Macroprudential Policy with Firm Heterogeneity

Emilio Zaratiegui

Columbia University

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Motivation

- Capital controls have become an important policy tool
- Prevent and mitigate crises by managing cross-border flows
- But this view ignores potential effects on investment and productivity

In this Paper

- I build a model combining macroprudential open economy literature and misallocation literature
- Show that negative effects on productivity reduce optimal capital controls
- Leverage sufficient statistic formula and firm-level microdata to quantify trade-off
- For baseline scenario, capital flows should be incentivized rather than restricted

Model - Overview

- Small, open economy model with a representative household à la Bianchi (2011)
- Consumes non-tradable endowment and tradable good, which is produced using capital and labor
- **Pecuniary Externality + Incomplete Markets:** Households can lend or borrow from the rest of the world but face a borrowing constraint that depends on their income
- **Firm Heterogeneity:** Firms differ in access to capital $\rightarrow$ misallocation $\rightarrow$ reduced productivity
- Today: Uncertainty and frictions are only present in $t = \tilde{t}$.

Model - Households

- Households maximize lifetime utility over final consumption

$$\mathbb{E}_0 \left[\sum_t \beta^t u(c_{T,t}, c_{N,t}) \right]$$

- Subject to budget constraint

$$c_{T,t} + p_t c_{N,t} + k_{t+1} = p_t y^N + w_t + (1 - \delta + R_t + \tau^k) k_t - (1 + r)(1 + \tau^d) d_t + d_{t+1} + \pi_t - T_t$$

- And borrowing constraint

$$d_{t+1} \leq \kappa(w_t + R_t k_t + \pi_t + p_t y^N)$$

A Sudden Stop

- What does a crisis look like in this model?

- Borrowing constraint binds $\rightarrow c_{T,t} \downarrow \rightarrow c_{N,t}$ Demand $\downarrow \rightarrow p_t \downarrow \rightarrow$ Vicious cycle

- Capital controls $\rightarrow$ Consumption in good times $\downarrow \rightarrow$ Consumption in bad times $\uparrow$

Firms

- A competitive firm buys varieties $y_t^T(i)$ at price $p(i)$ and produces y^T according to:

$$y^T = \left[\int_0^1 y^T(i)^{\frac{\eta-1}{\eta}} \mathrm{di} \right]^{\frac{\eta}{\eta-1}}$$

- Firm i uses capital and labor h to produce its variety

$$y(i) = k(i)^{\alpha} h(i)^{1-\alpha}$$

- Firm Heterogeneity: Firms differ in their ability to access capital
  - Paper: Firms also differ in heterogeneous productivity $A(i)$.

Aggregation

- Taking $k(i)$ as given, let $R(i)$ be the marginal revenue productivity of capital of firm i

$$R(i) \propto \frac{p(i)y^T(i)}{k(i)}$$

- Can aggregate firms into rep. firm

$$y_t^T = \mathrm{TFP}_t \; k_t^{\alpha} h_t^{1-\alpha},$$

where

$$\log \mathrm{TFP}_t \equiv \log \mathrm{TFP}_t^* - \frac{1}{2}\,\alpha(1+\alpha(\eta-1))\mathbb{V}ar\left[\log R(i)\right]$$

Productivity Losses

- Link between misallocation and capital controls?

- Reduced form specification:

$$k(i) = k\left(1 - \frac{F(i)}{k^{\nu}}\right)$$

- Yields closed form elasticity of productivity wrt k

$$\gamma_t = \alpha(1 + \alpha(\eta - 1))\nu\, \mathbb{V}ar\left[\log R(i)\right]$$

where,

$$\gamma_t \equiv \frac{\partial \log \mathrm{TFP}_t}{\partial \log k_t}$$

Productivity Losses

- Firms rent capital through intermediaries in segmented markets
- Intermediaries rent $\hat{k}(i)$ from HHs
- Must allocate $F(i)\hat{k}(i)^{1-\nu}$ to intermediation tasks
- Rents $\hat{k}(i) - F(i)\hat{k}(i)^{1-\nu}$ to firms
- If $F(i)$ is unobserved before choosing $\hat{k}(i) \to \hat{k}(i) = k$
- ν determines how intermediation frictions scale with lending. Baseline: $\nu \in (0, 1)$
- Paper: Also possible with heterogeneous borrowing constraints or access to equity

Constrained Efficient Allocation

- As benchmark, allow government to set capital control and investment subsidy
- Implicit assumption: Govt allocation of foreign borrowing
- Two sources of inefficiency and two instruments $\rightarrow$ no trade-off
  - Capital control τ_{ce}^{d} $\rightarrow$ overborrowing
  - Investment subsidy τ_{ce}^{k} $\rightarrow$ misallocation

Second-Best Capital Controls

- Now only allow govt to set capital control
- Govt controls level of foreign borrowing but not its allocatation
- Key object: marginal propensity to invest, mpi

$$\mathrm{mpi} \equiv \frac{\partial k_{\tilde{t}}}{\partial d_{\tilde{t}}}$$

- If total borrowing increases by 1 dollar, how many cents are invested?

Second-best Capital Controls

Proposition (Implementing the Second-Best Allocation)

The capital control τ^d_{sb} that implements the second-best allocation is

$$\tau^d_{sb} = \tau^d - \frac{\mathrm{mpi}}{1+r} \times \tau^k$$

- Additional constraint introduces a policy trade-off
  - Higher capital controls reduce consumption, addressing overborrowing
  - But they reduce investment and productivity
- Quantitatively relevant?

A sufficient statistic approach

$$\tau_{sb}^{d} = \tau_{ce}^{d} - \frac{\text{mpi}}{1+r} \times \tau_{ce}^{k}$$

- Can write τ_{sb}^{d} as function of measurable objects which capture macroprudential motive
  - Probability of crisis π
  - Strength of Pecuniary externality
  - Productivity losses γ
- Paper: Full description
- Today: Focus on effects on productivity, measured by γ.

Estimating the Investment Externality

$$\gamma_t = \alpha(1+\alpha(\eta-1)) \times \nu \times \mathbb{V}ar\left[\log R(i)\right]$$

- To estimate $\mathbb{V}ar\left[\log R(i)\right]$, follow indirect approach from Hsieh and Klenow (2009)
- Recall:

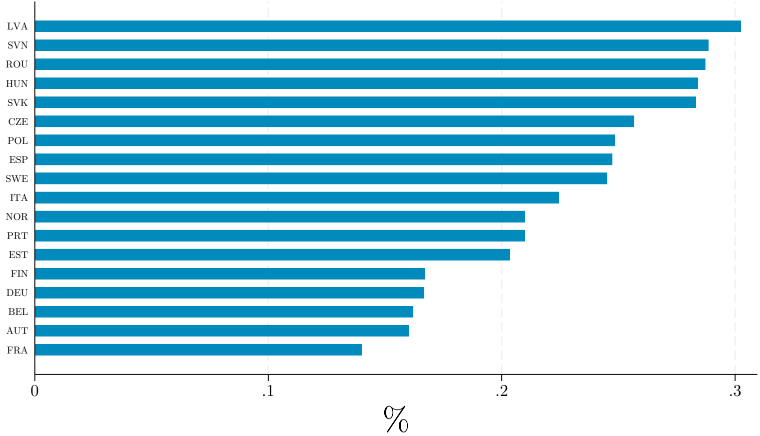
$$R(i) \propto \frac{\overbrace{p(i)y^T(i)}^{revenue}}{\underbrace{k(i)}_{capital\ \ stock}},$$

Estimating the Investment Externality

$$\gamma_t = \alpha(1+\alpha(\eta-1)) \times \nu \times \mathbb{V}ar\left[\log R(i)\right],$$

- Measuring $R(i)$ in the data requires firm's balance sheet data
- I use Orbis-Amadeus, which has extensive coverage over Europe (Kalemli-Özcan et al., 2024)
- The resulting sample spans 18 countries over the period 1996-2016, covering 1,050,610 unique firms for a total of 9,143,358 observations Summary Statistics Estimation details
- Pin down ν using TFP loss estimates from Pinardon-Touati (2024)

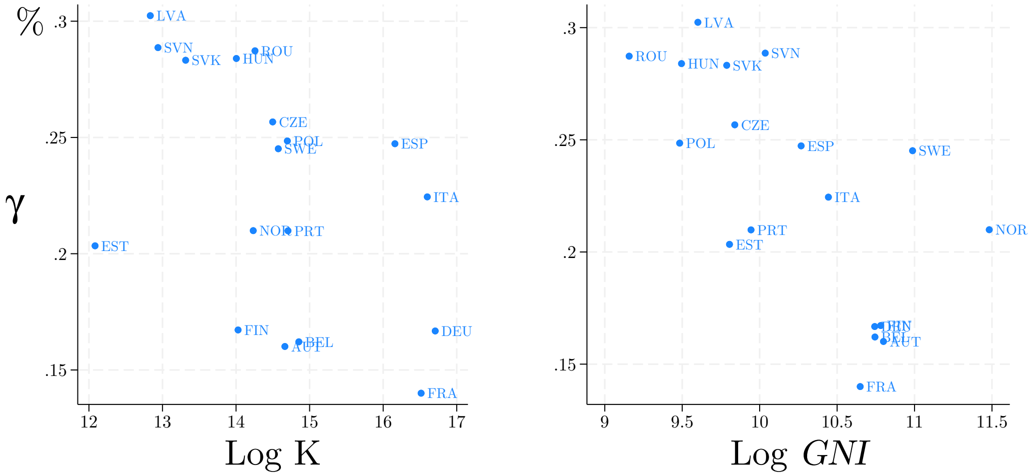
Estimates for γ_t



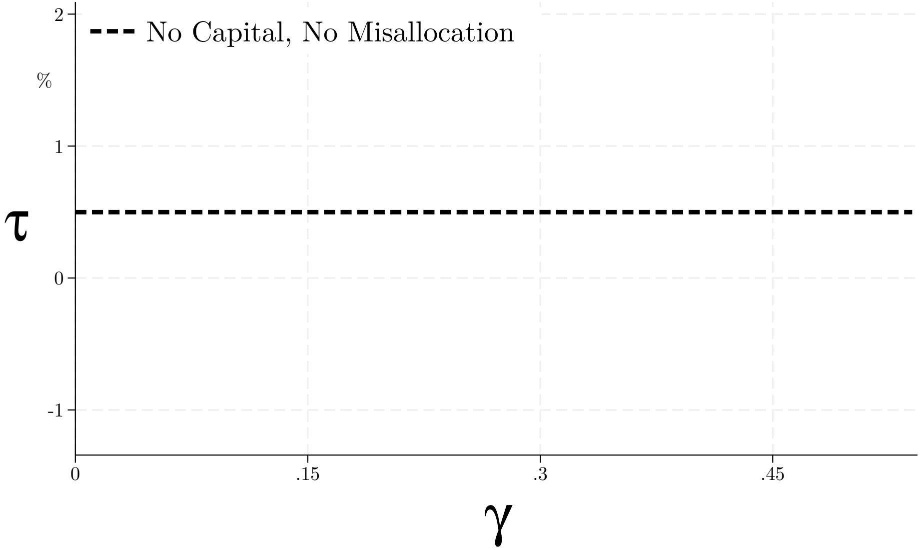
$$\gamma_t \equiv \frac{\partial \log \mathrm{TFP}_t}{\partial \log k_t}$$

Discussion of Estimates

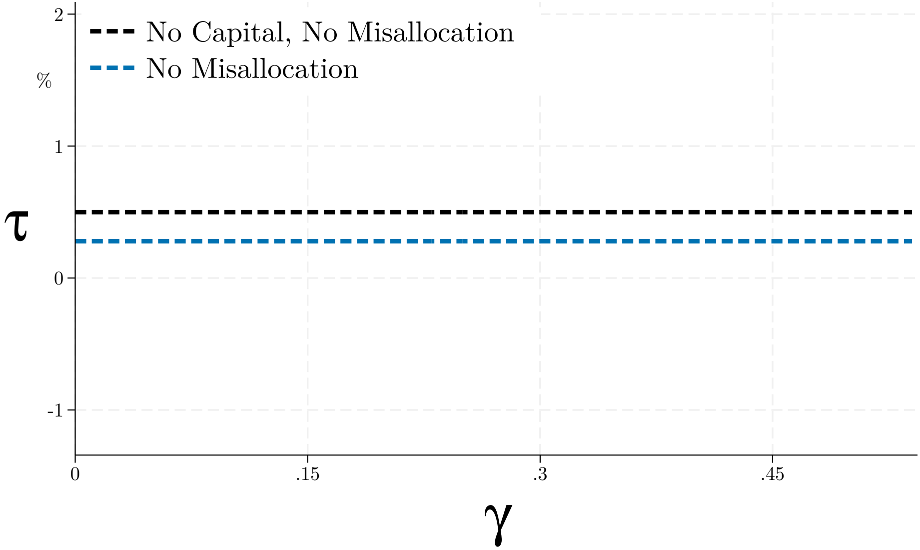
Estimates for γ_t



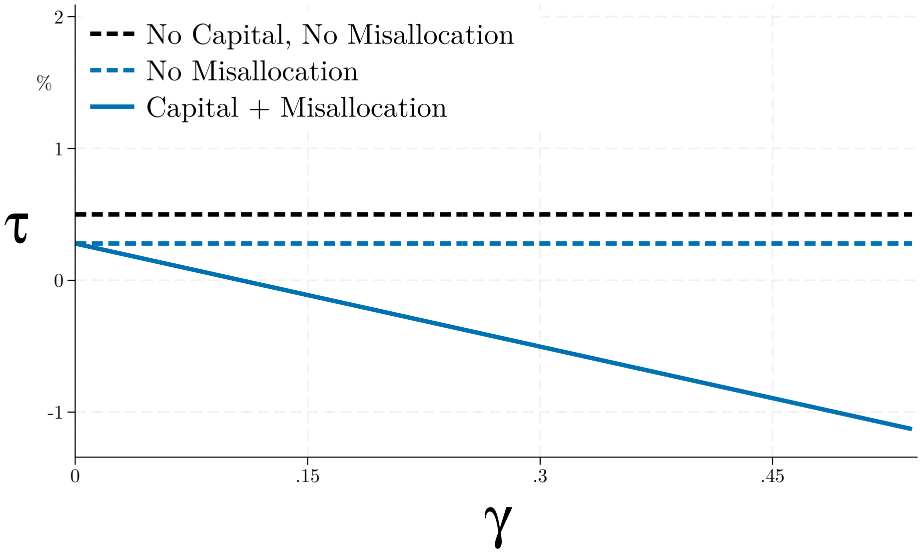
Second Best Capital Controls for $\pi = 3\%$



Second Best Capital Controls for $\pi = 3\%$

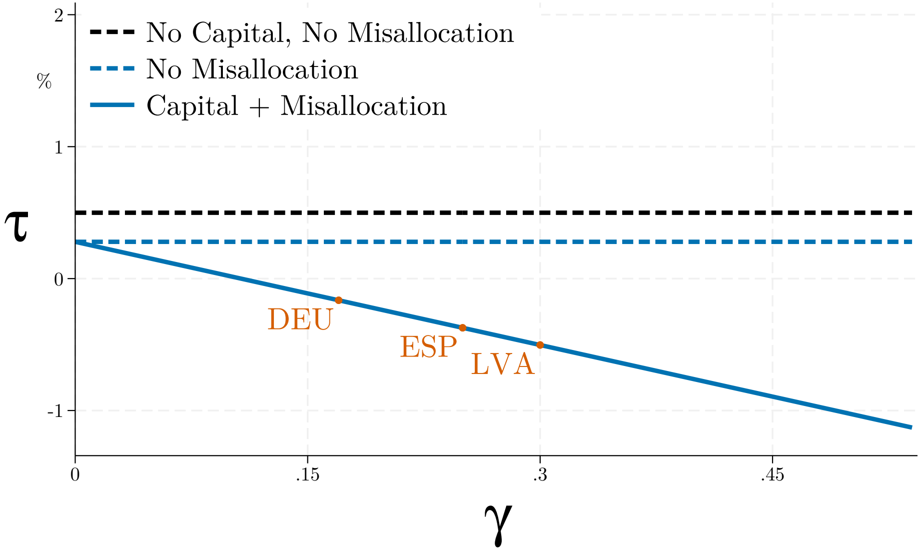


Second Best Capital Controls for $\pi = 3\%$



Second Best Capital Controls for $\pi = 3\%$

$\pi = 6\%$ $\pi = 25\%$



Conclusion

- Built model combining insights from literature on capital controls, and misallocation
- Show that negative effects on productivity can generate trade-off
- Leveraged sufficient statistic formulation together with rich micro-data to quantify trade-off
- Taking productivity losses into account $\rightarrow$ incentivize rather than restrict capital flows

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Proof of Firm Aggregation

Let MC be the marginal cost of the firm, derived from solving the cost minimization problem of the firm, with first order conditions:

$$R(i) = \alpha MC(i) \frac{y(i)}{k(i)} \tag{1}$$

$$w = (1-\alpha) MC(i) \frac{y(i)}{h(i)} \tag{2}$$

Combining into the production function yields the marginal cost of the firm:

$$MC(i) = A^{-1} \left(\frac{R(i)}{\alpha} \right)^{\alpha} \left(\frac{w}{1-\alpha} \right)^{1-\alpha} \tag{3}$$

Back

Proof of Firm Aggregation

We can now solve for the problem of the firm as:

$$\max_{y(i)} \frac{\eta}{\eta - 1} y(i)^{\frac{\eta-1}{\eta}} y^{\frac{1}{\eta}} - y(i) MC(i) \tag{4}$$

with solution:

$$y(i) = (MC(i))^{-\eta} y \tag{5}$$

Plugging back into the factor demands, we get:

$$k(i) = A(i)^{\eta-1} y \left(\frac{\alpha}{R(i)}\right)^{1+\alpha(\eta-1)} \left(\frac{1-\alpha}{w}\right)^{(1-\alpha)(\eta-1)} \tag{6}$$

$$h(i) = A(i)^{\eta-1} y \left(\frac{\alpha}{R(i)}\right)^{\alpha(\eta-1)} \left(\frac{1-\alpha}{w}\right)^{\alpha+(1-\alpha)\eta} \tag{7}$$

Back

Proof of Firm Aggregation

Then, we can obtain aggregate production as

$$y = \left[\int y(i)^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \tag{8}$$

$$= \frac{\left[\int y(i)^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}}}{\left(\int k_t(i) di \right)^{\alpha} \left(\int h_t(i) di \right)^{1-\alpha}} {k_t}^{\alpha} {h_t}^{1-\alpha} \tag{9}$$

$$= \frac{\left[\int A(i)^{\eta-1} R(i)^{-\alpha(\eta-1)} di \right]^{\frac{\eta}{\eta-1}}}{\left(\int (A(i))^{\eta-1} \left(R(i)^{-1}\right)^{1+\alpha(\eta-1)} di \right)^{\alpha} \left(\int (A(i))^{\eta-1} \left(R(i)^{-1}\right)^{\alpha(\eta-1)} di \right)^{1-\alpha}} {k_t}^{\alpha} {h_t}^{1-\alpha} \tag{10}$$

Back

Proof of Firm Aggregation

Assuming either log-normality or up to second order, we can write:

$$y = \mathrm{TFP} k^{\alpha} h^{1-\alpha} \tag{11}$$

where

$$\mathrm{TFP} = \left(\int A(i)^{\eta-1} \right)^{\frac{1}{\eta-1}} \exp\left[-\frac{1}{2}\alpha(1+\alpha(\eta-1))\mathbb{V}ar\left[\log R(i)\right] \right] \tag{12}$$

Back

Proof of $R(i)$ Determination

Start from capital demand (6) and solve for $R(i)$ as a function of $k(i)$,

$$R(i) = \alpha \left(k(i)^{-1} A(i)^{\eta-1} y \left(\frac{1-\alpha}{w} \right)^{(1-\alpha)(\eta-1)} \right)^{\frac{1}{1+\alpha(\eta-1)}} \tag{13}$$

Combining with local market clearing,

$$R(i) = \alpha \left(k^{-1} \left(1 + \frac{F(i)}{k^{\nu}} \right)^{-1} y \left(\frac{1-\alpha}{w} \right)^{(1-\alpha)(\eta-1)} \right)^{\frac{1}{1+\alpha(\eta-1)}}, \tag{14}$$

taking logs,

$$\log R(i) = \log \alpha + \frac{1}{1+\alpha(\eta-1)} \left(-\log k - \log \left(1 + \frac{F(i)}{k^{\nu}} \right) + \log y + \log \left(\frac{1-\alpha}{w} \right)^{(1-\alpha)(\eta-1)} \right), \tag{15}$$

Back

Proof of $R(i)$ Determination

Lastly, using the assumption of small $F(i)$,

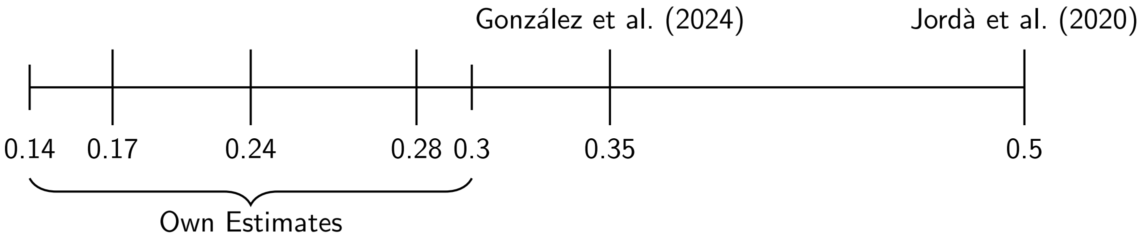
$$\log R(i) = \log \alpha + \frac{1}{1+\alpha(\eta-1)} \left(-\log k - \frac{F(i)}{k^{\nu}} + \log y + \log \left(\frac{1-\alpha}{w} \right)^{(1-\alpha)(\eta-1)} \right). \quad (16)$$

It follows that

$$\mathbb{V}ar \left[\log R(i) \right] = \left(\frac{1}{1+\alpha(\eta-1)} \frac{1}{k^{\nu}} \right)^{2} \mathbb{V}ar \left[F \right] \quad (17)$$

Back

Relationship of γ Estimates to Literature



Back

Relationship to Bau and Matray (2023)

- Bau and Matray (2023) study the differential response of high and low mrpk firms within industries exposed to changes in capital controls.

- Let i and j correspond to the former and the latter respectively.

- The diff-in-diff estimate in the model is given by

$$\Delta \log \mathrm{mrpk}(i) - \Delta \log \mathrm{mrpk}(j) = -\nu \left(\log \mathrm{mrpk}(i) - \log \mathrm{mrpk}(j)\right) \times \Delta \log k$$

Relationship to Bau and Matray

- Bau and Matray (2023) also show that firms with high mrpk reduced their mrpk by 32% more than low mrpk firms.

- They also mention that the former originally had a mprk 160% higher than the latter. Combining these, the prediction is

$$\Delta \log \mathrm{mrpk}(i) - \Delta \log \mathrm{mrpk}(j) = -0.22 \times 1.6 \times 0.32 = -0.11$$

- This undershoots their estimate of a -0.33% difference

Back

Local Credit Shocks Microfoundation

- $F(i)$ represents shocks to the credit supply of firms, as in the models of Chodorow-Reich (2013); Herreño (2023); Pinardon-Touati (2024)

- Can be overhead costs of the bank, monitoring or operating costs, additional sources of demand such as government credit demand or changes in the balance sheet of banks

$$S(i) = F(i)k^{\gamma}$$

- Let $\nu = 1 - \gamma$, then, as a result, the amount banks can lend is given by

$$k(i) = k\left(1 - \frac{F(i)}{k^{\nu}}\right)$$

Back

Borrowing Constraints Microfoundation

- The household in charge of the bank can divert a fraction of the credit. If they do that, the other households can seize a fraction of their capital k

- I assume that this diversion happens before any other trading occurs. Once the capital is seized, the household buys it again. (Bianchi and Mendoza, 2018)

- After diverting the credit, the household can hide a fraction $F(i)k(i)^{-\nu}$ of its assets

- It follows that, to avoid any diversion in equilibrium, the following incentive compatibility must hold with equality

$$k(i) = k\left(1 - \frac{F(i)}{k^{\nu}}\right)$$

Back

Heterogeneous Access to Equity

- Firms assemble capital by combining bank credit and equity $E(i)$ in the following way,

$$k(i) = \left(\theta k_b(i)^{\frac{\rho-1}{\rho}} + (1-\theta)(E(i))^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}} \tag{18}$$

- Equity is fixed. Then, total capital is given by

$$k(i) = \theta k_b(i) \left(1 + \frac{1-\theta}{\theta}\left(\frac{E(i)}{k_b(i)}\right)^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}} \tag{19}$$

- In equilibrium,

$$k(i) = \theta k \left(1 + \frac{1-\theta}{\theta}\left(\frac{E(i)}{k}\right)^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}} \tag{20}$$

$$\tag{21}$$

Back

Heterogeneous Access to Equity

- Let $F(i) \equiv \left(\frac{1-\theta}{\theta}E(i)\right)^{\frac{\rho-1}{\rho}}$ and $\nu \equiv \frac{\rho-1}{\rho}$ to write

$$k(i) = \theta k \left(1 + \frac{F(i)}{k^{\nu}}\right)^{\frac{1}{\nu}}, \tag{22}$$

Back

Competitive Equilibrium Characterization

$$w_t(s^t) = (1-\alpha)\,\mathrm{TFP}_t(s^t)\,k_t(s^{t-1})^{\alpha}$$

$$R_t(s^t) = \alpha\,\mathrm{TFP}_t(s^t)\,k_t(s^{t-1})^{\alpha-1}$$

$$c_{T,t}(s^t) + k_{t+1}(s^t) = \mathrm{TFP}_t(s^t)k_t(s^{t-1})^{\alpha} + (1-\delta)k_t(s^{t-1}) - (1+r)d_t(s^{t-1}) + d_{t+1}(s^t)$$

$$p_t(s^t) = \frac{1-\omega}{\omega}\left(\frac{c_{T,t}(s^t)}{y^N}\right)^{\frac{1}{\xi}}$$

$$d_{t+1}(s^t) \leq \kappa\left(\mathrm{TFP}_t(s^t)k_t(s^{t-1})^{\alpha} + \frac{1-\omega}{\omega}\left(\frac{c_{T,t}(s^t)}{y^N}\right)^{\frac{1}{\xi}} y^N\right)$$

Back

Competitive Equilibrium Characterization

$$c_{T,t}(s^t)^{-\sigma} = \frac{1}{1-\mu_t(s^t)} \mathbb{E}\left[c_{T,t+1}(s^{t+1})^{-\sigma}\right]$$

$$\frac{r+\delta+\mu_t(s^t)(1-\delta)}{1-\mu_t(s^t)} = \frac{\mathbb{E}\left[c_{T,t+1}(s^{t+1})^{-\sigma}\alpha\, \mathrm{TFP}_t(s^t)\, k_t(s^{t-1})^{\alpha-1}(1+\kappa\mu_{t+1}(s^{t+1}))\right]}{\mathbb{E}\left[c_{T,t+1}(s^{t+1})\right]^{-\sigma}} \mathrm{TFP}_t(s^t)$$

Back

Quantification - Calibration

Parameter	Value	Source
σ	2	Bianchi (2011)
ξ	0.5	Own
κ	0.32	Bianchi (2011)
r	0.04	Bianchi (2011)
α	0.3	Own
δ	0.05	Own
η	3	Hsieh and Klenow (2009)

Back

Quantification - Calibration

Sufficient Statistic	Value	Source
$\mathrm{mpc}_{\tilde{t}}$	0.62	Guntin et al. (2023)
mpi	0.1	Müller and Verner (2023)
π	0.017 - 0.45	Bianchi and Mendoza (2020); Greenwood et al. (2013)
$\frac{p_{\tilde{t}} y^N}{c_{T,\tilde{t}}}$	2	Bianchi and Mendoza (2020)

Back

Quantification - Estimation

Moment	Value
$\mathbb{E}\left[\left(\frac{c_{T,\tilde{t}}}{c_{T,\tilde{t}-1}}\right)^{-\sigma}\right]$	1
$\mathbb{E}\left[\left(\frac{c_{T,\tilde{t}}}{c_{T,\tilde{t}-1}}\right)^{-\sigma}\mu_{\tilde{t}} \middle\vert \mu_{\tilde{t}} > 0\right]$	0.13
$\mathbb{E}\left[\left(\frac{c_{T,\tilde{t}}}{c_{T,\tilde{t}-1}}\right)^{-\sigma}\mathrm{TFP}_{\tilde{t}}k_{\tilde{t}}^{\alpha-1}\right]$	0.28
$\mathrm{TFP}_{\tilde{t}}k_{\tilde{t}}^{\alpha-1}$	0.25

Back

Orbis Cleaning

- I follow the procedure by Kalemli-Özcan et al. (2024) as closely as possible
- To have consistent units, I keep only unconsolidated statements that cover 12 months.
- I drop spells with errors in the following way
  1. I tag unrealistic changes in assets or sales[1], or negative values for assets, sales, employment or liabilities
  2. I tag observations that do not report employment or report a number larger than 2 million, or where balance sheet identities don't hold.
- I drop all tagged observations and only keep the spell after the last identified error
- I focus on the manufacturing sector, defined using the 4-digit NACE classification.

Back

[1] In the order of 10^3

Orbis Cleaning - Summary

Country	N. Firms	N. Obs	Total Employees
Austria	9,283	88,004	72,401
Belgium	23,074	255,545	424,162
Czech Republic	42,064	314,829	823,799
Estonia	7,278	61,552	60,523
Finland	13,570	122,259	199,776
France	133,919	1,312,707	1,449,405
Germany	69,432	622,434	1,711,145
Hungary	144,485	1,084,401	483,002
Italy	204,584	1,659,439	2,042,621
Latvia	9,467	71,653	92,640
Norway	16,938	116,000	45,704
Poland	29,400	199,855	776,776
Portugal	55,038	462,410	352,406
Romania	62,621	539,698	807,445
Slovak Republic	22,344	136,706	190,646
Slovenia	20,231	138,929	116,640
Spain	158,426	1,634,164	1,520,580
Sweden	28,456	322,773	389,409

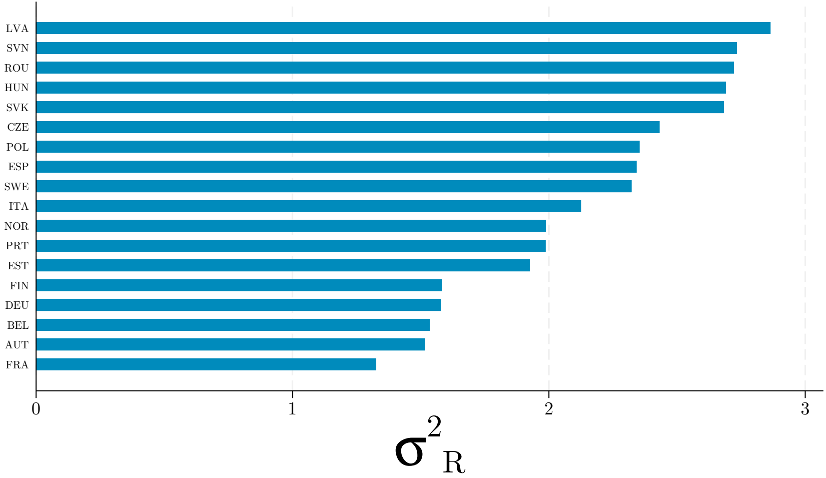
Back

Orbis - Firm-size Distribution

Panel A: Gross Output	AT	BE	CZ	DE	EE	ES	FI	FR	HU	IT	LV	NO	PL	PT	RO	SE	SI	SK
1 to 19 employees	0.05	0.03	0.07	0.01	0.14	0.20	0.07	0.09	0.04	0.13	0.03	0.16	0.02	0.20	0.13	0.21	0.12	0.16
20 to 249 employees	0.38	0.40	0.45	0.24	0.61	0.60	0.41	0.45	0.62	0.60	0.51	0.51	0.33	0.63	0.48	0.42	0.44	0.45
250+ employees	0.57	0.57	0.49	0.75	0.25	0.20	0.52	0.46	0.34	0.27	0.46	0.32	0.66	0.17	0.39	0.37	0.45	0.39
Panel B: Employment																		
1 to 19 employees	0.16	0.11	0.05	0.01	0.12	0.23	0.09	0.09	0.03	0.11	0.13	0.23	0.01	0.24	0.11	0.16	0.09	0.08
20 to 249 employees	0.38	0.40	0.39	0.30	0.56	0.47	0.41	0.33	0.31	0.50	0.54	0.48	0.34	0.53	0.35	0.33	0.39	0.38
250+ employees	0.45	0.50	0.55	0.69	0.32	0.30	0.49	0.58	0.65	0.38	0.33	0.29	0.65	0.22	0.54	0.51	0.52	0.53

Back

$\mathbb{V}ar\,[\log R(i)]$ Estimates



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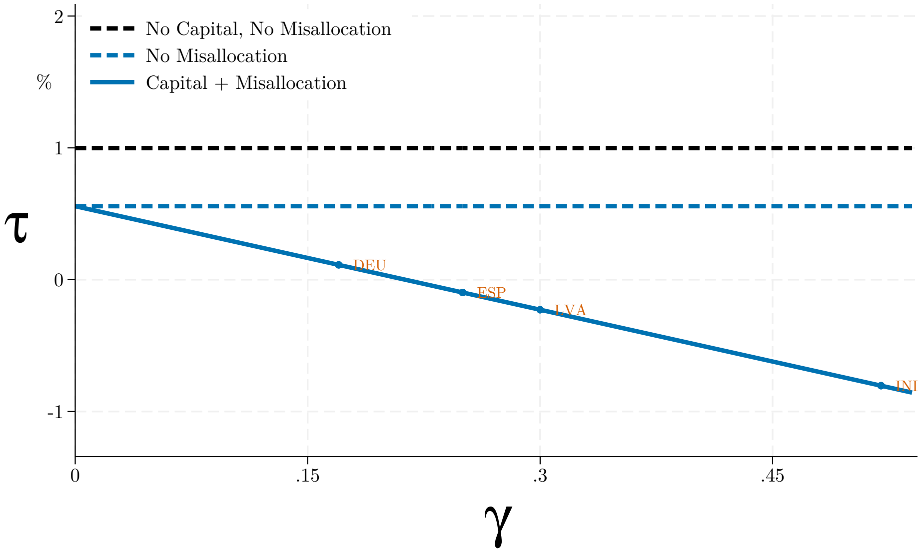
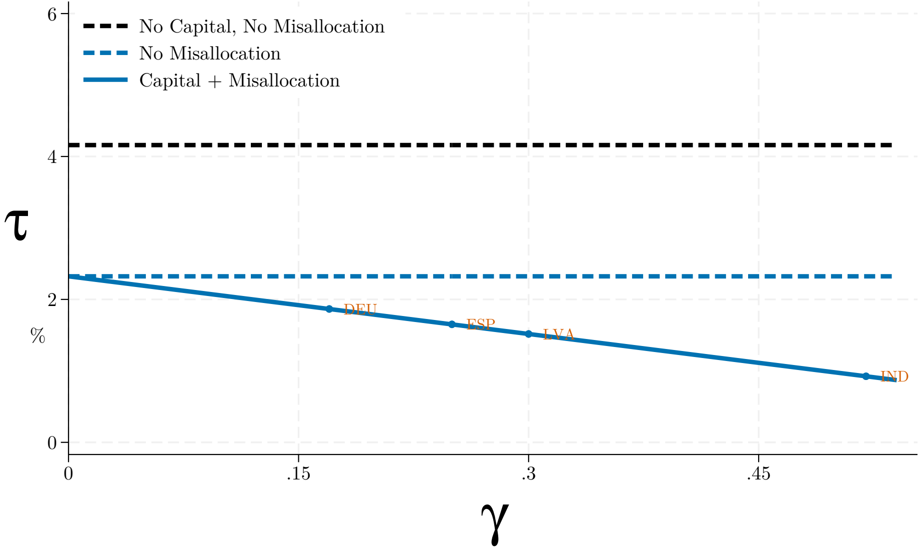
$\pi = 6\%$



No Capital, No Misallocation
No Misallocation
Capital + Misallocation
%
τ
γ
2
1
0
-1
0
.15
.3
.45
DEU
ESP
LVA
INI

Back

$\pi = 25\%$



No Capital, No Misallocation
No Misallocation
Capital + Misallocation
τ
%
6
4
2
0
0
.15
.3
.45
γ
DEU
ESP
LVA
IND

Back

Estimating $\mathbb{V}ar\left[\log R(i)\right]$

- I construct $p(i)y^T(i)$ by subtracting the cost of materials from the operating revenue of the firm

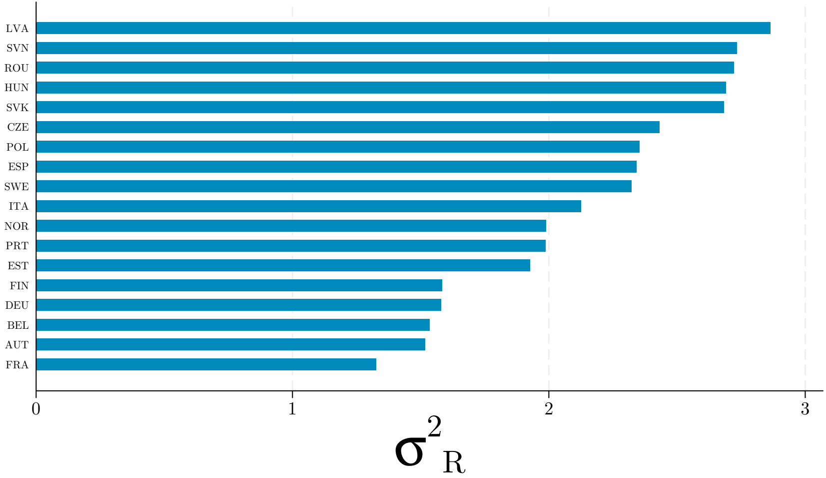
- I measure the capital stock as the sum of tangible and intangible fixed assets

- To mitigate measurement error, I winsorize both variables at the bottom and top 1%

- I estimate $\log R(i)$ at the firm level, compute its variance within 4-digit sectors

- Take the mean across industries, weighting by value added

$\mathbb{V}ar\left[\log R(i)\right]$ Estimates



Back