Commodity Exporters, Heterogeneous Importers, and the Terms of Trade

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Motivation

- Emerging markets are characterized by volatile consumption (e.g. Aguiar & Gopinath (2007): $\sim 3-4\%$)
  $\Longrightarrow$ **Natural question**: Which shocks explain this volatility?

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- In IRBC-models, aggregate productivity shocks explain 30-40% of consumption volatility
  $\Longrightarrow$ **But**: Little guidance on what these are.

- Recent literature stresses the importance of heterogeneous trade adjustment across firms
  - Adjustment at the firm-intensive ($\sim 95\%$) and firm-extensive margin ($\sim 5\%$) Fact 1
  - Adjustment both at firm-sub-extensive (($\sim 50\%$)) and at the firm-sub-intensive margin (($\sim 50\%$)) Fact 2
  - Bigger firms tend to adjust more on firm-sub-intensive margin Fact 3

  $\Longrightarrow$ Endogenous Δ TFP (e.g. Gopinath & Neiman (2014) $\sim 5.5\%$ for $\sim 70\%$ shock).

This paper

- **Question**: Does accounting for heterogeneous trade adjustment across firms increase the importance terms-of-trade shocks for consumption volatility relative to productivity shocks?

Literature

This paper

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- Tailored **SOE-IRBC framework** yields **three theoretical results**:
  1. Steady state of all the models can be solved in terms of "trade openness" H
  2. All models yield the same structural 1^{st}-order solutions, with different elasticities.
  3. Relative importance of ToT vs. TFP shocks is determined by the terms-of-trade elasticity, which differs across models

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- **Quantitative results** indicate that:
  - Conditional on structural parameters, terms-of-trade shocks are between 2-5 times more important.
  - Conditional on steady-state trade openness, different models deliver the same relative importance.

▸ Literature

Outline

- Theoretical Model
- Theoretical Results
- Quantitative exercise
- Conclusion

Theoretical Model

Sketch of the model

Insert Gopinath & Neiman (2014) in a basic SOE-IRBC structure:

- **Supply**: downstream services sector and upstream manufacturing sector
  - Manufacturing sector
    - Start with perfect competition roundabout benchmark ...
    - ... add monopolistic competition
    - ... add per-variety fixed costs of importing
    - ... add firm-level heterogeneity
  - Services is standard
- **Demand**: Representative household consumes final good, subject to imperfect international risk sharing
- **Shocks**: $A_{Dt}, A_{St}, P^{\$}_{Mt}, P^{\$}_{Xt}, \psi_t$

Theoretical Model - Manufacturing: Benchmark IRBC

- Homogenous firms solve cost minimization problem:

$$\min_{L_{St},Q_{Dt},Q_{Mt}} W_t L_{St} + P_{Dt} Q_{Dt} + P_{Mt} Q_{Mt}, \qquad \text{s.t.} \quad Y_{Dt} = \varphi A_{Dt} {L_{Dt}}^{1-\gamma} \left(\omega^{\frac{1}{\varepsilon}} {Q_{Dt}}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega)^{\frac{1}{\varepsilon}} {Q_{Mt}}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}\gamma}$$

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- Manufacturing firms compete under monopolistic competition;

$$P_{Dt} = \mathrm{MC}_{Dt}, \qquad \text{where} \qquad MC_{Dt} = \frac{1}{A_{Dt}} \frac{W_t^{1-\gamma} \left(\omega P_{Dt}^{1-\varepsilon} + (1-\omega) P_{Mt}^{1-\varepsilon} \right)^{\frac{\gamma}{1-\varepsilon}}}{(1-\gamma)^{1-\gamma} \gamma^{\gamma}}$$

Theoretical Model - Manufacturing: Adding monopolistic competition

- Homogenous firms solve profit maximization problem:

$$\max_{L_{Dt},Q_{Dt},Q_{Mt}} \Pi_t = \left(P_{Dt} - \mathrm{MC}_{Dt}\right) Y_{Dt}, \quad \text{s.t.} \quad Y_{Dt} = \varphi A_{Dt} L_{Dt}{}^{1-\gamma} \left(\omega^{\frac{1}{\varepsilon}} Q_{Dt}{}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega)^{\frac{1}{\varepsilon}} Q_{Mt}{}^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}\gamma}$$

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Theoretical Model - Manufacturing: Adding IRS to Importing

- Homogenous firms solve profit maximization problem:

$$\max_{L_{Dt}, Q_{Dt}, |\mathcal{L}_t|} \Pi_t = (P_{Dt} - \mathrm{MC}_{Dt})\, Y_{Dt} - f|\mathcal{L}_t|W_t, \quad \text{s.t.} \quad Y_{Dt} = \varphi A_{Dt} {L_{Dt}}^{1-\gamma} \left(\omega^{\frac{1}{\varepsilon}} {Q_{Dt}}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega)^{\frac{1}{\varepsilon}} Q_{Mt}\left(|\mathcal{L}_t|\right)^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}\gamma}$$

where $Q_{Mt} \equiv \left(\int_{k \in |\mathcal{L}_t|} {q_{Mkt}}^{\frac{\varepsilon-1}{\varepsilon}} dk \right)^{\frac{\varepsilon}{\varepsilon-1}}$

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Theoretical Model - Manufacturing: Adding firm heterogeneity

- Heterogenous firms solve profit maximization problem ($\varphi_i \sim \left(\frac{\varphi}{\varphi_i}\right)^{\kappa}$):

$$\max_{L_{Dit}, Q_{Dit}, |\mathcal{L}_{it}|} \Pi_{it} = (P_{Dit} - \mathrm{MC}_{Dit})\, Y_{Dit} - f|\mathcal{L}_{it}|W_t, \quad \text{s.t.} \quad Y_{Dit} = \varphi_i A_{Dt} L_{Dit}{}^{1-\gamma}\left(\omega^{\frac{1}{\varepsilon}} Q_{Dit}{}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega)^{\frac{1}{\varepsilon}} Q_{Mit}\left(|\mathcal{L}_{it}|\right)^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}\gamma}$$

where $Q_{Mit} \equiv \left(\int_{k\in|\mathcal{L}_{it}|} q_{Mikt}{}^{\frac{\varepsilon-1}{\varepsilon}} dk\right)^{\frac{\varepsilon}{\varepsilon-1}}$

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Theoretical Model - Services

- Homogenous producers in the services sector solve cost minimization problem:

$$\min_{L_{St},X_{st}} W_t L_{St} + P_{Dt} X_{Dt}, \qquad \text{s.t.} \quad Y_{St} = A_{St} {L_{St}}^{1-\mu} X_{St}^{\mu}, \quad \text{where} \quad X_{St} = \left(\int_i X_{Sit}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}},$$

- Services producers compete under perfect competition:

$$P_{St} = \text{MC}_{St}, \qquad \text{where} \qquad MC_{St} = \frac{1}{A_{st}} \frac{W_t^{1-\mu} P_{Dt}^{\mu}}{(1-\mu)^{1-\mu} \mu^{\mu}}$$

Theoretical Model - Demand and Market Clearing

- **Demand**: Homogeneous households with the ability to share risk internationally through B_t:

$$\max_{\{C_{St}\}_{t=0}^{\infty}} U = \sum_{t=0}^{\infty} \beta^t \ln C_{St}, \qquad \text{s.t.} \quad \frac{B_{t+1}}{R_t} - B_t = E_t P_{Xt}^{\$} X + W_t L - C_{St}, \quad \lim_{j\to\infty} \mathbb{E}_t \left[\frac{B_{t+j+1}}{\prod_{s=0}^{j} R_{t+s}} \right] \geq 0$$

$$R_t = R^{\$} + \chi_2 \left(e^{-(b_{t+1}-\bar{b})} - 1 \right) + \chi_1 \left(e^{\psi_t} - 1 \right)$$

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- Households supply labor exogenously (can be relaxed) and labor markets clear:

$$L = L_{St} + \int_i \left(L_{Dit} + L_{Mit} \right) di$$

- Goods markets clear:

$$Y_{St} = C_{St}, \qquad Y_{Dit} = \left(\frac{P_{it}}{P_{Dt}} \right)^{-\sigma} \left(X_{St} + Q_{Dt} \right)$$

Theoretical Results

Theoretical Result 1 - Zero-debt steady state solution

All models can be solved in terms of **trade openess** H_t, defined implicitly from:

$$\frac{B_{t+1}}{R_t} - B_t = \underbrace{E_t P^{\$}_{Xt} X}_{\text{Exports}} + \underbrace{W_t \int_i \left(L_{Sit} + L_{Mit} + L_{Dit}\right) di + \int_i \Pi_{it} di - C_{St}}_{\text{Imports}}$$

$$= E_t P^{\$}_{Xt} X - \mu\gamma \frac{\sigma - 1}{\sigma} \cdot \underbrace{H_t}_{\text{Import-to-consumption}} \cdot C_{St}$$

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Proposition (Steady-state equilibrium)

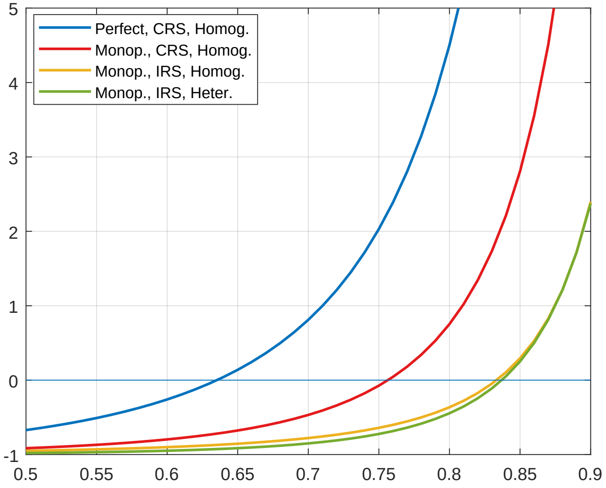
In each model, zero debt steady-state equilibrium is represented by one non-linear equation in H_t:

$$F_m\left(H\left(\Theta\right); \Theta\right) = 1, \qquad \forall m \in \{PC, MC, IRS, Het\}$$

The steady-state equilibrium is unique for the following models: (1) perfectly competitive benchmark; (2) monopolistic competition model; (3) increasing returns to importing model.

Theoretical Result 1 - Zero-debt steady state solution

Figure 1: Steady state H equation for different models



Theoretical Result 2 - Goods and labor markets equilibrium

Theorem (General Structure)

In each model, goods and labor market clearing imply:

$$c_{St} = \frac{\mu}{1-\gamma} a_{Dt} + a_{St} + \nu_{cH}\left(H_m;\Theta\right)\eta_t$$

$$\eta_t = \frac{1}{\nu_{qH}\left(H_m;\Theta\right)}\left(\frac{1-\mu}{1-\gamma} a_{Dt} - a_{St} + p_{Mt}^{\$} + q_t\right)$$

where $q_t \equiv e_t - p_{St}$ *is the real exchange rate and* $\eta_t \equiv \frac{H_t - H}{H}$. *Also,* $\nu_{cH}\left(H_m;\Theta\right) > 0$ *and* $\nu_{qH}\left(H_m;\Theta\right) < 0$.

Theoretical Result 3 - Relative Importance of ToT

Proposition (Terms-of-trade relative to TFP)

Under

- *Financial autarky*

the relative importance of ToT to TFP shocks in the volatility of consumption:

$$\frac{\mathbb{V}\left(c_{St} | p^{\$}_{Mt}, p^{\$}_{Xt}\right)}{\mathbb{V}\left(c_{St} | a_{Dt}, p_{St}\right)} = \frac{\sigma_X^2}{\sigma_A^2} \frac{\left(\nu_c\left(H_m;\Theta\right)\right)^2}{\frac{\sigma_S^2}{\sigma_D^2} + \left(\frac{\mu - \nu_c(H_m;\Theta)}{1-\gamma}\right)^2}, \qquad \textit{where} \quad \frac{\partial \frac{\mathbb{V}\left(c_{St}|p^{\$}_{Mt}, p^{\$}_{Xt}\right)}{\mathbb{V}\left(c_{St}|a_{Dt}, p_{St}\right)}}{\partial \nu_c\left(H_m;\Theta\right)} > 0$$

where and σ_D^2, σ_S^2, σ_X^2 and σ_M^2 are the variances of the shock processes.

Theoretical Result 3 - Relative Importance of ToT

Proposition (Terms-of-trade relative to TFP)

Under

- *Financial autarky*
- *Integrated and segmented financial markets (e.g. Itskhoki & Mukhin (2021)) with* $\rho_D, \rho_X, \rho_M \to \infty$

the relative importance of ToT to TFP shocks in the volatility of consumption growth:

$$\frac{\mathbb{V}\left(\Delta c_{St} | p_{Mt}^{\$}, p_{Xt}^{\$}\right)}{\mathbb{V}\left(\Delta c_{St} | a_{Dt}, p_{St}\right)} = \frac{\sigma_{\varepsilon,X}^2}{\sigma_{\varepsilon,A}^2} \frac{\left(\nu_c\left(H_m;\Theta\right)\right)^2}{\frac{\sigma_{\varepsilon,S}^2}{\sigma_{\varepsilon,D}^2} + \left(\frac{\mu-\nu_c(H_m;\Theta)}{1-\gamma}\right)^2}, \qquad \textit{where} \quad \frac{\partial \frac{\mathbb{V}\left(\Delta c_{St}|p_{Mt}^{\$},p_{Xt}^{\$}\right)}{\mathbb{V}\left(\Delta c_{St}|a_{Dt},p_{St}\right)}}{\partial \nu_c\left(H_m;\Theta\right)} > 0$$

where and $\sigma_{\varepsilon,D}^2$, $\sigma_{\varepsilon,S}^2$, ${}^2_{\varepsilon,X}$ *and* ${}^2_{\varepsilon,M}$ *are the variances of the innovations to the shock processes.*

Explaining the terms-of-trade elasticity

Proposition (Terms-of-trade elasticity ν_c)

The general equilibrium elasticity ν_c has the following common structure across frameworks.

$$\nu_c^m\left(H^m(\Theta);\tilde{\Theta}\right) = \underbrace{\mu\gamma H^m(\Theta)}_{\text{Trade openness}} \cdot \underbrace{\Lambda^m\left(H^m(\Theta),\tilde{\Theta}\right)}_{\text{Distortion}}$$

where $\Lambda^m(\cdot) = 1$ in perfect competition benchmark model.

Quantitative Excercise

Heterogeneous Trade Adjustment

- Firm-level import distribution is Generalized Pareto ▸ Lemma ▸ Data vs model
- Firm extensive is dominated by firm intensive margin ▸ Lemma
- Firm sub-intensive vs. Firm sub-extensive margin rises with firm size ▸ Data vs model
- Endogenous TFP movements in response to terms-of-trade shocks ▸ Aggregate Production Function

▸ Calibration

Quantitative excercise

Table 1: TOT relative to TFP

Model	H^m	$\nu_c^m\left(H,\tilde{\Theta}\right)$	H^m/H^{PC}	$\Lambda^m(H,\Theta)$	$\frac{\mathbb{V}\left(c_{St}\vert p^{\$}_{Mt},p^{\$}_{Xt}\right)}{\mathbb{V}\left(c_{St}\vert a_{Dt},p_{St}\right)}$
PANEL A: CONDITIONAL ON Θ					
Perfect competition	0.652	0.1695	1	1	[0.0201; 0.0662]
Monopolistic competition	0.794	0.1995	1.217	0.967	[0.0300; 0.121]
IRS	0.926	0.2401	1.420	0.997	[0.0477; 0.276]
Complete model	0.929	0.2425	1.425	1.004	[0.0489; 0.290]
PANEL B: CONDITIONAL ON $H^m(\Theta)$					
Perfect competition	0.929	0.2416	1	1	[0.0484; 0.285]
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Conclusion

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- We study the relative importance of terms-of-trade shocks in explaining consumption volatility
- We develop a framework to evaluate the role of accounting for heterogeneous trade adjustment across firms
- **Short answer**: Does not really matter...
  - Conditional on the same structural parameters, accounting for heterogeneous trade adjustment increases rel. importance of terms-of-trade shocks by ~ 2 to ~ 5
  - Conditional on trade openness, the predictions of the models do not differ anymore

APPENDIX

Related literature - ▸ Back

- **IRBC and real shocks**:
  - (NON-)STATIONARY PRODUCTIVITY SHOCKS: Kydland & Zarazaga (2002), Aguiar & Gopinath (2007) and García-Cicco et al. (2010)
  - TERMS-OF-TRADE SHOCKS: Mendoza (1995), Kose (2002), Drechsel & Tenreyro (2018), Fernández et al. (2018) and Kohn et al. (2021)

  $\Longrightarrow$ Insert model of heterogeneous trade adjustment

- **Heterogeneous trade adjustment**: Amiti & Konings (2007), Gopinath & Neiman (2014) and Halpern et al. (2015)

  $\Longrightarrow$ Relative importance of shocks in explaining consumption volatility

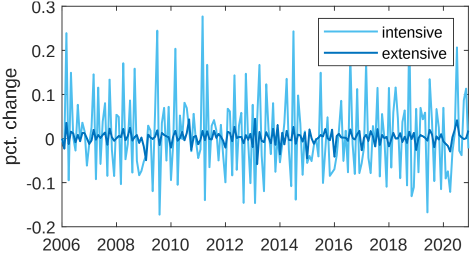
- **Trade openness and volatility**: Koren & Tenreyro (2007), Giovanni & Levchenko (2009) and Caselli et al. (2020)

  $\Longrightarrow$ Theoretically-founded measure of openness

Stylized fact 1: Firm-intensive margin dominates - Back

$$\underbrace{\frac{\Delta m_t}{m_{t-1}}}_{\Delta \text{ Aggregate Imports}} = \underbrace{\sum_{i \in \Omega_t^f \cap \Omega_{t-1}^f} \frac{m_{it} - m_{it-1}}{m_{t-1}}}_{\text{Firm-intensive margin}} + \underbrace{\sum_{i \in \Omega_t^f \setminus \Omega_{t-1}^f} \frac{m_{it}}{m_{t-1}} - \sum_{i \in \Omega_{t-1} \setminus \Omega_t^f} \frac{m_{it-1}}{m_{t-1}}}_{\text{Firm-extensive margin}}$$

(a) Firm-Intensive vs Firm-Extensive



Muted extensive margin

Lemma

Following the assumptions of the model with increasing returns to scale and selection, the dollar amount imported by firm i, $M^{\$}_{it}$, can be written as the product of the fixed costs of importing and the firm-specific import measure.

$$E_t M^{\$}_t(\varphi) = (\varepsilon - 1) W_t f \mathcal{L}_t(\varphi)$$

Applying Leibniz-rule and using $\mathcal{L}_t(\varphi_{Mt}) = 0$:

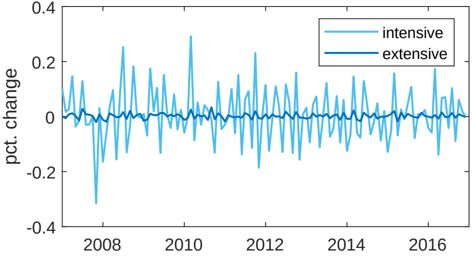
$$-\frac{\partial \ln M_t}{\partial \ln x_t} = -\frac{x_t}{M_t}\left[\underbrace{\int_{\varphi_{Mt}}^{\infty} \frac{\partial}{\partial x_t} \tilde{M}_t \mathcal{L}_t(\varphi) dG(\varphi)}_{\text{Intensive}} - \underbrace{\tilde{M}_t \mathcal{L}_t(\varphi_{Mt}) \frac{\partial}{\partial x_t} \varphi_{Mt}}_{\text{Extensive}}\right]$$

Back

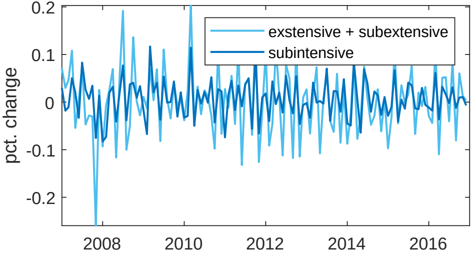
Stylized fact 2: Firm-adjustment - Back

$$\underbrace{\frac{\Delta m_t}{m_{t-1}}}_{\Delta \text{ Aggregate Imports}} = \underbrace{\sum_{i\in\Omega^f_t\setminus\Omega^f_{t-1}} \frac{m_{it}}{m_{t-1}} - \sum_{i\in\Omega_{t-1}\setminus\Omega^f_t} \frac{m_{it-1}}{m_{t-1}}}_{\text{Firm-extensive margin}} + \underbrace{\sum_{i\in\Omega^f_t\cap\Omega^f_{t-1}} \left[\underbrace{\sum_{j\in\Omega^p_{it}\setminus\Omega^p_{it-1}} \frac{m_{ijt}}{m_{it-1}} - \sum_{j\in\Omega^p_{it-1}\setminus\Omega^p_{it}} \frac{m_{ijt-1}}{m_{it-1}}}_{\text{Firm sub-extensive firm}} + \underbrace{\sum_{j\in\Omega^p_{it}\cap\Omega^p_{it-1}} \frac{m_{ijt}-m_{ijt-1}}{m_{t-1}}}_{\text{Firm sub-intensive firm}} \right]}_{\text{Firm-intensive margin}}$$

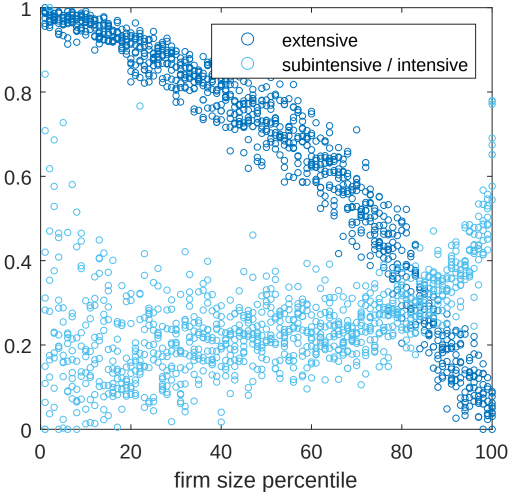
(a) Firm-Intensive vs Firm-Extensive



(b) Firm sub-Intensive vs Firm (Sub)-Extensive



Stylized fact 3: Firm sub-intensive(φ) vs. Firm sub-extensive(φ) - Back



Generalized Pareto distribution of Imports

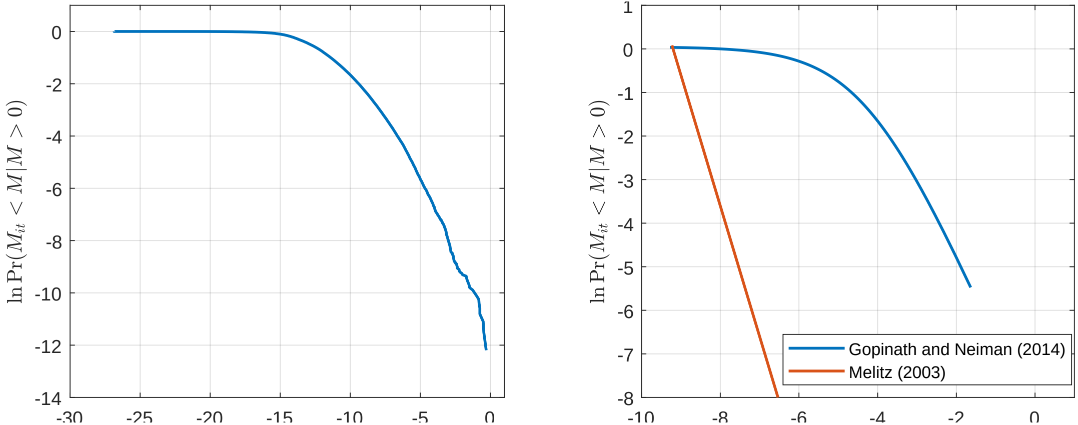
Proposition

The distribution of firm imports conditional on importing is Generalized Pareto as follows.

$$\Pr\left(M^{\$}_{it} < M | M > 0\right) = 1 - \left[1 + \frac{1}{\varepsilon - 1}\frac{E_t}{W_t f}\frac{1-\omega}{\omega}\left(\frac{P_{Dt}}{E_t P^{\$}_{Mit}}\right)^{\varepsilon - 1} M\right]^{-\kappa\frac{\varepsilon-1-\gamma(\sigma-1)}{(\sigma-1)(\varepsilon-1)}}$$

Generalized Pareto distribution of Imports - ctd. - ▸ Back

Figure 4: Power Law for Imports

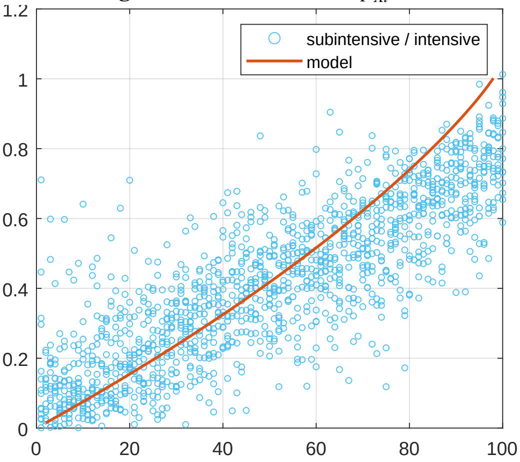


▸ Back

Slope of the Firm sub-intensive vs Firm sub-extensive margin - Back quad

Back

Figure 5: Conditional on a $p^{\$}_{Xt}$ shock



Endogenous TFP movements

$$Y_{Dt} = \underbrace{A_{Dt}}_{\text{Technology}} \underbrace{{L_{Dt}}^{1-\gamma} {X_{Dt}}^{1-\gamma}}_{\text{Input and factor use}} \underbrace{\left[\int_{\underline{\varphi}}^{\infty} \left(\varphi_i \left(\frac{L_{Dt}(\varphi)}{L_{Dt}} \right)^{1-\gamma} \left(\frac{X_{Dt}(\varphi)}{X_{Dt}} \right)^{\gamma} \right)^{\frac{\sigma-1}{\sigma}} d(\varphi) \right]^{\frac{\sigma}{\sigma-1}}}_{\text{Allocative efficiency}}$$

▸ Back

Calibration - Back

Table 2: Calibration of main parameters

Manufacturing sector			*Services sector*		
Parameter	Value	Reference	Parameter	Value	Reference
γ	0.65	Country IO-tables	μ	0.40	Country IO-tables
ω	0.50	Gopinath & Neiman (2014)	σ	3.00	Gopinath & Neiman (2014)
ε	3.00	Gopinath & Neiman (2014)	*Intertemporal paramters*		
θ	3.00	Restriction	β	0.98	Kohn et al. (2021)
$\underline{\varphi}$	1.00	Melitz & Redding (2015)	χ_1	1	Kohn et al. (2021)
κ	6.95	Estimation	χ_2	0.001	Kohn et al. (2021)
f	0.05	Blaum et al. (2018)	$\bar{b}$	0	Itskhoki & Mukhin (2021)

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