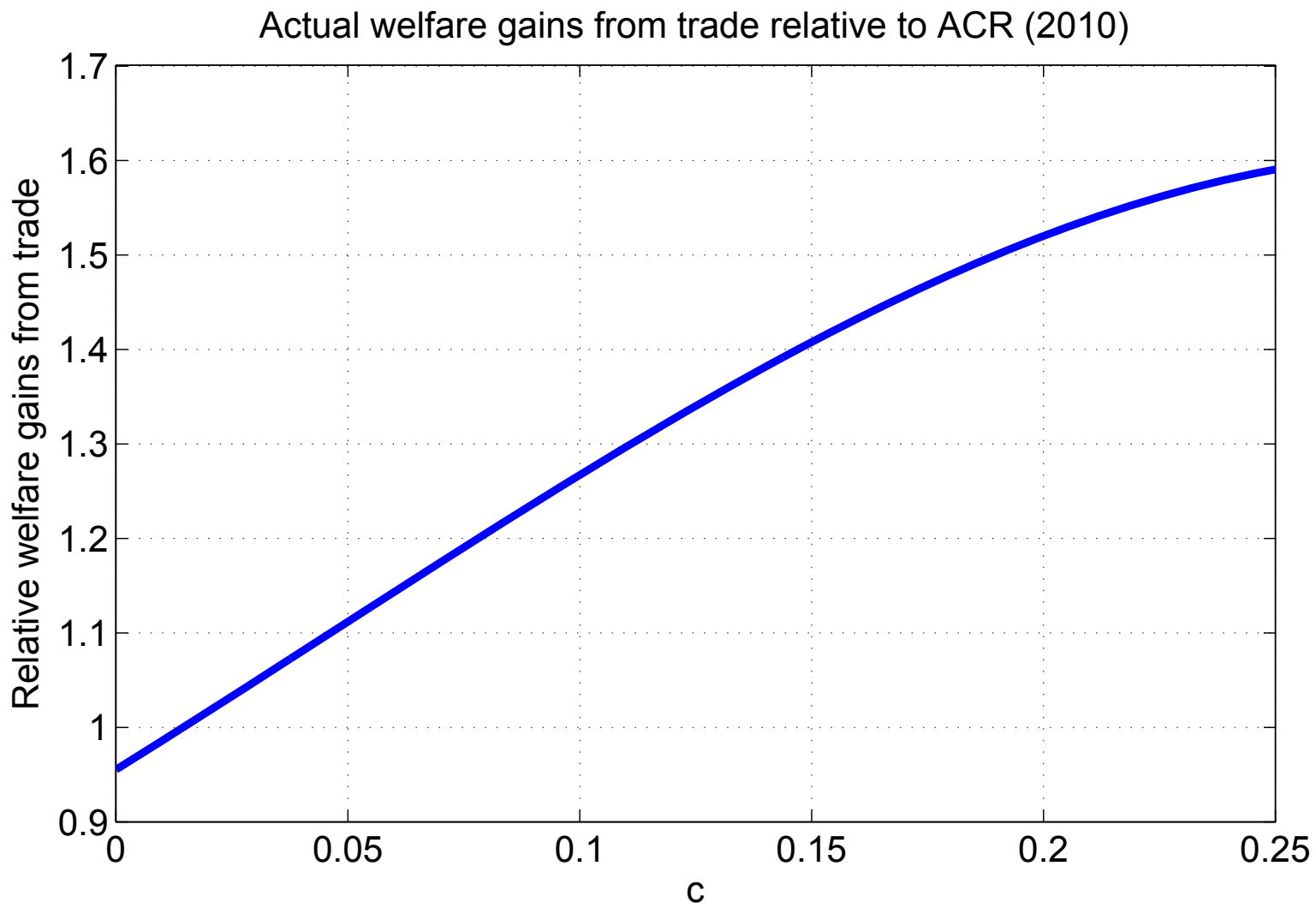
Welfare relative to Melitz



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Moments Data Source

- Share of firms that export: Bernard, et al. (2007)
- Average size of firms and size distribution of firms: 2002 Statistics of U.S. Businesses from the U.S. Census Bureau
- Share of education employees: Career Guide to Industries (CGI) from BLS Current Population Survey for 2008
  - CGI reports number of employees per occupations in different industries. We use the number reported for the Educational Services sector
- Total expenditure and share of expenditure on domestic goods: TRAINS database. We use data on imports from the manufacturing sector and gross production from the bundled sector

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