Financial Frictions, Market Power, and Innovation

Pedro Armada

Fordham University

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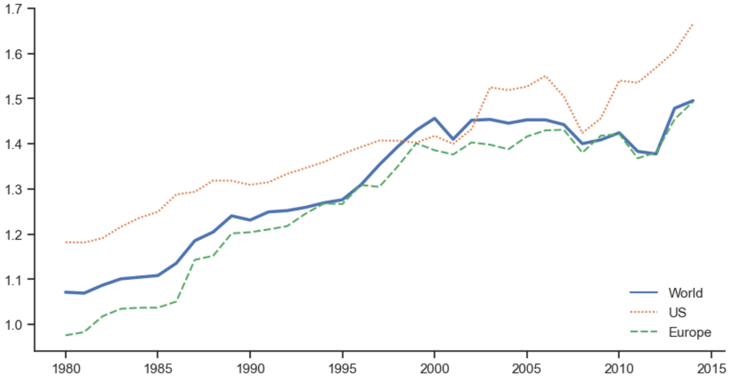
Eastern Economic Association

Introduction

- Key indicators of market power are rising across many industries in the U.S. and Europe. (De Loecker et al., 2020; De Loecker and Eeckhout, 2018; Akcigit et al., 2021)

Evolution of Global Markups



Notes: The markup is the sales-weighted average of all firms' individual markup in the geographical region in a given year. *Sources:* De Loecker et al. (2020) for the U.S., and De Loecker and Eeckhout (2018) for the World and Europe.

Introduction

- Vigorous debate about policies to address rising market power fueled by concerns about higher prices for consumers, fewer job opportunities for workers, and lower innovation.
  - Rising market power has mostly been observed among large publicly listed firms (De Loecker et al., 2020; Diez et al., 2021), which tend to have better access to external funding (Dinlersoz et al., 2019).
  - How should we think about competition policies in contexts where firms face different degrees of financial constraints?

- How do financial frictions and market power interact in shaping firms' incentives to innovate?
  - When firms have limited access to external funding, they rely on internal funds to grow.
  - The intensity of competition matters for their ability to overcome financial constraints.
  - Crucial for innovation – high upfront costs with distant uncertain returns, limited pledgeability of intangible assets.
  - More competition: stronger incentive to innovate, but more difficult to accumulate internal funds.
  - Less competition: easier to accumulate internal funds, but weaker incentive to innovate.

This Paper

- In this paper, I ask:
  - How does the economy's competitive structure affect innovation when firms are financially constrained?
  - What role does financial development play in influencing the impact of competition policies?
- Novel quantitative framework that bridges two strands of literature:
  - Macroeconomic impact of financial frictions: Buera et al. (2011), Midrigan and Xu (2014), Moll (2014), Gopinath et al. (2017), Itskhoki and Moll (2019), Buera and Fattal-Jaef (2018), Ottonello and Winberry (2023)
  - Market power at the macro-level: De Loecker et al. (2020), Basu (2019), Syverson (2019), Crouzet and Eberly (2019), Covarrubias et al., (2020), Ridder et al. (2022), Raval (2023)
- **Key takeaways**:
  - Optimal competition policy depends on the degree of financial development.
    - With binding constraints, intensifying competition lowers entrepreneurial profits and slows down the accumulation of internal funds, leading to lower innovation.
  - Financial development policies have *pro-competitive* effects.
    - With improved funding access, smaller firms can grow more rapidly and compete with larger incumbents, increasing innovation.

Outline

1. **Empirical Analysis**:
   - large administrative firm-level dataset covering the population of non-financial firms in Portugal ▸ Fin Dev PT
   - stylized facts about innovation
2. **Quantitative Model**:
   - general equilibrium framework with heterogeneous producers engaged in monopolistic competition
   - firms make dynamic decisions regarding investment and innovation
3. **Policy Counterfactuals**:
   - competition policy reforms
   - financial development policies

Data

- The empirical analysis is based on the Central Balance Sheet Database (CBSD) maintained by the Bank of Portugal.
  - Harmonized annual data: balance sheet + income statement + demographic/corporate info
  - Mandatory annual declaration → covers the population of non-financial corporations in Portugal from 2006 to 2019
- Two complementary metrics to proxy for innovation:
  - Employees engaged in R&D (include those working on new product design, manufacturing, commercialization, or process improvement)
  - Book value of intangible assets (although costs related to R&D activities are typically recognized as an expense on the income statement, certain R&D expenses related to the development of new products, processes, or software can be capitalized as intangible assets)

Data

- To obtain firm-level markups, I rely on the production approach (Hall, 1988; De Loecker and Warzynski, 2012; De Loecker et al., 2020), which is based on the cost minimization of a variable input of production.

- A translog production function is estimated separately for each sector, assuming Hicks-neutral productivity shocks:

$$y_{it} = f(k_{it}, l_{it}, m_{it}; \omega_{it})$$

  - y_{it}: output (total turnover)
  - k_{it}: capital (book value of fixed assets)
  - l_{it}: labor (employee expenses)
  - m_{it}: materials (cost of goods sold + supplies)

- Estimation methodology described in Levinsohn and Petrin (2003) and Ackerberg et al. (2015) to obtain consistent estimates of the output elasticities in the presence of unobserved productivity shocks and measurement error.

Data

- Based on the estimated output elasticities, firm-level markups are given by:

$$\mu_{ist} = \frac{\theta_{st}^{V}}{\alpha_{ist}^{V}}$$

where θ_{st}^{V} is the output elasticity of a variable input (estimated for each sector) and $\alpha_{ist}^{V} = P_{it}^{V} V_{it} / P_{it} Q_{it}$ is the revenue share of that input.

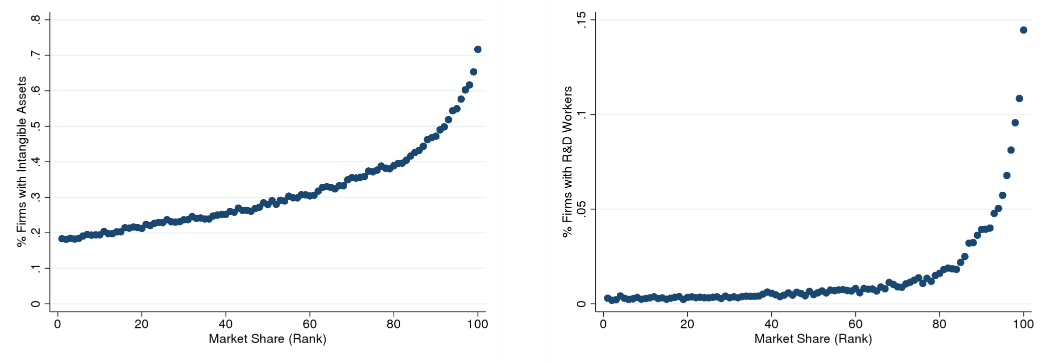
- Allows for inferring the full distribution of markups without imposing parametric assumptions on consumer demand, the underlying nature of competition, or returns to scale.
  - Literature discussing the validity of estimating markups using the production approach: Flynn et al. (2019), Kirov and Traina (2021), Ridder et al. (2022), Raval (2023), Bond et al. (2021), Basu (2019), Syverson (2019), Doraszelski and Jaumandreu (2021)

Extensive Margin

- The prevalence of intangible capital and R&D labor increases with firm size.

Panel A: Share of Firms with Intangible Capital

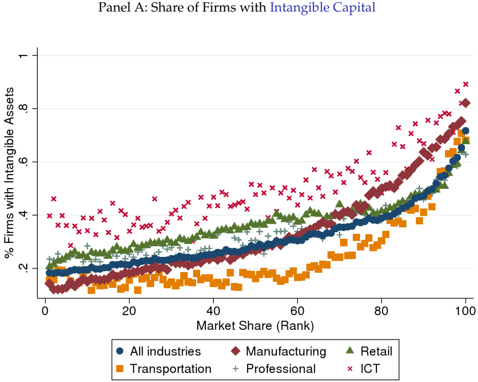
Panel B: Share of Firms with R&D Labor

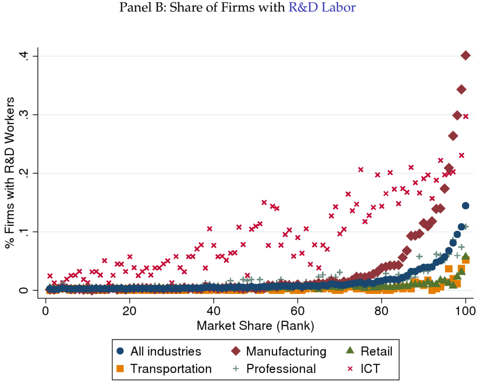


Notes: Binscatter showing the extensive margins of intangible capital and R&D along the size distribution. Firms are ranked according to market share in their respective industries (defined as the first level of NACE codes - 18 industries). Each bin groups together firms with similar market shares and displays the fraction of firms with positive intangible assets in Panel A and the fraction of firms with workers allocated to R&D activities in Panel B.

Extensive Margin

- The prevalence of intangible capital and R&D labor increases with firm size.





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Intensive Margin

- Higher innovation intensity is associated with higher market shares.

$$\text{Log(Market Share)}_{it} = \beta_0 + \beta_1 X_{it} + \Gamma' Z_{it} + \Omega' W_i + \delta_t + \varepsilon_{it}$$

	Log(Market Share)	
	(1)	(2)
Log(R&D Labor)	0.480***	
	(0.011)	
Log(Intan Capital)		0.160***
		(0.001)
Industry FE	Y	Y
Year FE	Y	Y
Firm Controls	Y	Y
Observations	12,642	273,581
Adjusted R^2	0.448	0.527

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the firm's (log) market share, with markets defined as the first level of NACE codes (18 industries). Firm controls include size, age, export status.

Robustness

Intensive Margin

- Higher innovation intensity is associated with higher markups.

$$\text{Log(Markup)}_{it} = \beta_0 + \beta_1 X_{it} + \Gamma' Z_{it} + \Omega' W_i + \delta_t + \varepsilon_{it}$$

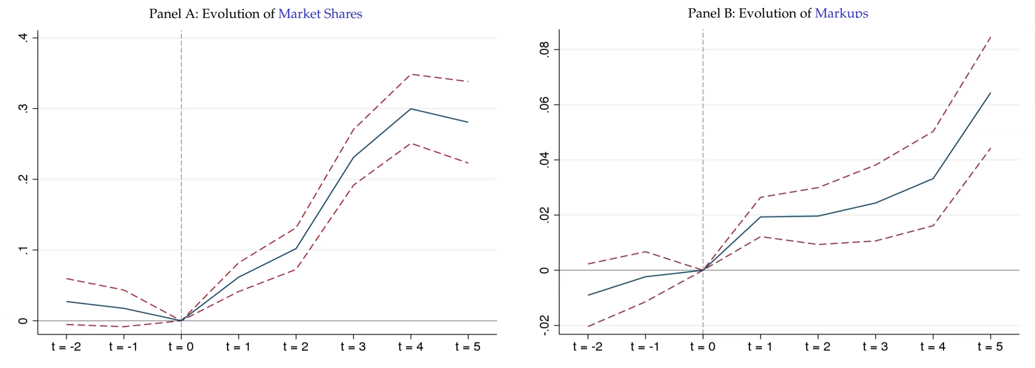
	Log(Markup)	
	(1)	(2)
Log(R&D Labor)	0.022***	
	(0.002)	
Log(Intan Capital)		0.001***
		(0.0002)
Industry FE	Y	Y
Year FE	Y	Y
Firm Controls	Y	Y
Observations	12,642	273,581
Adjusted R^2	0.239	0.205

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the (log) markup estimated following with a translog production function. Firm controls include size, age, export status.

▸ Robustness

Innovation Spells

- An innovation spell refers to a continuous period of time during which the firm has at least one R&D worker in every consecutive year after previously having none.



Notes: Estimated trajectories of market shares (Panel A) and markups (Panel B) before and after an innovation spell. The estimated regression is: $y_{it} = \sum_{\tau=-2}^{\tau=5} \mathbb{I}(t = \tau) + \Gamma' Z_{it} + \Omega' W_i + \delta_t + \varepsilon_{it}$. Innovation spells begin at $t = 1$. Outcomes are expressed in relation to the reference year $t = 0$ (omitted category), i.e., the year immediately preceding the start of the innovation spell. All estimated trajectories are conditional on industry- and year-fixed effects. Firm demographics include size, age, and export status. The dashed lines correspond to 95% confidence intervals.

Robustness

Model

- Standard model of heterogeneous entrepreneurs à la Buera et al. (2011) and Gopinath et al. (2017) augmented to include:
  - Variable markups
  - Innovation choice

- Innovation is modeled as a a productivity-enhancing process, capturing both *product* and *process* innovation.

- Firms engaged in R&D activities are more productive and able to capture higher market shares. As such, their products face lower demand elasticity and command higher markups.

- Since innovation is costly, a firm's ability to exercise market power determines how quickly it can overcome financial constraints and engage in innovation.

The Economy

- There is a large number of infinitely lived firms, indexed by $i = 1, \dots, N$, that produce differentiated varieties.

- Firms are owned by risk-averse agents with lifetime utility given by:

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t u(c_{it})$$

  where $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$ and γ denotes the coefficient of relative risk aversion.

- Entrepreneurs can save and borrow in a one-period bond at an exogenous real interest rate r_t.

- There is a fixed mass $\bar{L}$ of hand-to-mouth workers who supply labor inelastically at an equilibrium wage rate w_t.

The Economy

- **Technology**: Firms have a choice between two production technologies.
  - Traditional technology (τ)

    Production function:

    $$y_{it}^{\tau} = \exp(z_{it})\, k_{it}^{\alpha}\, l_{it}^{1-\alpha}$$

    Profit function:

    $$\pi_{it}^{\tau} = p_{it} y_{it}^{\tau} - (r_t + \delta) k_{it} - w_t l_{it}$$

  - R&D-intensive technology (κ)

    Production function:

    $$y_{it}^{\kappa} = \exp(z_{it} + \phi(\nu_{it}))\, k_{it}^{\alpha}\, (l_{it} - \nu_{it})^{1-\alpha}$$

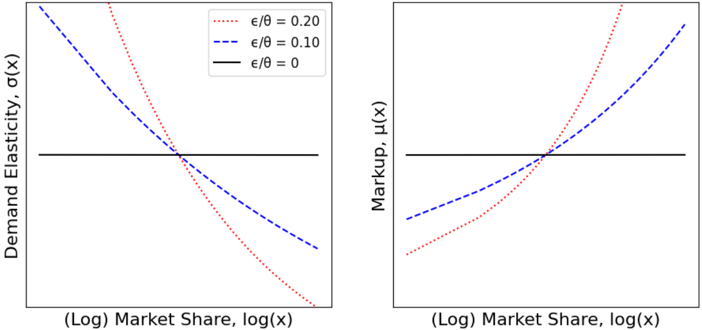
    Profit function:

    $$\pi_{it}^{\kappa} = p_{it} y_{it}^{\kappa} - (r_t + \delta) k_{it} - w_t l_{it} - c_f$$

The Economy

- **Market Structure**: Firms are monopolistically competitive and face downward-sloping demand curves.
  - Each firm i is the sole supplier of a given variety. There is a total number of N_t varieties.
  - A perfectly competitive final good firm produces the homogeneous output good Y_t by assembling all available varieties:
  $$\int_0^{N_t} \Upsilon\left(\frac{y_{it}}{Y_t}\right) di = 1$$
  where Υ is the Kimball aggregator, with $\Upsilon' > 0$, $\Upsilon'' < 0$, with $\Upsilon(1) = 1$.
  - Adopting the Klenow and Willis (2016) specification yields the following inverse demand function for each variety i:
  $$p(y_{it}) = \Upsilon'\left(\frac{y_{it}}{Y_t}\right) = \left(\frac{\theta - 1}{\theta}\right) \exp\left(\frac{1 - \left(\frac{y_{it}}{Y_t}\right)^{\frac{\epsilon}{\theta}}}{\epsilon}\right)$$
  - Under this specification, demand elasticity and markups vary according to the firm's market share.

The Economy



- Demand elasticity = $-\frac{\Upsilon'(x)}{\Upsilon''(x)x} = \theta x^{-\frac{\epsilon}{\theta}}$ (large firms face less elastic demand)
- Superelasticity of demand = $-\frac{d \ln \sigma(x)}{d \ln x} = \frac{\epsilon}{\theta}$ (rate of change of elasticity is constant)
- The firm accrues market power as it grows in size: the demand elasticity of each firm's variety decreases with its market share. The rate at which demand elasticity falls with market share is governed by the *superelasticity* of demand.

The Economy

- **Productivity**:
  - Partly endogenous from R&D technology adoption.
  - Idiosyncratic persistent shocks that evolve according to an AR(1) Markov process:

$$z_{it+1} = \rho z_{it} + \varepsilon_{it} \qquad \varepsilon_{it} \sim N(0, \sigma^2)$$

  - No aggregate uncertainty.

- **Financial Markets**:
  - Borrowing limited by imperfect enforceability of contracts: firms can only borrow up to a fraction of their capital stock.

$$k_{it+1} \leqslant \lambda a_{it+1}$$

where λ controls the tightness of the borrowing constraint, and a_{it+1} is the firm's net worth (capital stock minus debt).

Recursive Formulation

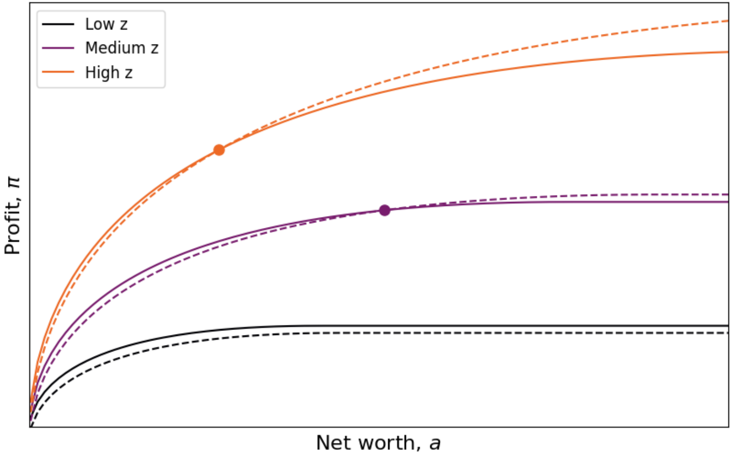
Letting $a_{it} = k_{it} - b_{it}$ denote the firm's net worth, and using primes to denote next-period variables, we can rewrite the firm's problem in recursive form as follows:

$$V(a,z) = \max\{V^{\tau}(a,z), V^{\kappa}(a,z)\}$$

$$\begin{aligned}
V^{\tau}(a,z) &= \max_{c,a'}\{u(c) + \beta \mathbb{E} V(a',z')\} \\
\text{s.t.:} \quad & c + a' = \pi + (1+r)a \\
& \pi = \max_{k,l}\{py - (r+\delta)k - wl\} \\
& y = \exp(z)\, k^{\alpha}\, l^{1-\alpha} \\
& p = \Upsilon'\left(\frac{y}{Y}\right) \\
& k \leqslant \lambda a
\end{aligned}$$

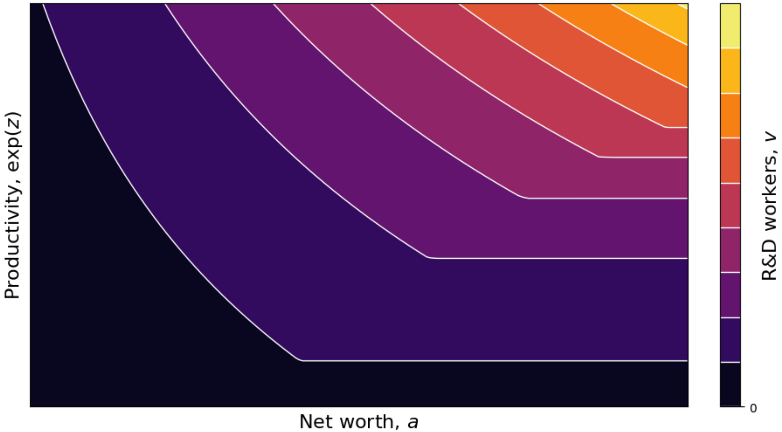
$$\begin{aligned}
V^{\kappa}(a,z) &= \max_{c,a'}\{u(c) + \beta \mathbb{E} V(a',z')\} \\
\text{s.t.:} \quad & c + a' = \pi + (1+r)a \\
& \pi = \max_{k,l,\nu\leqslant l}\{py - (r+\delta)k - wl - c_f\} \\
& y = \exp\left(z + \xi \log \nu\right)\, k^{\alpha}\, (l-\nu)^{1-\alpha} \\
& p = \Upsilon'\left(\frac{y}{Y}\right) \\
& k \leqslant \lambda a
\end{aligned}$$

Extensive Margin



Notes: Profit functions for traditional and R&D-intensive technology according to productivity and net worth. Solid lines represent profit under traditional technology. Dashed lines represent profit under R&D-intensive technology.

Intensive Margin



Notes: Contour plot shows the intensive margin of innovation according to productivity and net worth. While productivity plays a crucial role in determining the number of workers assigned to R&D activities, these decisions are also significantly influenced by the level of net worth. In particular, high-productivity firms with low net worth will pursue suboptimal levels of R&D activity.

Policy Counterfactuals

- Calibrate the model to match key features of the Portuguese firm-level data.
- Validate by ability to match untargeted moments.
- Evaluate the aggregate effect of two policy counterfactuals:
  - **Competition policy reforms**
    - *Model parameter:* Superelasticity of demand (speed at which firms accumulate market power)
  - **Financial development policies**
    - *Model parameter:* Collateral requirement (tightness of borrowing constraint)
- Change on parameter at a time and allow for the economy's general equilibrium response (labor and goods markets clear).

Model Solution

The model does not admit a closed-form solution, so I solve it numerically using discrete state-space methods on a finely discretized grid of productivity and net worth.

1. Guess aggregate output Y and equilibrium wage rate w.
2. Solve static problems (optimal inputs and technology) using a constrained maximization algorithm (SLSP).
3. Solve dynamic problems using Howard's policy iteration.
4. Simulate a panel of N firms for T periods using Monte Carlo simulation.
5. Compute the stationary distributions of agents over individual states.
6. Compute the aggregate variables and check aggregate consistency conditions.
7. Update guesses for Y and w if necessary using a root-finding algorithm (Powell's conjugate direction).

Calibration

Externally calibrated

γ	β	δ	α	r
1.50	0.87	0.06	0.33	0.05

Internally calibrated

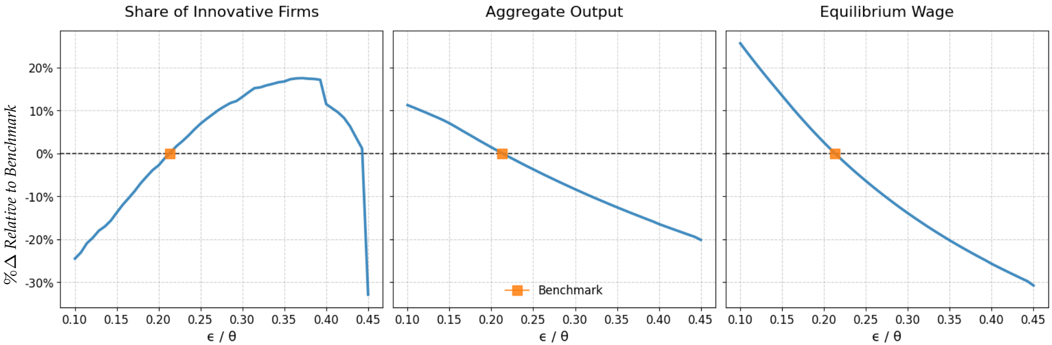
Targeted Moments	Data	Model	Parameter	Value
Serial Correlation of Output	0.730	0.921	ρ	0.918
Top 10% Employment Share	0.509	0.528	σ	0.340
Avg Debt-to-Equity	0.281	0.263	λ	1.283
Average Markup	1.245	1.324	θ	4.039
P90 Markup	1.765	1.773	ϵ/θ	0.213
Avg Share of R&D Workers	0.072	0.062	ξ	0.044
Relative Scale of R&D firms	8.808	9.887	c_f	0.001

Model fit

Untargeted Moments	Data	Model
Share R&D Firms	0.115	0.105
Elasticity of Market Share wrt R&D	0.539	1.434
Elasticity of Markup wrt R&D	0.022	0.620

Policy I: Competition Policy Reforms

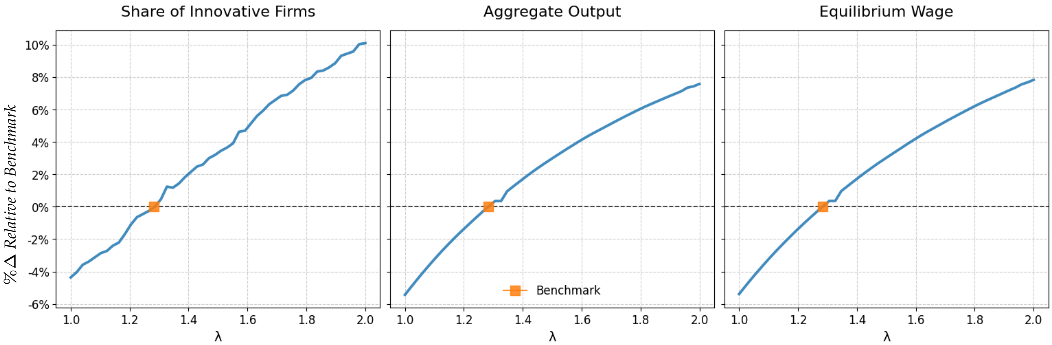
- In the model, the speed at which firms can accumulate market power is governed by the superelasticity of demand ϵ/θ. (intensifying competition $\Rightarrow \downarrow \epsilon/\theta$)



- Policies that intensify competition among firms can come at a cost of lower innovation if borrowing constraints are severe.

Policy II: Financial Development Policies

- In the model, the tightness of the borrowing constraint and therefore the level of financial development is governed by the parameter λ. (improving financial development $\Rightarrow \uparrow \lambda$)



- Improving firms' access to external funding increases the share of innovative firms by allowing productive firms to expand and grow out of their financial constraints. This increases aggregate output and wages.

Conclusion

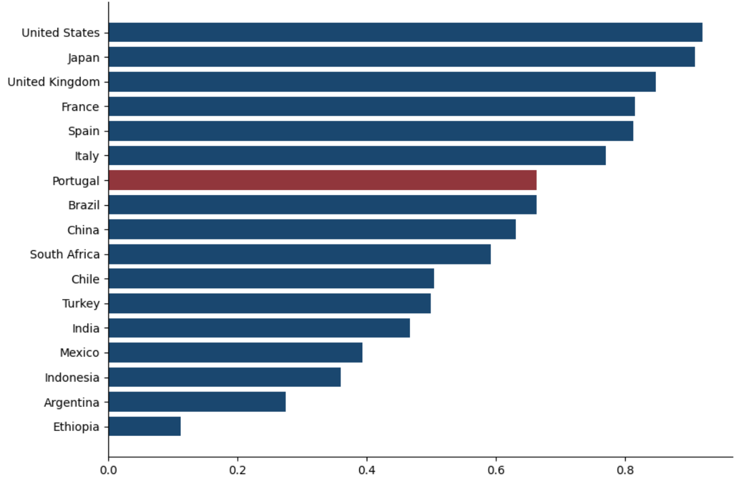
- Documented **stylized facts about innovation** using an administrative firm-level dataset from Portugal.
  - R&D labor and intangible capital are associated with higher market shares and markups, both at the extensive and intensive margins.
  - Innovation spells are accompanied by large and persistent increases in both markups and market shares.
- Motivated by the empirical evidence, I develop a **novel quantitative framework** of imperfectly competitive heterogeneous producers that make dynamic decisions regarding investment and innovation.
  - Stricter antitrust enforcement comes at the cost of lower innovation when borrowing constraints are binding.
  - Improving financial markets allows more firms to expand and engage in innovation.
- **Policy implications**:
  - Competition policies should be tailored to a country's degree of financial development.
  - Financial development policies as a lever to stimulate innovation and competition. *(Draghi report, Sep 2024)*

Thank you!

www.pedroarmada.com

pxarmada@fordham.edu

Financial Development



Notes: The figure shows the Financial Development (FD) index in 2019 for a selection of countries, sourced from the IMF's Financial Development Index Database (Svirydzenka, 2016). The FD index captures the development of financial institutions and markets, focusing on three dimensions: depth, access, and efficiency.

▸ Back

Intensive Margin

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$$\text{Log(Market Share)}_{it} = \beta_0 + \beta_1 X_{it} + \Gamma' Z_{it} + \Omega' W_i + \delta_t + \varepsilon_{it}$$

	Log(Market Share)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(R&D Emp)	0.539***	0.480***	0.107***			
	(0.012)	(0.011)	(0.008)			
Log(Intan Cap)				0.172***	0.160***	0.023***
				(0.001)	(0.001)	(0.001)
Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Firm Controls	-	Y	Y	-	Y	Y
Firm FE	-	-	Y	-	-	Y
Observations	12,646	12,642	11,280	273,582	273,581	259,264
Adjusted R^2	0.305	0.448	0.975	0.445	0.527	0.970

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the firm's (log) market share, with markets defined as the first level of NACE codes (18 industries). Firm controls include size, age, export status.

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	Log(Markup)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(R&D Emp)	0.022***	0.022***	0.009***			
	(0.005)	(0.002)	(0.003)			
Log(Intan Cap)				0.001***	0.001***	0.002***
				(0.0002)	(0.0002)	(0.0002)
Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Firm Controls	-	Y	Y	-	Y	Y
Firm FE	-	-	Y	-	-	Y
Observations	12,646	12,642	11,280	273,582	273,581	259,264
Adjusted R^2	0.237	0.239	0.802	0.202	0.205	0.809

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable is the (log) markup estimated following with a translog production function. Firm controls include size, age, export status.

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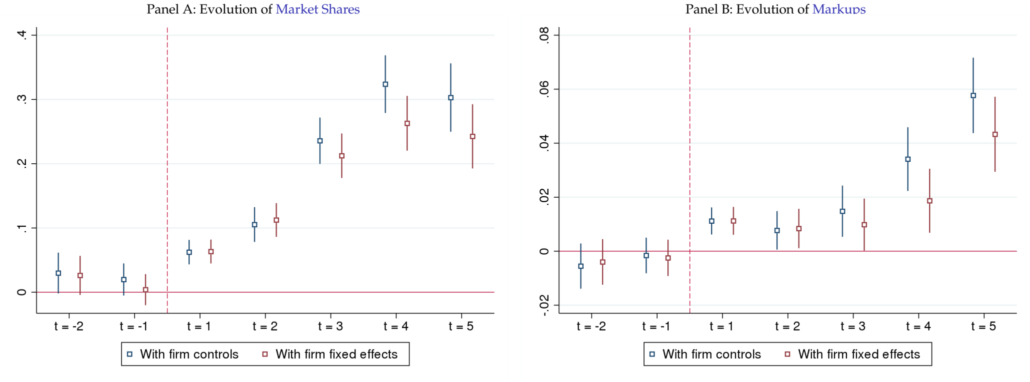

Notes: Estimated trajectories of market shares (Panel A) and markups (Panel B) before and after an innovation spell. The estimated regression is: $y_{it} = \sum_{\tau=-2}^{\tau=5} \mathbb{I}(t=\tau) + \Gamma' Z_{it} + \Omega' W_i + \delta_t + \varepsilon_{it}$. Innovation spells begin at $t = 1$. Outcomes are expressed in relation to the reference year $t = 0$ (omitted category), i.e., the year immediately preceding the start of the innovation spell. All estimated trajectories are conditional on industry- and year-fixed effects. Firm demographics include size, age, and export status. The vertical lines correspond to 95% confidence intervals.

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