Firm Distribution

Ping Wang
Department of Economics
Washington University in St. Louis

April 2024

A. Introduction

Conventional macroeconomic models employ aggregate production at national or industrial level, ignoring the interplays between firm dynamics, growth and cycles.

- **Foundation:**
  - **Jovanovic (1979), Hopenhayn (1992): firm dynamics (entry and exit)**
  - **Mortensen-Pissarides (1994): job creation and job destruction**
- **Firm distribution, productivity and trade:**
  - **Basics: Eaton-Kortum (1999, 2002), *Bernard-Eaton-Jensen-Kortum (2003)*, *Melitz (2003)*, *Arkolakis, Costinot & Rodríguez-Clare (2012)***
  - **Generalization: Alvareza-Lucas (2007), Matsuyama (2007), Atkeson-Burstein (2008), Burstein-Melitz (2015), Riezman-Hsu-Wang-Yang (2022)**
- **Firm distribution, innovation and growth**
  - **Basic theory: Klette-Kortum (2004), *Ghironi,-Melitz (2005)***
  - **Generalization: Luttmer(2007), Impullitti-Licandro (2017), Buera-Oberfield (2020), Cai-Li-Santacreu (2022), Chen-Hsu-Peng-Wang (2023)**
- **Firm distortions, misallocation and productivity: Rustucia-Rogerson (2008), *Hsieh-Klenow (2009)*, Hopenhyne (2013), Adamopoulos-Restuccia (2014), Asker Collard-Wexler De Loecker (2014), Jovanovic (2014), David-Hopenhayn-Venkateswaran (2016), Uras-Wang (2016), Hsieh-Hurst-Jones-Klenow (2019), *Lise-Robin (2017)*, Deng-Tang-Wang-Wu (2022), Elsby (2023)**

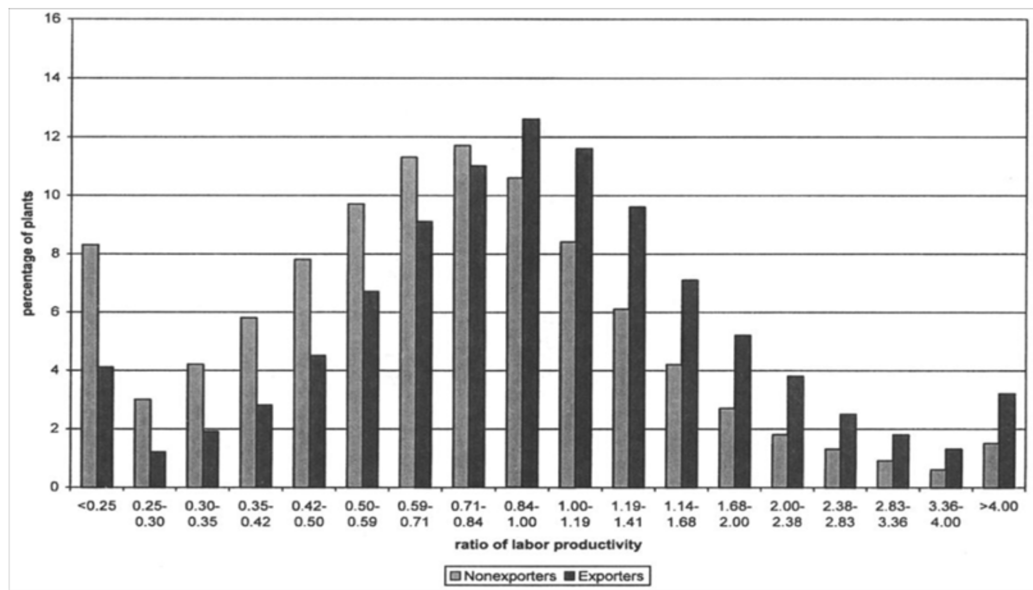
B. Empirical Regularities: Bernard-Eaton-Jensen-Kortum (2003)

BEJK highlight 5 important stylized facts based on U.S, Census of Manufacturers:

- **(S0-a) large plant productivity dispersion**
- **(S0-b) low export intensity**
- **(S1) low earning from exporting**
- **(S2) higher productivity among exporters**
- **(S3) larger size of exporters (measured by value of sales)**

(S0) helps guide model setting (long tail distribution and ability and cost to export), while (S1)-(S3) are to be explained by the model

Export status	Percentage of all plants
No exports	79
Some exports	21
Export intensity of exporters (percent)	**Percentage of exporting plants**
0 to 10	66
10 to 20	16
20 to 30	7.7
30 to 40	4.4
40 to 50	2.4
50 to 60	1.5
60 to 70	1.0
70 to 80	0.6
80 to 90	0.5
90 to 100	0.7

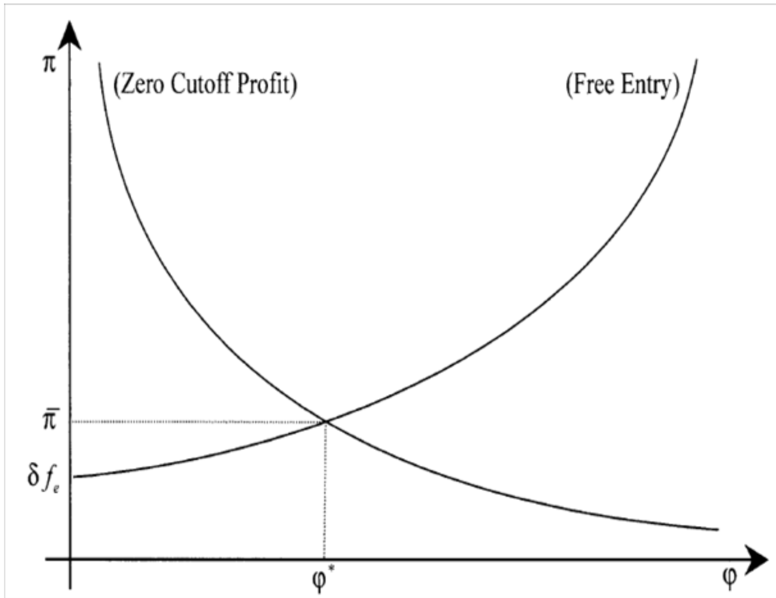


C. Firm Distribution, Productivity and Trade: Melitz (2003)

- **Key: introduce trade to the Hopenhayn (1992) firm entry-exit model under a Spence (1976) and Dixit-Stiglitz (1977) monopolistic competition framework with endogenously determined number of varieties**
- **Preference for variety:** $U = \left[\int_{\omega\in\Omega} q(\omega)^{\rho} d\omega\right]^{1/\rho}$**, with elasticity =** $\sigma = 1/(1-\rho) > 1$
- **Monopolistic pricing:** $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$**, with markup =** $\sigma/(\sigma-1) = 1/\rho$
- **Consumption and expenditure:**
  - **consumption:** $q(\omega) = Q\left[\frac{p(\omega)}{P}\right]^{-\sigma}$**, where Q = U**
  - **expenditure:** $r(\omega) = R\left[\frac{p(\omega)}{P}\right]^{1-\sigma}$**, where** $R = PQ = \int_{\omega\in\Omega} r(\omega) d\omega$
- **Labor demand:** $l = f + q/\varphi$ **(Krugman 1980)**
  - **identical fixed cost *f***
  - **different productivity φ**
- **Pricing and profit:** $p(\varphi) = \frac{w}{\rho\varphi}$ **and** $\pi(\varphi) = r(\varphi) - l(\varphi) = \frac{r(\varphi)}{\sigma} - f = \frac{R}{\sigma}(P\rho\varphi)^{\sigma-1} - f$

- **Size and productivity:** $\frac{q(\varphi_1)}{q(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma}$ **=> more productive firms are larger and charging lower prices => (S2) and (S3) are connected**
- **Aggregation:**
    - **average productivity:** $\tilde{\varphi} = \left[\int_0^{\infty} \varphi^{\sigma-1}\mu(\varphi)d\varphi\right]^{\frac{1}{\sigma-1}}$ **(μ = conditional prob.)**
    - **aggregate price:** $P = \left[\int_0^{\infty} p(\varphi)^{1-\sigma} M\mu(\varphi)d\varphi\right]^{\frac{1}{1-\sigma}} = M^{1/(1-\sigma)} p(\tilde{\varphi})$
    - **aggregate output:** $Q = M^{1/\rho} q(\tilde{\varphi})$
    - **aggregate revenue:** $R = PQ = Mr(\tilde{\varphi})$
    - **aggregate profit:** $\Pi = M\pi(\tilde{\varphi})$
    - **all aggregate variables depend on the *mass* and the *average productivity* of firms**
- **Firm entry-exit:**
    - **entry cost:** $f_e > 0$ **(measured in units of labor)**
    - **productivity draw upon entry,** φ **from a common distribution** $g(\varphi)$
    - **exit:**
        - **non-producing firms exit immediately**
        - **producing firms face an exogenous exit rate, δ, that is solved endogenously to ensure steady state M**
        - **this exogenous exiting becomes firm discounting**

- **Firm's value:** $v(\varphi) = \max\left\{0, \sum_{t=0}^{\infty}(1-\delta)^t \pi(\varphi)\right\} = \max\left\{0, \frac{1}{\delta}\pi(\varphi)\right\}$
  - **$\exists$ a cutoff productivity for producing firms, φ^*=inf{φ: $v(\varphi)$>0}, satisfying the zero cutoff profit condition $\pi(\varphi^*)$=0 (*ex post*):**
    (ZCP) $\bar{\pi} = \Pi/M = k(\varphi^*)f = \{[\tilde{\varphi}(\varphi^*)/\varphi^*]^{\sigma-1} - 1\}f$
  - **conditional probability:** $\mu(\varphi) = \dfrac{g(\varphi)}{1-G(\varphi^*)}$ if $\varphi \geq \varphi^*$
  - **average productivity:** $\tilde{\varphi}(\varphi^*) = \left[\frac{1}{1-G(\varphi^*)}\int_{\varphi^*}^{\infty} \varphi^{\sigma-1} g(\varphi)\, d\varphi\right]^{\frac{1}{\sigma-1}}$
  - **free entry (*ex ante*):**
    $v_e = p_{in}\bar{v} - f_e = \dfrac{1-G(\varphi^*)}{\delta}\bar{\pi} - f_e = 0 \Rightarrow$
    (FE) $\bar{\pi} = \dfrac{\delta f_e}{1-G(\varphi^*)}$
- **Equilibrium (φ,π):**
  - **ZCP downward-sloping: higher φ => can have lower π to survive**
  - **FE upward-sloping: higher φ => lower p_{in} => require higher π to ensure ex ante zero profit**
  - **unique interior solution (φ^*,$\bar{\pi}$)**



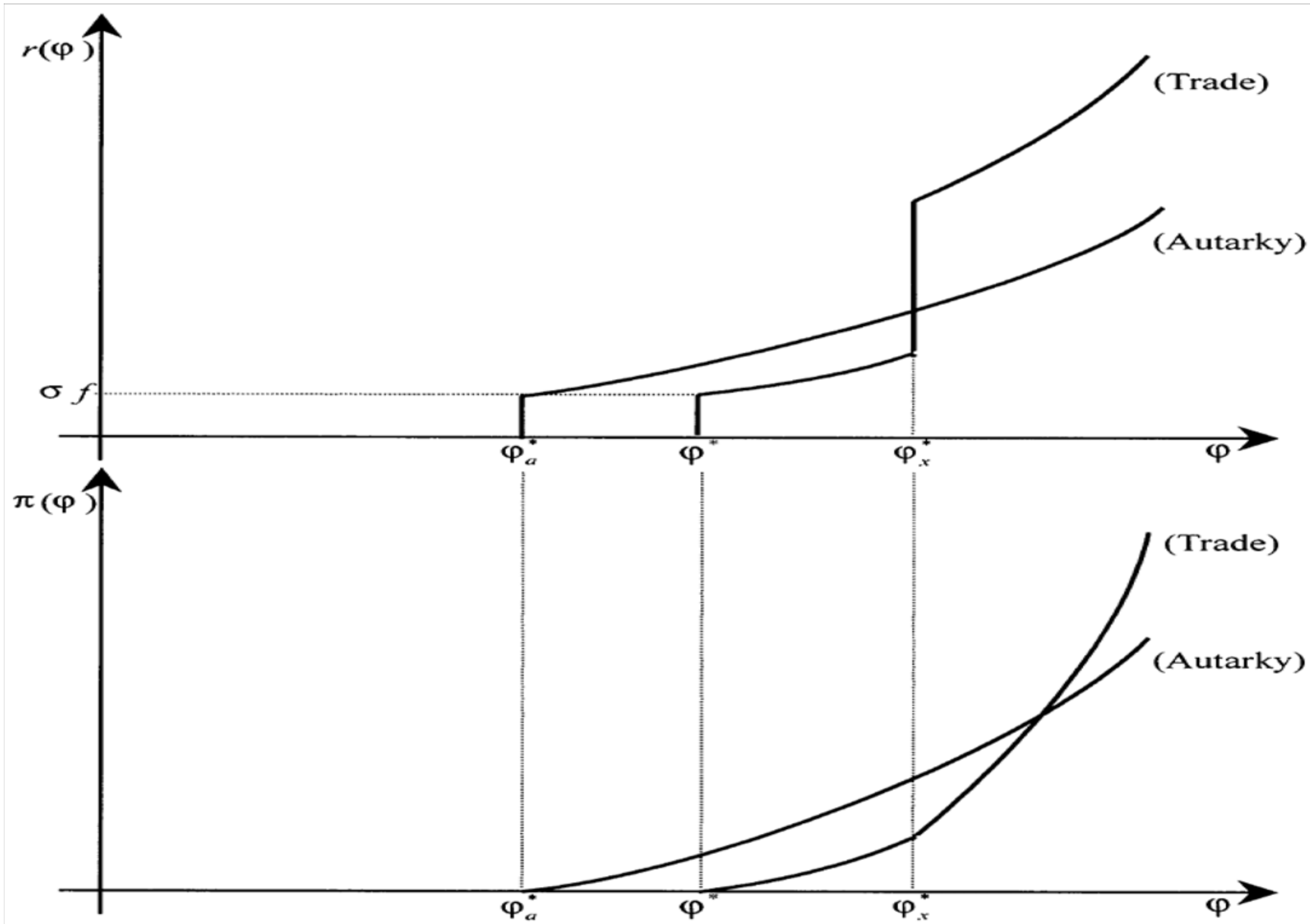
- **Stationary state in the closed economy:**
  - **constant population:** $p_{in}M_e = \delta M$
  - **labor-market clearing:** $L = L_p + L_e$
    - **investment-use of L:** $L_e = M_e f_e$
    - **production-use of L:** $L_p = R - \Pi$
  - **combining the above expressions:**
    - $R = L_p + \Pi = L_p + L_e$
    - $\mathrm{M} = \dfrac{L}{\sigma(\bar{\pi} + f)}$, **lower if higher cut-off profit due to higher entry cost**
- **Open economy:**
  - **combined revenue from domestic and export sales:**

$$r(\varphi) = \begin{cases} r_d(\varphi) & \text{if the firm does not export,} \\ r_d(\varphi) + nr_x(\varphi) = (1 + n\tau^{1-\sigma})r_d(\varphi) & \\ & \text{if the firm exports to all countries} \end{cases}$$

    - **domestic:** $r_d(\varphi) = R(P\rho\varphi)^{\sigma-1}$
    - **export:** $r_x(\varphi) = \tau^{1-\sigma} r_d(\varphi)$ **(iceberg cost)**
  - **flow cost of investment in exporting:** $f_x = \delta f_{ex}$
  - **profit:** $\pi_d(\varphi) = \dfrac{r_d(\varphi)}{\sigma} - f, \qquad \pi_x(\varphi) = \dfrac{r_x(\varphi)}{\sigma} - f_x$
  - **average productivity of exporting firms:** $\tilde{\varphi}_x = \tilde{\varphi}(\varphi_x^*)$
  - **trade-off between larger (world) market and higher trade & entry costs**

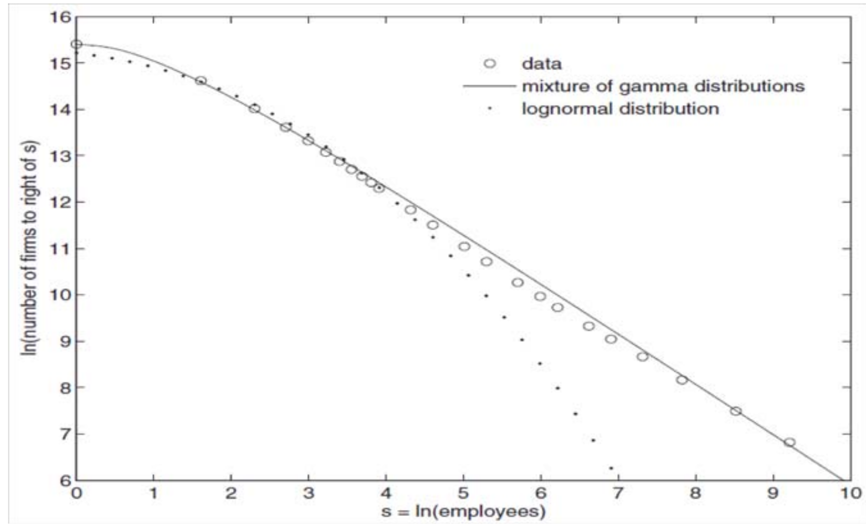
- **aggregation:**
  - **total varieties:** $M_t = M + nM_x$
  - **average productivity of all firms:** $\tilde{\varphi}_t = \left\{ \frac{1}{M_t} \left[M\tilde{\varphi}^{\sigma-1} + nM_x(\tau^{-1}\tilde{\varphi}_x)^{\sigma-1} \right] \right\}^{\frac{1}{\sigma-1}}$
  - **average profit of all firms:** $\bar{\pi} = \pi_d(\tilde{\varphi}) + p_x n \pi_x(\tilde{\varphi}_x)$
- **equilibrium conditions:**
  - **zero cutoff profit condition:** $\pi_d(\tilde{\varphi}) = fk(\varphi^*)$ **and** $\pi_x(\tilde{\varphi}_x) = f_x k(\varphi_x^*)$ **=>**

    $\bar{\pi} = fk(\varphi^*) + p_x n f_x k(\varphi_x^*)$ **with** $\varphi_x^* = \varphi^* \tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}}$ **(PP)**
  - **free entry condition:** $\bar{\pi} = \frac{\delta f_e}{1 - G(\varphi^*)}$ **(unchanged)**
  - **solving unique interior solution (φ^*, $\bar{\pi}$) as before, then plugging into (PP) to obtain $\varphi_x^* > \varphi^*$ (small export intensity, large-size exporters)**
- **Effect of trade:**
  - **cutoff φ^* is higher => crowd-out of domestic firms (selection effect)**
  - **total variety rises (variety effect)**
  - **consumer welfare increases**
  - **revenue rises among exporting firms**
  - **profit rises among more productive exporting firms (low earning from exporting)**



- **main findings: only highly productive firms export (S2), which are larger (S3) but may not earn bigger profit as a result of higher fixed costs (S1)**

D. Firm Distribution, Innovation and Growth: Ghironi-Melitz (2005)



- **Key: power-law firm size distribution**
- **Extend the Melitz model to a DSGE setting with shocks to productivity and sunk entry or trade cost**
- **Endogenously determine:**
  - **firm dynamics (entry/exit, i.e., whether to sink resources for entry facing future productivity uncertainty)**
  - **macro dynamics (in particular, composition of consumption across countries over time and endogenous nontraded-range of tradables)**
- **Generate persistent deviation from PPP due to firm entry/exit**
- **Main result: more productive countries induce more entries =>**
  - **home market effect: more attractive due to increased size**
  - **induced labor demand: higher real wage due to derived demand**
  - **Balassa-Samuelson effect: higher average prices due to rising labor cost and marginal cost pricing/constant mark-up pricing**

E. Gains from Trade: Arkolakis, Costinot & Rodríguez-Clare (2012)

- **With all the exciting development in modern trade theory and firm distribution, what are the new insights toward assessing the gains from trade?**
- **ACR's seminal contribution produces a *negative* answer: "so far, not much"**
- **Key: Observational Equivalence**
  - **regardless of micro details, the mapping between trade data and welfare is uniform across an important class of models, such as Krugman (1980), Eaton-Kortum (2002), Anderson-van Wincoop (2003), Melitz (2003) and follow-up studies, satisfying: (i) *constant markup*, (ii) *constant import demand elasticity*, and (iii) *bilateral trade balance***
  - **in these models, gains from trade are measured by two aggregate statistics:**
    - **the share of expenditure on domestic goods of the given country**
    - **the trade elasticity based on the gravity model measuring the extent to which imports response to trade costs**

1. Organizing Framework: The Gravity Model with Only Aggregate Restrictions

- **n countries, one factor (labor), an variety of goods $\omega \in \Omega$**
- **each country is population with a continuum of workers with identical tastes**

- **Dixit-Stiglitz preferences:** $U_i = \left[\int_{\omega\in\Omega} q_i(\omega)^{\frac{\sigma}{\sigma-1}}\, d\omega\right]^{\frac{\sigma-1}{\sigma}}$
- **Total expenditure = sum of imports (including own j):** $Y_j \equiv \sum_{i'=1}^{n} X_{i'j}$
- **Share of country j's import from country i:** $\lambda_{ij} \equiv X_{ij}/Y_j$
- **Bilateral import:** $X_{ij} = \int_{\omega\in\Omega_{ij}} p_j(\omega)\, q_j(\omega)\, d\omega$
- **Bilateral trade cost:** $\tau_{il}\tau_{lj} \geq \tau_{ij}$ **(triangle inequality)**
- **CES import demand system (IDS):**
  - **elasticity of relative import:** $\varepsilon_j^{ii'} \equiv \partial \ln(X_{ij}/X_{jj}) / \partial \ln \tau_{i'j}$
  - ***trade elasticity matrix*** **(n-1 x n-1): in trade equilibrium, we have**

$$\boldsymbol{\varepsilon}_j \equiv \left\{\varepsilon_j^{ii'}\right\}_{i,i'\neq j} = \boldsymbol{\varepsilon}_j = \begin{pmatrix} \varepsilon & 0 & \dots & 0 \\ 0 & \dots & \dots & \dots \\ \dots & \dots & \dots & 0 \\ 0 & \dots & 0 & \varepsilon \end{pmatrix}$$ **with ε < 0, which summarizes IDS**

- ***Gravity equation*****:** $\ln X_{ij}(\boldsymbol{\tau}, \mathbf{E}) = A_i(\boldsymbol{\tau}, \mathbf{E}) + B_j(\boldsymbol{\tau}, \mathbf{E}) + \varepsilon \ln \tau_{ij} + \nu_{ij}$
- **Asymptotic behavior: for all** $i \neq j,\ \lim_{\tau_{ij}\to+\infty} (w_i\tau_{ij}/w_j) = +\infty$

2. Perfect Competition (Eaton-Kortum 2002, Anderson-van Wincoop 2003)

- **Competitive profit condition:** $p_j(\omega) = \dfrac{w_i \tau_{ij}}{z_i(\omega)}$, for all $\omega \in \Omega_{ij}$
- **Cost minimization =>** $\Omega_{ij} = \left\{ \omega \in \Omega | \dfrac{w_i \tau_{ij}}{z_i(\omega)} = \min\limits_{1 \le i' \le n} \dfrac{w_{i'} \tau_{i'j}}{z_{i'}(\omega)} \right\}$
- **Aggregate income = wage payment:** $Y_j = w_j L_j$
- **% change in aggregate consumer price index:**
  $\widehat{P}_j = \int_{\Omega} \lambda_j(\omega) \widehat{p}_j(\omega) d\omega = \sum_{i=1}^{n} \lambda_{ij} (\widehat{w}_i + \widehat{\tau}_{ij})$ **=>** $\widehat{P}_j = -\widehat{\lambda}_{jj} / \varepsilon$
- **Welfare consequences of changing τ to τ′:** $W_j = 1 - (\lambda_{jj} / \lambda'_{jj})^{1/\varepsilon}$
- ***Gains from trade*** **(in income equivalence):**
  $\overline{W}_j$ **=** $(\lambda_{jj})^{1/\overline{\varepsilon}} - 1$ **(or** $\overline{W}_j = (\lambda_{jj})^{1/\overline{\varepsilon}} (1 + T_j) - 1$**)**
- ***Import demand system*****:** $X_{ij} = \dfrac{T_i (w_i \tau_{ij})^{\varepsilon} w_j L_j}{\sum_{i'=1}^{I} T_{i'} (w_{i'} \tau_{i'j})^{\varepsilon}}$
  - **Anderson-van Wincoop (2003):** if $a_i(\omega) < +\infty$, then $a_{i'}(\omega) = +\infty$ for all $i' \neq i$ **,** **ε = 1 - σ (σ is elasticity of substitution between goods)**
  - **Eaton-Kortum (2002): ε = - θ (θ is the tail parameter of the Pareto distribution)**

3. Monopolistic Competition (Krugman 1980, Melitz 2003)

- **Price markup:** $p_j(\omega) = \dfrac{\sigma \tau_{ij} w_i}{(\sigma - 1) z(\omega)}$ for all $\omega \in \Omega_{ij}$
- **Local monopoly profit:** $\pi_{ij}(\omega) = \left[\dfrac{\sigma \tau_{ij} w_i}{(\sigma - 1) z(\omega) P_j}\right]^{1-\sigma} \dfrac{Y_j}{\sigma} - w_i f_{ij}$
- **Operative condition:** $\Omega_{ij} = \{\omega \in \Omega | \pi_{ij}(\omega) \geq 0\}$
- **Zero-profit cutoff:** $z_{ij}^* = \left[\dfrac{\sigma \tau_{ij} w_i}{(\sigma - 1) P_j}\right] \left(\dfrac{w_i f_{ij} \sigma}{Y_j}\right)^{\frac{1}{\sigma - 1}}$
- **Free entry condition:** $\sum_{i=1}^n E[\pi_{ji}(\omega)] = w_j f_e$
- **Aggregate income:** $Y_j = w_j L_j$
- **% change in aggregate consumer price index:**

$$\widehat{P}_j = \sum_{i=1}^n \lambda_{ij} \left[(\widehat{w}_i + \widehat{\tau}_{ij}) - \frac{\widehat{M}_i}{\sigma - 1} + \frac{\gamma_{ij} \widehat{z_{ij}^*}}{\sigma - 1}\right]$$

where $\gamma_{ij} \equiv (z_{ij}^*)^\sigma g_i(z_{ij}^*) / \int_{z_{ij}^*}^{+\infty} z^{\sigma - 1} g_i(z)\, dz$, $\hat{M}_i$ **captures variety effect**

=> $\widehat{P}_j = -\widehat{\lambda}_{jj} / \varepsilon$

- **Welfare consequences of changing τ to τ′:** $W_j = 1 - \left(\lambda_{jj}/\lambda'_{jj}\right)^{1/\varepsilon}$
- ***Gains from trade*** **(in income equivalence):** $\overline{W}_j = (\lambda_{jj})^{1/\bar{\varepsilon}} - 1$
- ***Import demand system*:** $X_{ij} = \dfrac{M_i T_i (w_i f_{ij})^{1+\frac{\varepsilon}{\sigma-1}} (w_i \tau_{ij})^{\varepsilon} w_j L_j}{\sum_{i'=1}^{I} M_{i'} T_{i'} (w_{i'} f_{i'j})^{1+\frac{\varepsilon}{\sigma-1}} (w_{i'} \tau_{i'j})^{\varepsilon}}$
- **Special cases:**
  - **Krugman (1980):** $z_{ij}^* = \gamma_{ij} = 0$, $\hat{M}_i = 0$, $\varepsilon = 1 - \sigma$
  - **Melitz (2003):** $\hat{M}_i = 0$, $\varepsilon = -\theta$

4. Main Findings

- **In an important class of models with a CES import demand system satisfying the gravity equation and a regularity condition on the asymptotic behavior, the *mapping between trade data and welfare is independent of micro-level details* of the model: it depends on only *two aggregate statistics:***
  - **λ_{jj}: share of expenditure on j's domestic goods**
  - **ε: trade elasticity based on the gravity model**
- **Thus, regarding the insight toward understanding the gains from trade, the new development in trade and firm distribution *so far* has *not* generated *much* compared to the conventional wisdom.**

5. Generalization

- **Trade induced changes in productivity: Melitz-Redding (2015), Chen-Cheng-Peng-Riezman-Wang (2023)**
- **Gains from intermediate trade: Caliendo-Parro (2015), Sampson (2016), Halpern-Koren-Szeidl (2015), Bloom-Romer-Terry-Van Reenen (2021), Caliendo-Opromolla-Parro-Sforza (2021), Hsieh-Klenow-Nath (2021), Perla-Tonetti-Waugh (2021), Lai-Peng-Riezman-Wang (2023)**
- **The role of variable markups: Hsieh-Li-Ossa-Yang (2016), Chen-Cheng-Peng-Riezman-Wang (2023)**
- **Export versus outsourcing: Cheng-Riezman-Wang (2021)**

6. Open Issues

- **Are larger firms more productive and exporting firms larger/more productive?**
- **Is the cost of entry the primary determinant of firm distribution?**
- **What are the dynamic gains from trade with heterogenous firms and endogenous reallocation among firms?**
- **What is the implications of firm heterogeneity for wage inequality?**
- **How to explain large cross-country/industry variations in firm dynamics?**

F. Distortions, Factor Misallocation and Productivity: Hsieh-Klenow (2009)

- **Cross-country differences in income and TFP are large and widened (see a nice survey in the North-Holland Handbook of Economic Growth by Caselli 2005**
- **Restuccia-Rogerson (2008) argue that factor misallocation across firms can have large effects on aggregate TFP**
- **Lewis (2004, McKinsey Global Institute) argues that country-specific institutions and policies can result in resource misallocation**
- **This paper ties all such bolts and nuts together**

1. The Basic Model: Monopolistic Competition

- **In addition to production efficiency differences as in Melitz (2003), firms also face different output and capital distortions**
- **A single final good is produced with a basket of industry goods, taking a Cobb-Douglas form:**
    - $Y = \prod_{s=1}^{S} Y_s^{\theta_s}$, **with** $\sum_{s=1}^{S} \theta_s = 1$
    - **industry s's output is a CES aggregate of M differentiated products:** $Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$
    - **firm/plant i's production (Cobb-Douglas):** $Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}$

- **Profit of firm i in industry s yields:** $\pi_{si} = (1-\tau_{Ysi})P_{si}Y_{si} - wL_{si} - (1+\tau_{Ksi})RK_{si}$
  - **τ_{Ysi} and τ_{Ksi} measure output and capital distortions tied to economic institutions and policies**
    - **τ_{Ysi} captures entry barriers, good market imperfections, income taxes, and/or transport costs**
    - **τ_{Ksi} capture capital barriers, credit market imperfections, capital taxes and/or intermediation costs**
  - **profit maximization implies:**
    - **MRTS = relative cost:** $\dfrac{K_{si}}{L_{si}} = \dfrac{\alpha_s}{1-\alpha_s} \cdot \dfrac{w}{R} \cdot \dfrac{1}{(1+\tau_{Ksi})}$
    - **competitive profit:** $P_{si} = \dfrac{\sigma}{\sigma-1}\left(\dfrac{R}{\alpha_s}\right)^{\alpha_s}\left(\dfrac{w}{1-\alpha_s}\right)^{1-\alpha_s}\dfrac{(1+\tau_{Ksi})^{\alpha_s}}{A_{si}(1-\tau_{Ysi})}$
  - **induced demand for labor:** $L_{si} \propto \dfrac{A_{si}^{\sigma-1}(1-\tau_{Ysi})^{\sigma}}{(1+\tau_{Ksi})^{\alpha_s(\sigma-1)}}$
  - **firm output:** $Y_{si} \propto \dfrac{A_{si}^{\sigma}(1-\tau_{Ysi})^{\sigma}}{(1+\tau_{Ksi})^{\alpha_s\sigma}}$
  - **marginal revenue product of labor:** $MRPL_{si} \triangleq (1-\alpha_S)\dfrac{\sigma-1}{\sigma}\dfrac{P_{si}Y_{si}}{L_{si}} = w\dfrac{1}{1-\tau_{Ysi}}$
  - **marginal revenue product of capital:** $MRPK_{si} \triangleq \alpha_S \dfrac{\sigma-1}{\sigma}\dfrac{P_{si}Y_{si}}{K_{si}} = R\dfrac{1+\tau_{Ksi}}{1-\tau_{Ysi}}$

- **Industry factor demand:**
  - **labor:** $L_s \equiv \sum_{i=1}^{M_s} L_{si} = L \frac{(1-\alpha_s)\theta_s / \overline{MRPL}_s}{\sum_{s'=1}^{S}(1-\alpha_{s'})\theta_{s'} / \overline{MRPL}_{s'}}$, **with** $\overline{MRPL}_s \propto \left(\sum_{s=1}^{M_s} \frac{1}{1-\tau_{Ysi}} \frac{P_{si}Y_{si}}{P_s Y_s}\right)$
  - **capital:** $K_s \equiv \sum_{i=1}^{S} K_{si} = K \frac{\alpha_s \theta_s / \overline{MRPK}_s}{\sum_{s'=1}^{S} \alpha_{s'} \theta_{s'} / \overline{MRPK}_{s'}}$, **with** $\overline{MRPK}_s \propto \left(\sum_{s=1}^{M_s} \frac{1+\tau_{Ksi}}{1-\tau_{Ysi}} \frac{P_{si}Y_{si}}{P_s Y_s}\right)$
  - **aggregate factor demand:** $L \equiv \sum_{s=1}^{S} L_s$ **and** $K \equiv \sum_{s=1}^{S} K_s$
- **Final sector:**
  - **aggregate output:** $Y = \prod_{s=1}^{S}\left(TFP_s \cdot K_s^{\alpha_s} \cdot L_s^{1-\alpha_s}\right)^{\theta_s}$
  - **cost minimization implies:** $P_s Y_s = \theta_s P Y$, **where** $P \equiv \prod_{s=1}^{S}\left(\frac{P_s}{\theta_s}\right)^{\theta_s}$
- **Measurement of TFP:**
  - **physical productivity of firm i in industry s:** $TFPQ_{si} \triangleq A_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}$
  - **revenue productivity of firm i in industry s:** $TFPR_{si} \triangleq P_{si}A_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}$**, or,** $TFPR_{si} \propto (MRPK_{si})^{\alpha_s}(MRPL_{si})^{1-\alpha_s} \propto \frac{(1+\tau_{Ksi})^{\alpha_s}}{1-\tau_{Ysi}}$**, which** ***increases in both distortions*****, implying that those facing larger barriers are smaller than the optimal size and hence have higher marginal products (under diminishing returns)**

- **industry TFP:** $TFP_s = \left(\sum_{i=1}^{M_s} \left\{ A_{si} \cdot \frac{\overline{TFPR}_s}{TFPR_{si}} \right\}^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$**, with** $\overline{TFPR}_s \propto \left(\overline{MRPK}_s\right)^{\alpha_s} \left(\overline{MRPL}_s\right)^{1-\alpha_s}$
- **if TFPQ (A) and TFPR are jointly log-normally distributed, then:** $\log TFP_s = \frac{1}{\sigma-1} \log\left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right) - \frac{\sigma}{2} \mathrm{var}\left(\log TFPR_{si}\right)$**, that is, greater dispersion of marginal products worsens the extent of misallocation, thus lowering industry TFP**

2. Applications: China/India versus U.S.

- **Calibration: based on the theory developed above, we can back out the two distortion measures as well as firm-level productivity:**
  - **capital distortion:** $1 + \tau_{Ksi} = \frac{\alpha_s}{1-\alpha_s} \frac{wL_{si}}{RK_{si}}$
  - **output distortion:** $1 - \tau_{Ysi} = \frac{\sigma}{\sigma-1} \frac{wL_{si}}{(1-\alpha_s) P_{si} Y_{si}}$
  - **firm productivity:** $A_{si} = \kappa_s \frac{(P_{si} Y_{si})^{\frac{\sigma}{\sigma-1}}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}}$**, with** $\kappa_s = w^{1-\alpha_s} \left(P_s Y_s\right)^{-\frac{1}{\sigma-1}} / P_s$ **set as one to infer P_s from observed value $P_s Y_s$**

- **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

- **TFP gains from equalizing TFPR within industries**
  - **China: 115.1% in 1998 86.8% in 2005**
  - **India: 100.4% in 1987 127.5% in 1994**
  - **U.S.: 36.1% in 1977 42.9% in 1997**

- **TFP gains from equalizing TFPR relative to 1997 U.S. gains**
  - **China: 50.5% in 1998 30.5% in 2005**
  - **India: 40.2% in 1987 59.2% in 1994**

- **TFP by ownership in China and India**

TFP by ownership

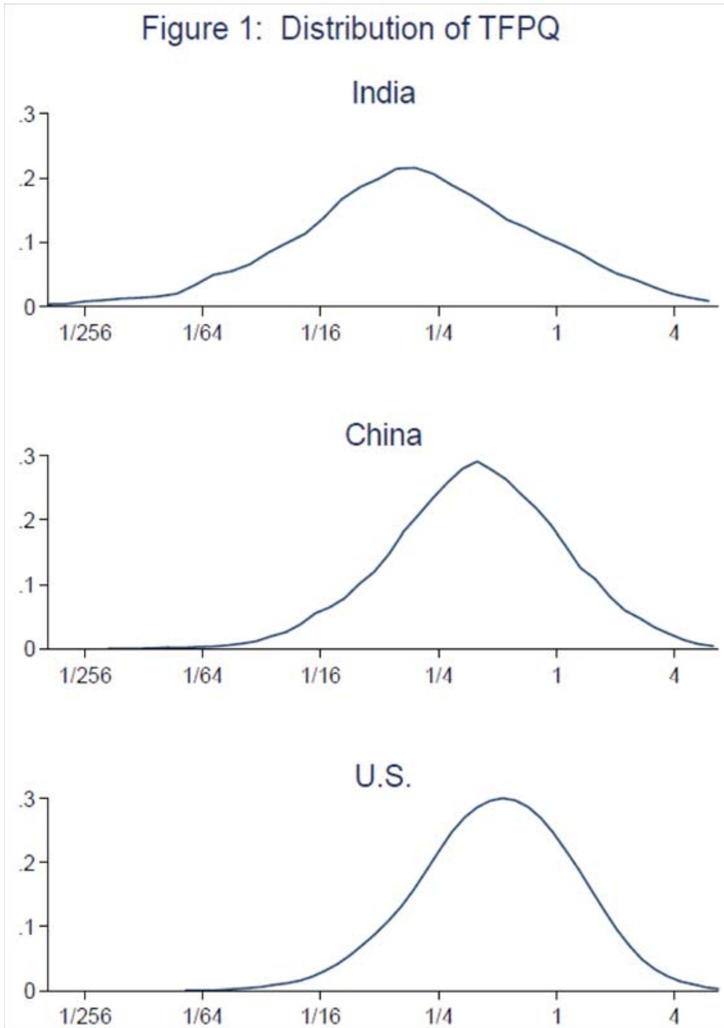
China

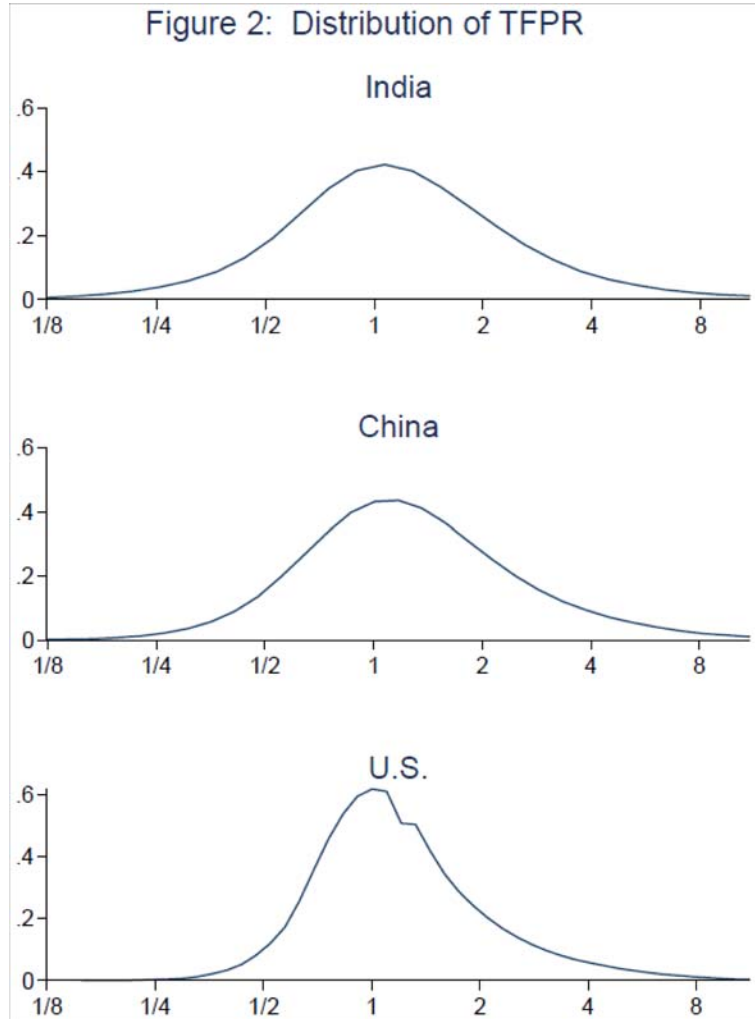
	TFPR	TFPQ
State	-0.415 (0.023)	-0.144 (0.090)
Collective	0.114 (0.010)	0.047 (0.013)
Foreign	-0.129 (0.024)	0.228 (0.040)

India

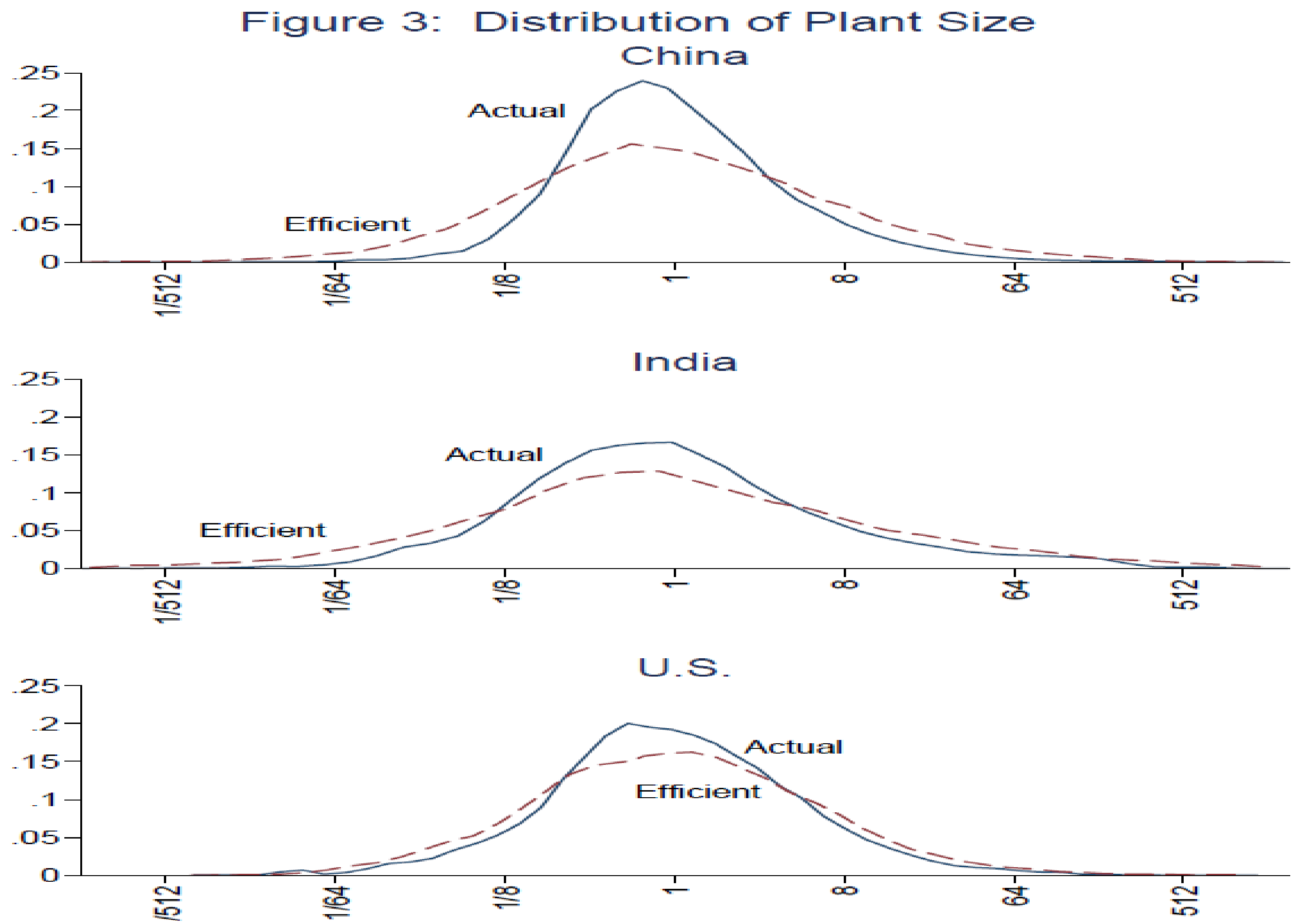
	TFPR	TFPQ
State (Central)	-0.285 (0.082)	0.717 (0.295)
State (Local)	-0.081 (0.063)	0.425 (0.103)
Joint Public/Private	-0.162 (0.037)	0.671 (0.085)

- **China and India have lower TFPQ and higher TFPR than the U.S.:**

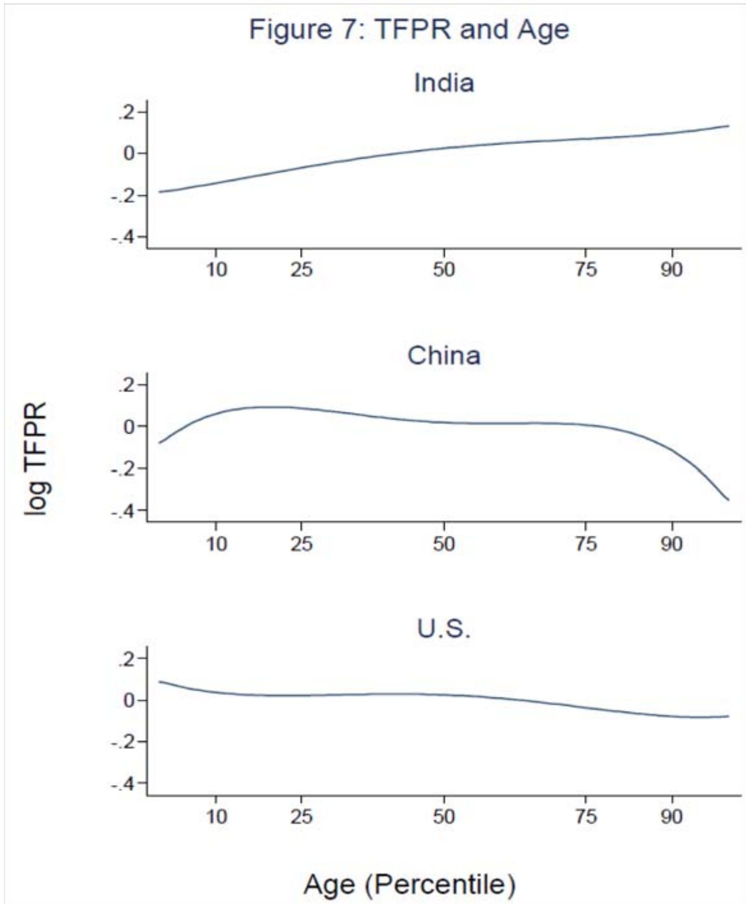


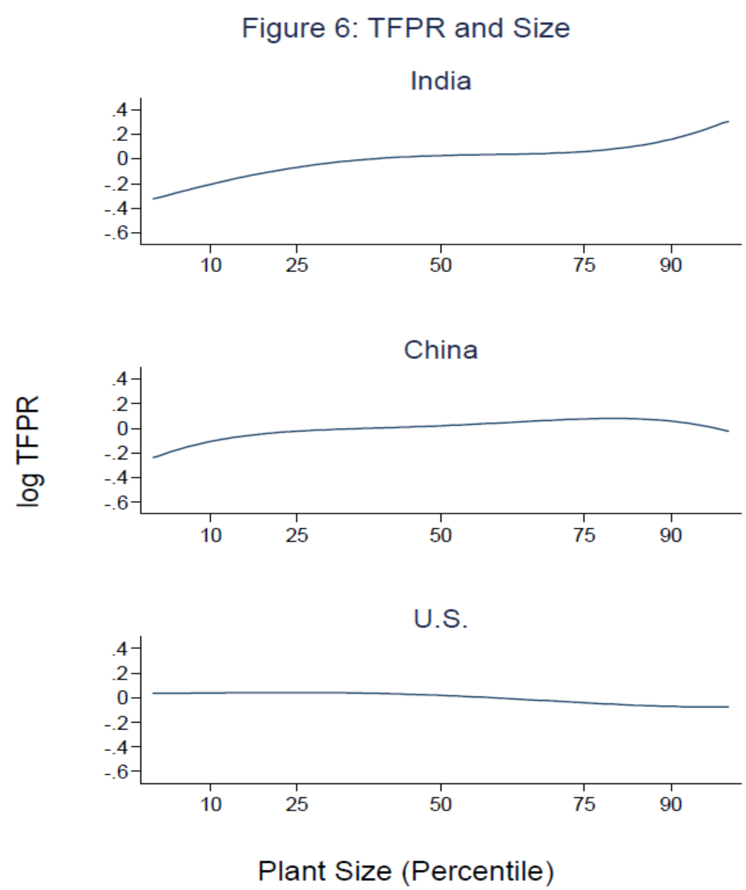


- **China and India have overly concentrated plan size distribution than the efficient one**



- **Experienced and larger firms in the U.S. have lower TFPR (less barriers)**
  - **in India, the results are *opposite* (need theory to explain)**
  - **in China, experienced and *small* firms have lower TFPR (need theory)**





G. The New Economics of Industrial Policy: Juhász-Lane-Rodrik (2023)

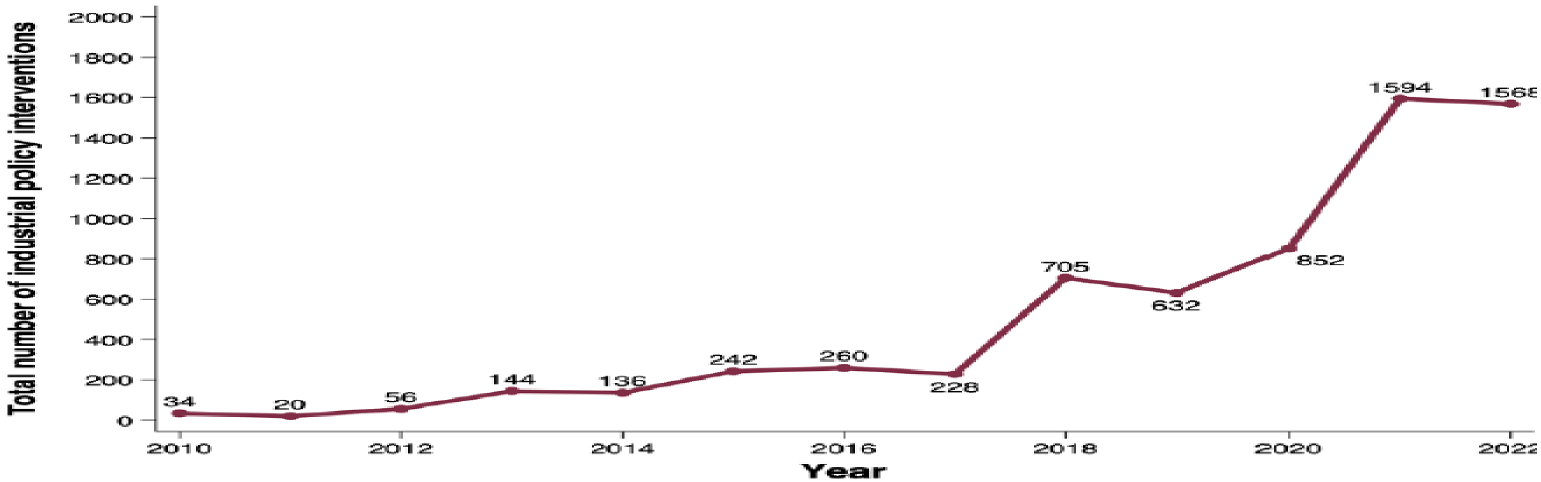
- **Institutional factors and government policies are underlying drivers of the distortionary wedges in Hsieh-Klenow (2009), among which industrial policy is of particular relevance**
- **However, more recent empirical work offers a more positive take on industrial policy, upon paying close attention to measurement, causal inference, and underlying economic structure**
- **This is particularly so in East Asian economies where industrial policy is being reshaped by a new understanding of governance, a richer set of policy instruments beyond subsidies, and the reality of deindustrialization**
- **To illustrate the challenge of evaluating industrial policy, consider that an economy's macroeconomic performance g is a function of macroeconomic fundamentals A subject to market failure whose degree of severity is measured by θ: $g(\theta) = (1 - \theta)A$, which may be referred to as a "growth equation"**
- **Let government intervention be summarized by a subsidy be at the rate s that comes with an agency or fiscal cost of $\varphi\alpha(s)$ where the cost is increasing and convex ($\alpha' > 0$ and $\alpha'' > 0$)**
- **Thus, the growth equation is modified as:** $g(s,\theta,\varphi) = (1-\theta(1-s))A - \varphi\alpha(s)$ **and the growth-maximizing subsidy policy satisfies** $g_s(s,\theta,\varphi) = \theta A - \varphi'\alpha(s) = 0$

- **The government, however, may be rent seekers or have different agenda, which can be generally referred to as political benefit $\pi(s)$ with $\pi' > 0$ and $\pi'' < 0$, measured in the same unit as g**
  - **government objective:** $\max_s u(s;\theta,\varphi) = \lambda g(s,\theta,\varphi) + \pi(s)$
  - **(FOC)** $\lambda g_s(s,\theta,\varphi) + \pi'(s) = \lambda[\theta A - \varphi\alpha'(s)] + \pi'(s) = 0$
  - **thus, with $\pi' > 0$, it must be true that** $\theta A - \varphi\alpha'(s)$ **< 0, implying over-subsidy or excessive intervention**
- **This simple structure entails different positions on industrial policy:**
  - **the "developmentalist" view: governments can successfully identify and support growth/efficiency-enhancing firms/industries ($\lambda \to \infty$)**
  - **the "inefficacy" view: governments seek growth/efficiency but do a poor job of supporting appropriate activities ($\lambda < 1$)**
  - **the "rent-seeking" view: governments are beholden to special interests and do not seek desirable economic outcomes ($\lambda \to 0$)**

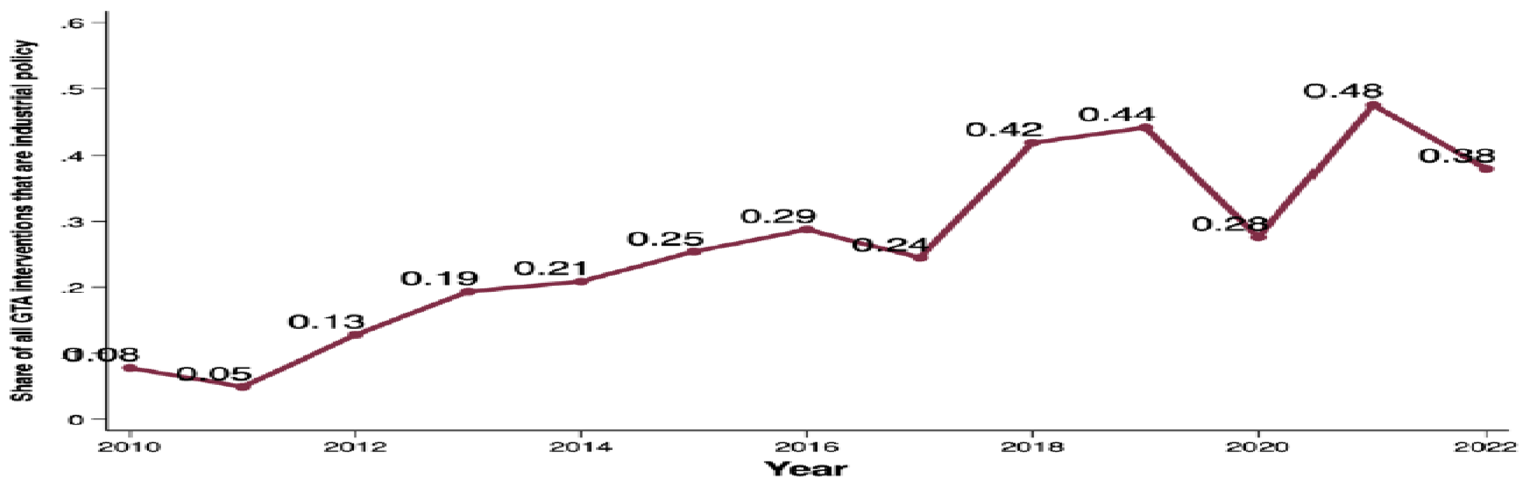
- **Traditional and new industrial policies**

	Traditional industrial policy	New industrial policy
Market failures targeted	R&D, innovation, learning externalities; coordination failures in investment	Traditional markets failures, plus good-job externalities, direction of innovation, and missing public inputs
Sectors	Manufacturing, tradable sectors	Services in addition to manufacturing
Firms	Large, globally competitive firms	All sizes of firms, including SMEs
Assumptions about the government	Governments can identify market failures ex ante and is sufficiently insulated from capture	Knowledge about location and magnitude of market failures is widely dispersed; government faces substantial uncertainty; state capacity is endogenous
Types of incentives	Tax, credit subsidies	A portfolio of business services, including marketing, management & tech assistance, customized training, infrastructure, seed capital/loans for directed technologies
Application of incentives	Fixed schedule of incentives, except for incentive packages for large firms which may be negotiated	Customized to firms' needs and adapted to context
Selection criteria	Pre-specified	Voluntary buy-in and participation
Conditionality	Hard; rigid ex-ante criteria	Soft; provisional, open-ended and evolving
Relationship with recipients	Arms'-length	Collaborative, iterative; active project management

- **Trend of industrial policy**

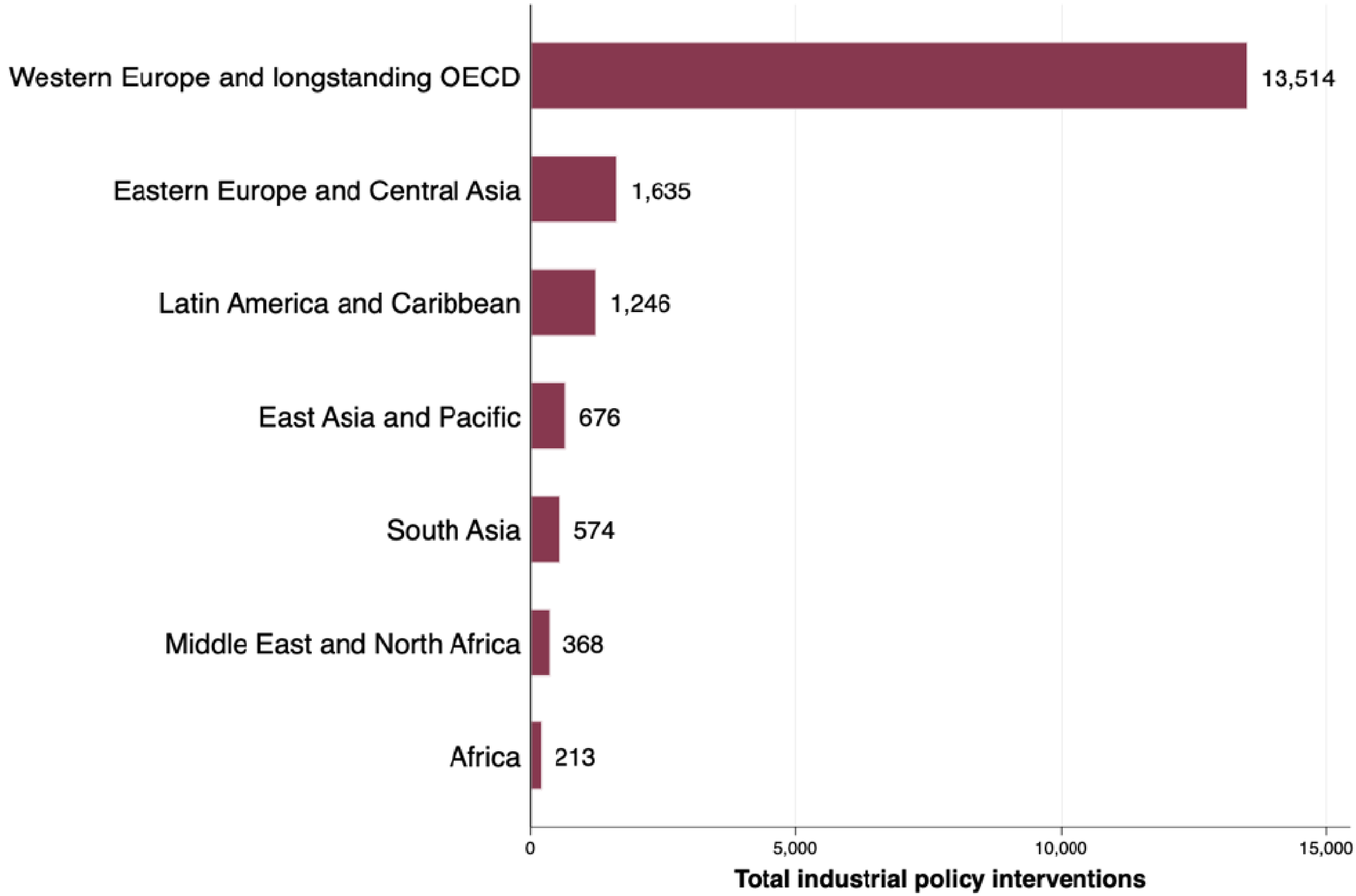


Panel A: Total number of industrial policy interventions

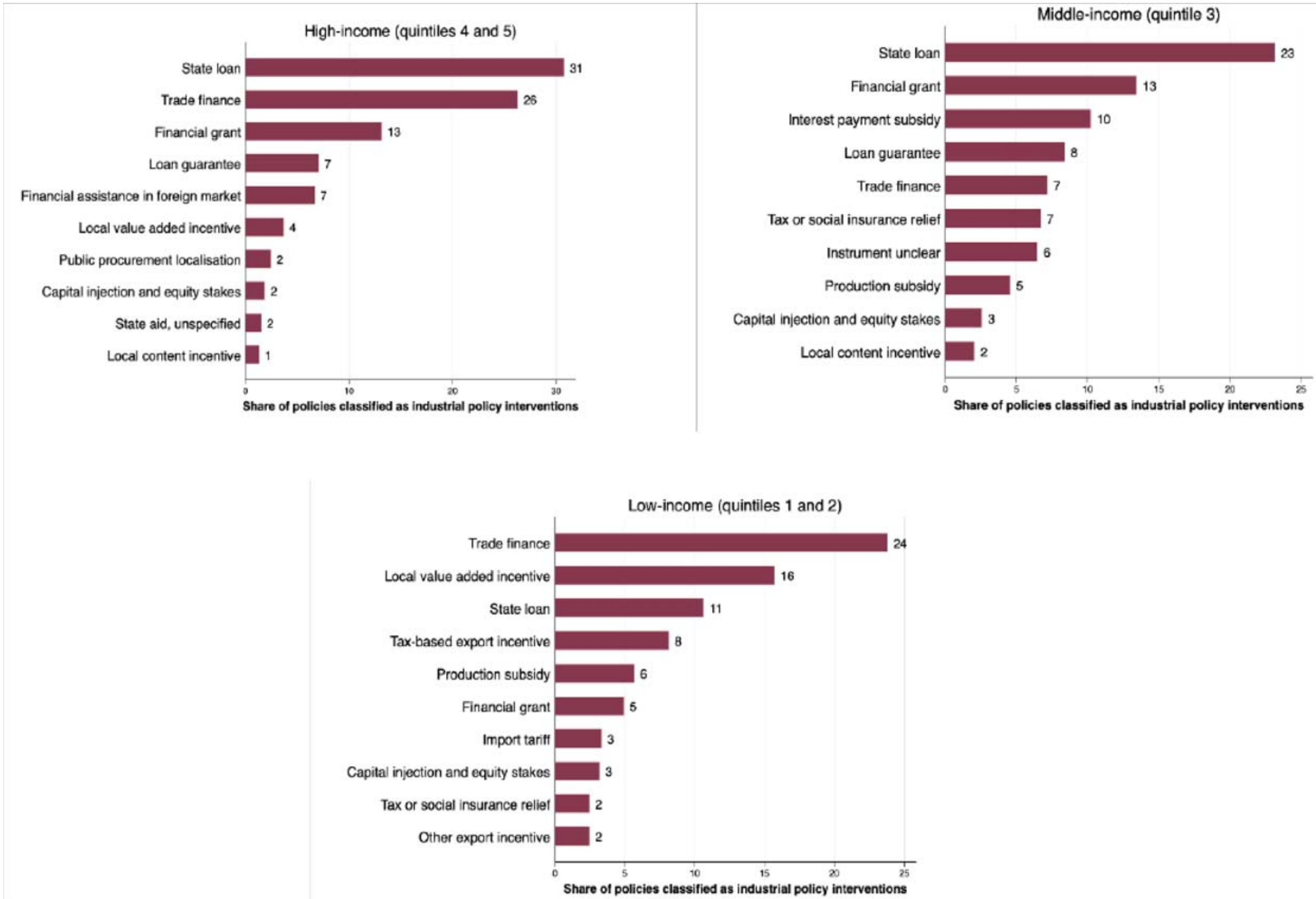


Panel B: Share of all interventions classified as industrial policy

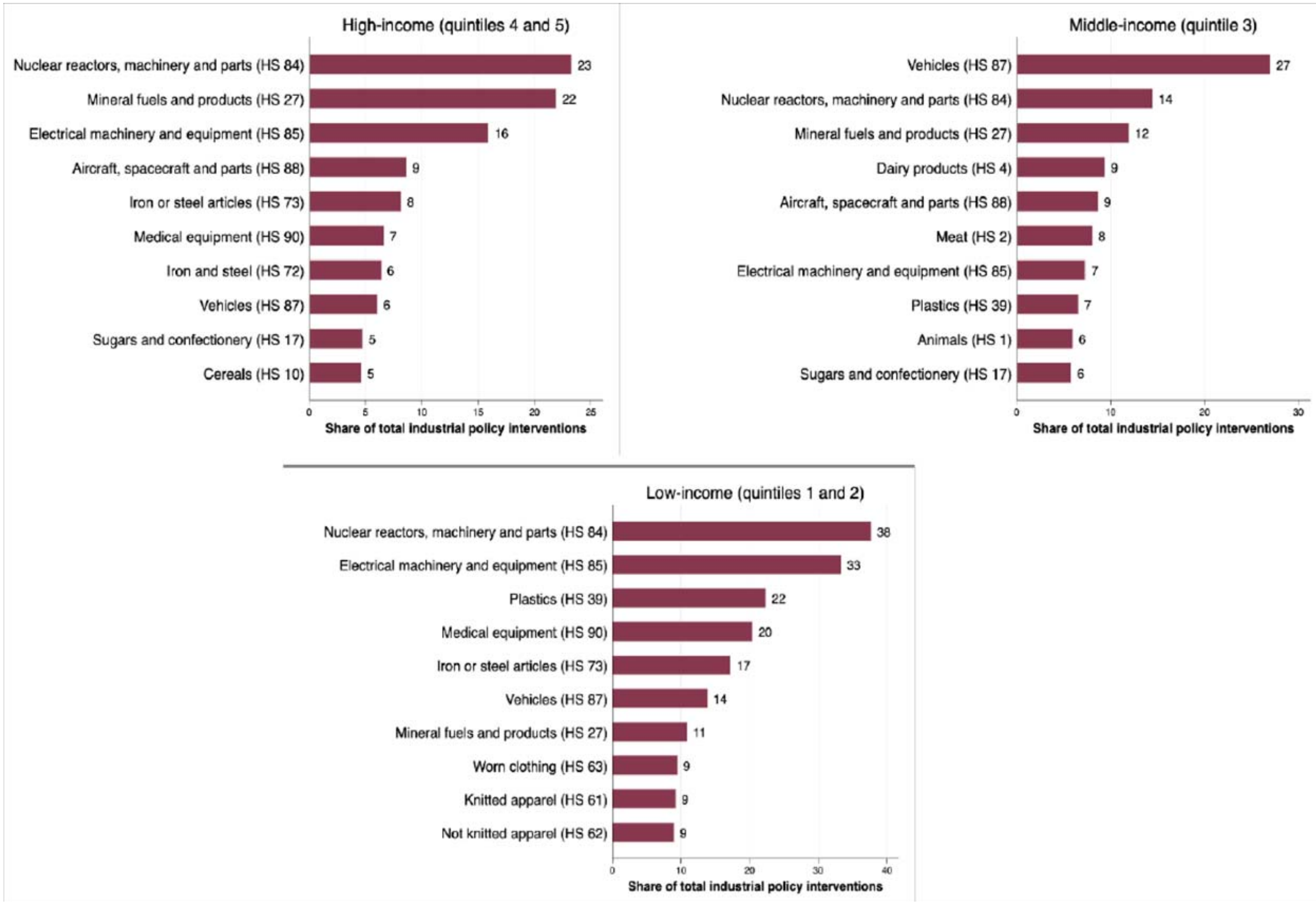
- **Industry policy interventions by country income quintile:**



● Industrial policies by types



- ## Industrial policies by sectors



H. Heterogeneities Workers/Firms and Mismatches: Lise-Robin (2017)

- **Literature:**
  - **heterogeneous workers and firms: Crawford and Knoer (1981), Burdett-Mortensen (1998), Postel-Vinay & Robin (2012)**
  - **heterogeneous workers and firms with technological changes: Chen-Mo-Wang (2000)**
- **Production is match-specific, depending on (x,y,z) = (worker type, firm type, technology)**
  - **aggregate productivity: p(x,y,z) increasing in each**
  - **complementarity: $p_{xy} > 0$**
- **Basic structure (Postel-Vinay & Robin 2012):**
  - **firms pin unemployed workers down at their reservation B(x)**
  - **employed workers conduct on the job search, inducing firms to have Bertrand competition**
- **Surplus of match:** $S_t(w,x,y) = W_t(w,x,y) - B_t(x) + \Pi_t(w,x,y)$
  - **unemployed:** $W_t(w,x,y) - B_t(x) = 0$
  - **employed:** $W_t(w',x,y') - B_t(x) = S_t(x,y)$
  - **after productivity shock wage renegotiation:**
    $0 \leq W_t(w',x,y) - B_t(x) \leq S_t(x,y)$

- S only depend on aggregate z: this is because outside offers do not affect matching surplus accrued but worker/firm shares of the surplus
- Search workers and vacancies:
  - after productivity shock unmatched:

$$u_{t+}(x) = u_t(x) + \int \left[1\{S_t(x,y) < 0\} + \delta 1\{S_t(x,y) \geq 0\}\right] h_t(x,y)\,\mathrm{d}y$$

    - all jobs with S < 0 are destroyed
    - a fraction δ of viable jobs with S > 0 are separated
  - after productivity shock matched: $h_{t+}(x,y) = (1-\delta)1\{S_t(x,y) \geq 0\} h_t(x,y)$, that is, nonseparated viable jobs
  - effective search: $L_t \equiv s_0 \int u_{t+}(x)\,\mathrm{d}x + s_1 \iint h_{t+}(x,y)\,\mathrm{d}x\,\mathrm{d}y$
  - aggregate vacancies: $V_t \equiv \int v_t(y)\,\mathrm{d}y$ (each v with flow cost c(v))
- Meeting technology: $M_t \equiv \min\{\alpha L_t^{\omega} V_t^{1-\omega}, L_t, V_t\}$ (random, one-for-one)
  - so job finding rate of an unemployed is $\lambda_{0,t} = s_0 M_t / L_t$
  - job finding rate of an employed: $\lambda_{1,t} = s_1 M_t / L_t$
  - recruitment rate: $q_t = M_t / V_t$

- **Laws of motion:**
  - **unemployed (outflow = job finders):**

$$u_{t+1}(x) = u_{t+}(x)\left[1 - \int \lambda_{0,t}\frac{v_t(y)}{V_t}\mathbf{1}\{S_t(x,y) \geq 0\}\,\mathrm{d}y\right]$$

  - **employed (outflow = poached by more productive firms, inflow = poaching less productive firms + new job finders from unemployed pool):**

$$\begin{aligned} h_{t+1}(x,y) = h_{t+}(x,y)&\left[1 - \int \lambda_{1,t}\frac{v_t(y')}{V_t}\mathbf{1}\{S_t(x,y') > S_t(x,y)\}\,\mathrm{d}y'\right] \\ &+ \int h_{t+}(x,y')\lambda_{1,t}\frac{v_t(y)}{V_t}\mathbf{1}\{S_t(x,y) > S_t(x,y')\}\,\mathrm{d}y' \\ &+ u_{t+}(x)\lambda_{0,t}\frac{v_t(y)}{V_t}\mathbf{1}\{S_t(x,y) \geq 0\} \end{aligned}$$

- **Bellman equation of unemployed:**

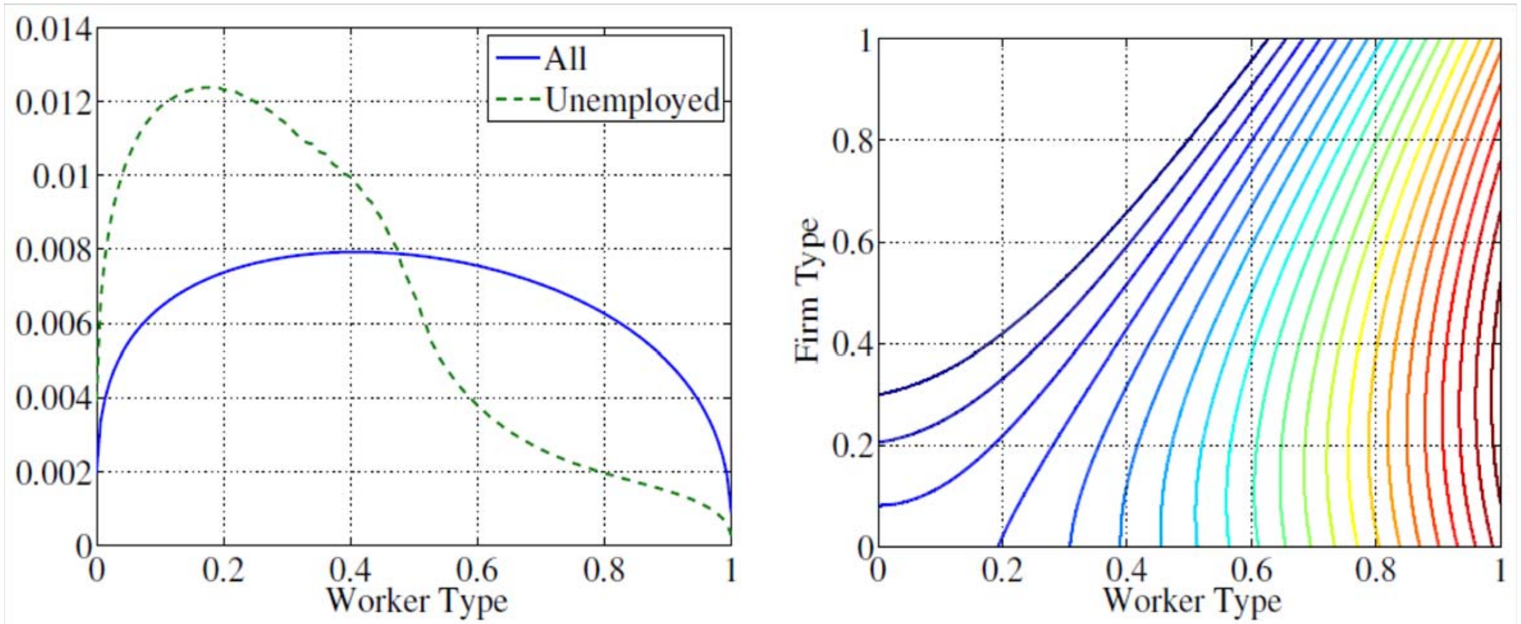
$$\begin{aligned} B_t(x) = b(x,z) + \frac{1}{1+r}\mathbb{E}_t&\Big[\left(1-\lambda_{0,t+1}\right)B_{t+1}(x) \\ &+ \lambda_{0,t+1}\int \max\left\{W_{t+1}(\phi_{0,t+1}(x,y),x,y), B_{t+1}(x)\right\}\frac{v_{t+1}(y)}{V_{t+1}}\,\mathrm{d}y\Big] \end{aligned}$$

  - **reduced to** $B_t(x) = b(x,z) + \frac{1}{1+r}\mathbb{E}_t B_{t+1}(x)$ **because they are pinned at reservation B = W**

- **Expected value of newly filled vacancies by both unemployed and employed:**

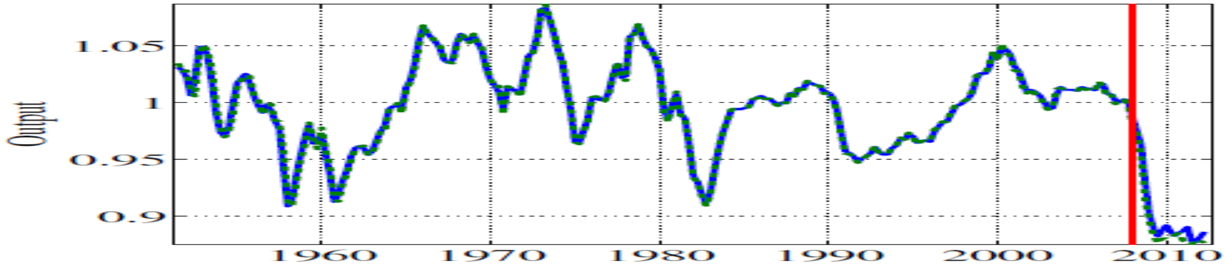
$$J_t(y) = \int \frac{\lambda_{0,t} u_{t+}(x)}{M_t} S(x,y,z)^+ \, \mathrm{d}x + \iint \frac{\lambda_{1,t} h_{t+}(x,y')}{M_t} [S(x,y,z) - S(x,y',z)]^+ \, \mathrm{d}x \, \mathrm{d}y'$$

- **FOC vacancy creation:** $c'[v_t(y)] = q_t J_t(y)$ **(MC = expected MB)**
- **Calibration analysis:**
    - **estimated worker distribution and production:**

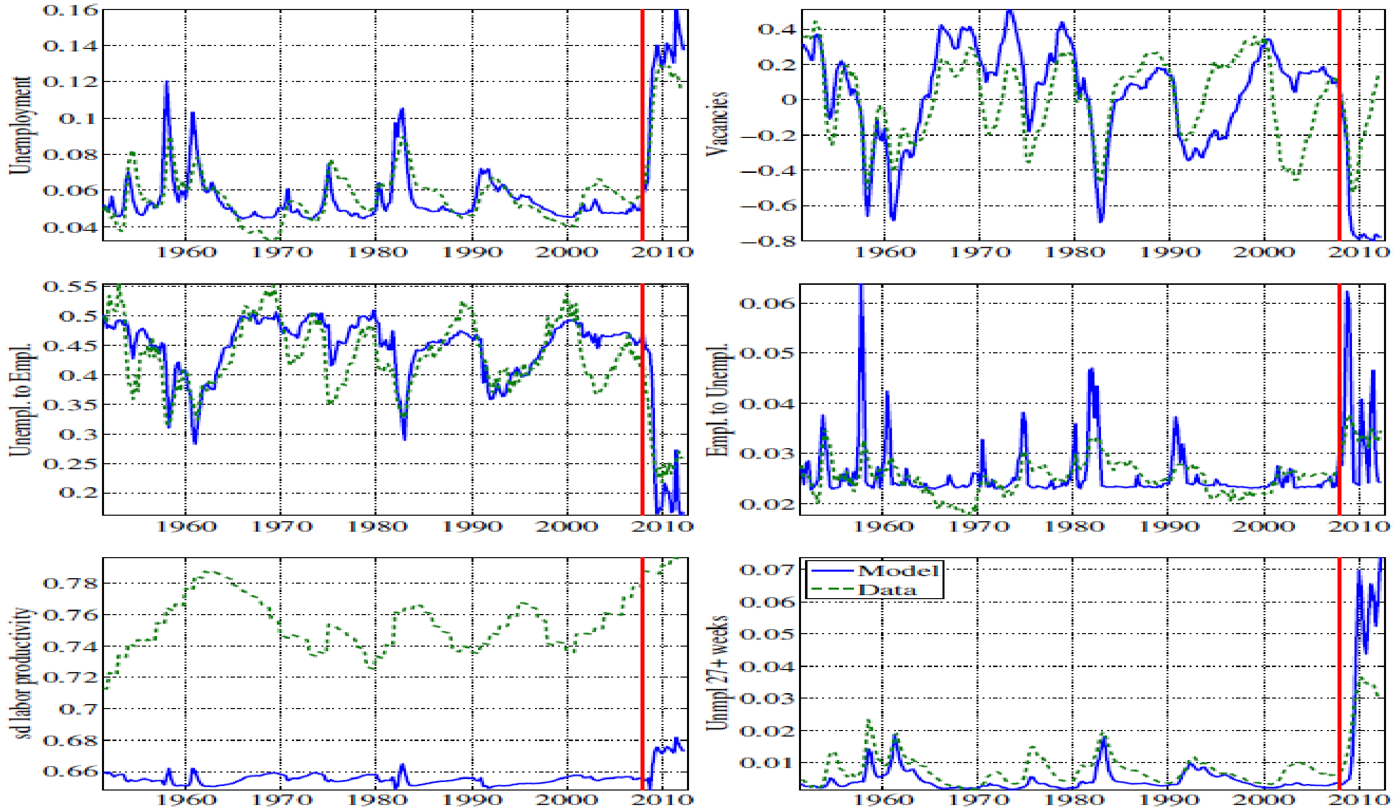


(a) Distribution of worker types (b) Production function

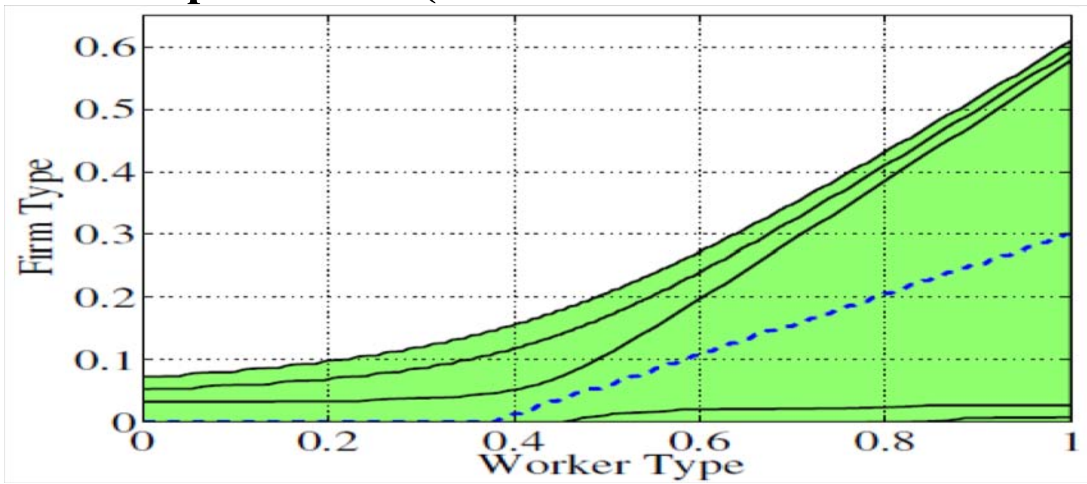
- **estimated productivity shock**



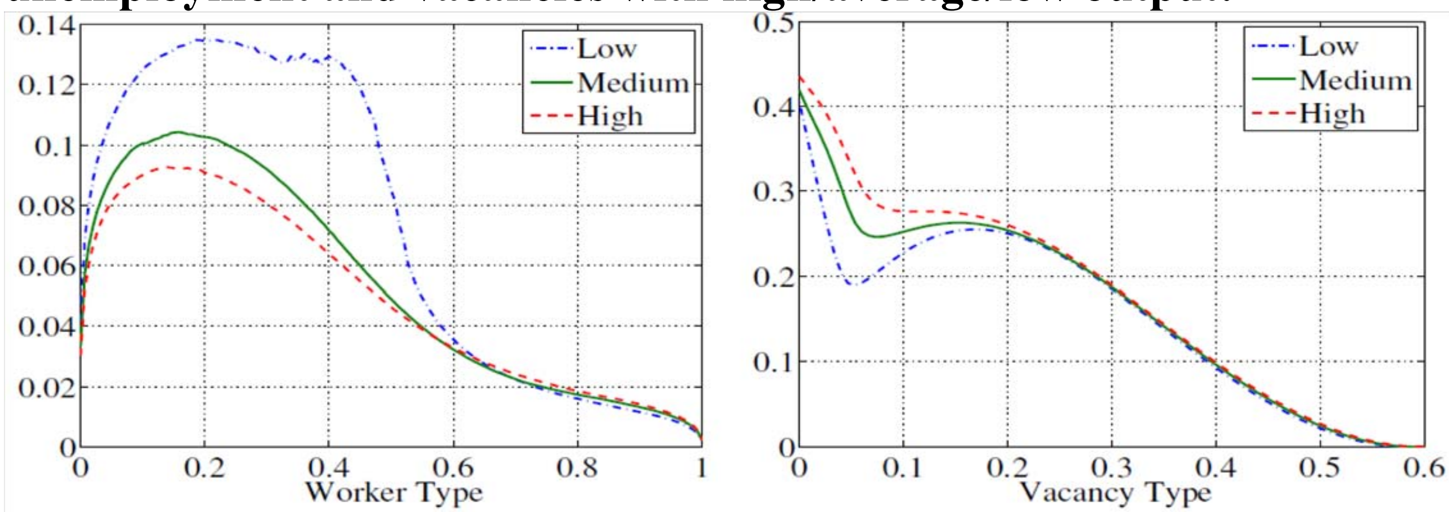
- **model fit (51-07)/prediction (08-12):** ***vacancie, labor productivity volatility***



- *mismatch*: **dotted = optimal match, solid = boundaries for z shocks at the 90/50/10 percentiles (wider => more severe mismatch in booms)**



- **unemployment and vacancies with high/average/low output:**



(b) $u_t(x)$

(c) $v_t(y)$