Financial Frictions, Market Power, and Innovation

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Introduction

- Key indicators of market power are on the rise across many industries in the U.S. and Europe, suggesting that large firms are increasingly dominating their respective markets. (De Loecker et al., 2020; De Loecker and Eeckhout, 2018; Akcigit et al., 2021)

- In addition to raising prices for consumers and limiting job opportunities for workers, growing market power also hinders innovation, a crucial driver of long-term economic growth.

- To the extent that 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), an important question is whether and how financial frictions and market power interact in shaping firms' incentives to innovate.

- 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?

This Paper

- I use an administrative firm-level dataset covering the population of non-financial firms in Portugal to document that firm innovation is associated with higher market shares and markups, both at the extensive and intensive margins.

- Motivated by the empirical evidence, I develop a general equilibrium framework with heterogeneous producers engaged in monopolistic competition that make dynamic decisions regarding investment and innovation.

- In the model, financial frictions constrain firms' productive capacity, reduce competition, and distort innovation.

- Two counterfactual analyses:
  - Policies that promote a country's financial development improve aggregate output and wages by allowing firms to expand and engage in innovation.
  - Policies that intensify competition among firms can come at a cost of lower innovation when firms face severe borrowing constraints.

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 capital (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

- I estimate firm-level markups using 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 (intermediate inputs):

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

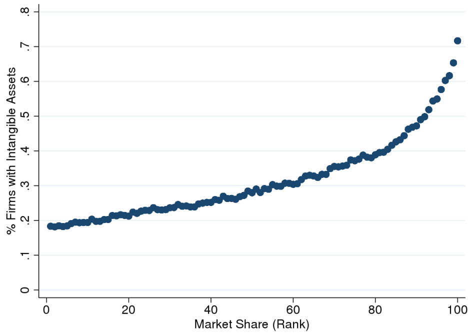
where θ_{st}^{V} is the output elasticity of a variable input (estimated for each sector) and the revenue share of that input $\alpha_{ist}^{V} = P_{it}^{V} V_{it} / P_{it} Q_{it}$.

- Allows for inferring the full distribution of markups without imposing parametric assumptions on consumer demand, the underlying nature of competition, or returns to scale.

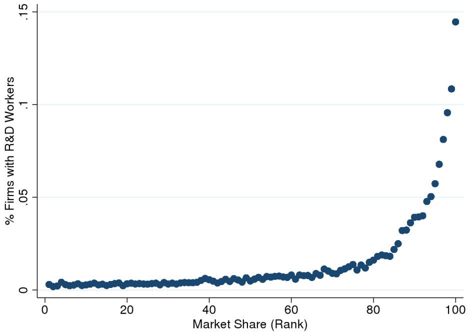
Extensive Margin

- 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 Workers



Notes: Binscatter displaying the extensive margins of R&D and Intangible Capital 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.

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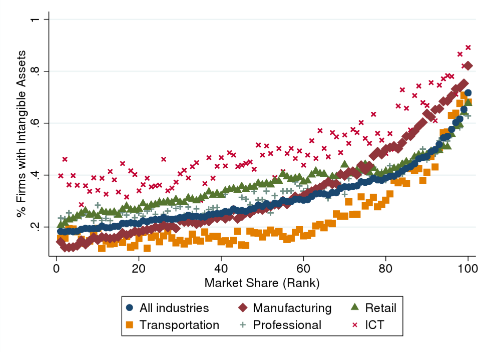

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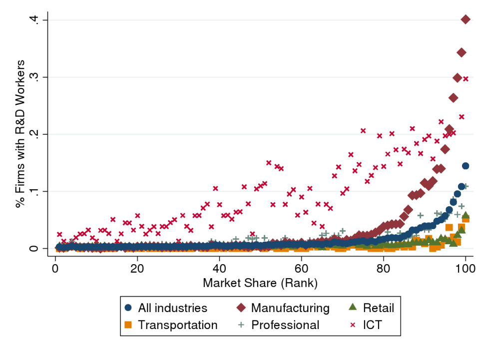

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Intensive Margin

- 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 Emp)	0.480***	
	(0.011)	
Log(Intan Cap)		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.

Intensive Margin

- Higher innovation intensity is associated with higher markups.

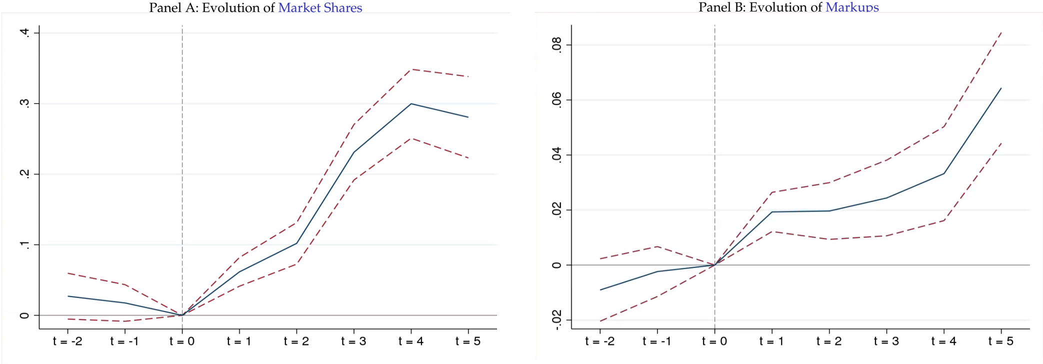
$$\text{Log(Markup)}_{it} = \beta_0 + \beta_1 X_{it} + \Gamma' Z_{it} + \Omega' W_i + \delta_t + \varepsilon_{it}$$

	Log(Markup)	
	(1)	(2)
Log(R&D Emp)	0.022***	
	(0.002)	
Log(Intan Cap)		0.001***
		(0.000)
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.

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 vertical lines correspond to 95% confidence intervals.

Model

- Since innovation is an endogenous decision that reflects the selection of firms along unobservable characteristics, I turn to a quantitative model that rationalizes the decision to innovate on both margins.
- Standard model of heterogeneous entrepreneurs à la Buera et al. (2011) and Gopinath et al. (2017) augmented to include:
  - Variable markups
  - Innovation choice
- The fact that R&D activities are associated with higher markups and higher market shares motivates the choice of modeling innovation as a productivity-enhancing process.
- 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.

The Economy

- There is a large number of infinitely lived firms, indexed by $i = 1, \ldots, N$, that produce differentiated varieties.
- Firms are owned by risk-averse entrepreneurs who 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.
- Firms have a choice between two production technologies:
  - Traditional technology (τ)
  - R&D-intensive technology (κ)

Traditional Technology

- The production function with traditional technology is a Cobb-Douglas, constant returns-to-scale function:

  $$y^{\tau}_{it} = \exp(z_{it})\, k^{\alpha}_{it}\, l^{1-\alpha}_{it}$$

  where y_{it} denotes physical output, z_{it} is the firm's idiosyncratic productivity, k_{it} is the capital stock, l_{it} is labor.

- Given factor prices w_t and r_t, the profit of a firm operating the traditional technology is:

  $$\pi^{\tau}_{it} = p_{it} y^{\tau}_{it} - (r_t + \delta) k_{it} - w_t l_{it}$$

  where p_{it} is the price of its variety, and δ is the rate of depreciation of capital.

R&D-Intensive Technology

- The production function using R&D-intensive technology is given by:

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

  where ν_{it} represents the portion of the firm's workforce allocated to R&D activities. Labor allocated to R&D is not available to produce.

- Taking the path of r_t and w_t as given, the profit of the R&D-intensive firm is:

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

  where c_f denotes fixed operating costs. All labor (including productive and R&D work) is assumed to be remunerated at the same wage rate.

- The function $\phi(\nu_{it}) = \xi \log \nu_{it}$ disciplines the relative productivity of R&D work.

Market Structure

- 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:

$$\int_0^{N_t} \Upsilon\left(\frac{y_{it}}{Y_t}\right) di = 1 \tag{1}$$

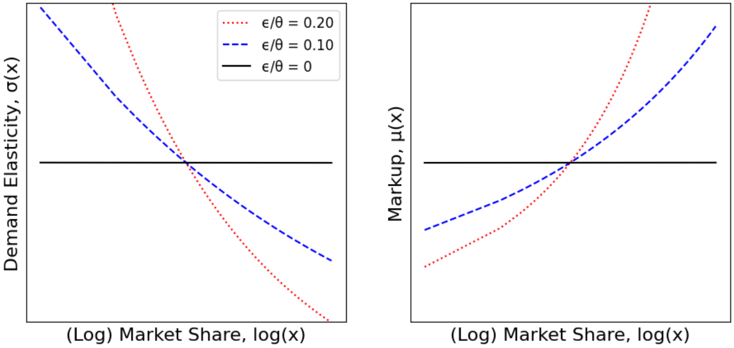
  where Υ is the Kimball aggregator, which is strictly increasing and concave, that is, $\Upsilon' > 0$, $\Upsilon'' < 0$, with $\Upsilon(1) = 1$.

- Following the literature, I adopt the Klenow and Willis (2016) which yields the following inverse demand function for each variety i:

$$p(y_{it}) = \Upsilon'\left(\frac{y_{it}}{Y_t}\right) = \left(\frac{\theta - 1}{\theta}\right) \exp\left(\frac{1 - \left(\frac{y_{it}}{Y_t}\right)^{\frac{\epsilon}{\theta}}}{\epsilon}\right) \tag{2}$$

- Under this specification, demand elasticity and markups vary according to the firm's market share.

Market Structure



- 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)
- CES case when $\epsilon \to 0$

Productivity

- Firms are subject to idiosyncratic productivity shocks but there is no aggregate uncertainty.

- Productivity z_{it} is stochastic and evolves according to an AR(1) Markov process:

$$z_{it+1} = \rho z_{it} + \varepsilon_{it} \qquad \varepsilon_{it} \sim N(0, \sigma^2) \tag{3}$$

  where ρ measures the degree of persistence in productivity, and σ^2 is the variance of stochastic idiosyncratic risk.

Financial Markets

- Firms can only borrow intra-temporally up to a portion of their capital stock. The borrowing constraint is given by:

$$b_{t+1} \leqslant \chi k_{t+1} \tag{4}$$

  where χ indexes the tightness of the borrowing constraint.

- If $\chi = 0$, firms operate in a zero credit environment, whereas if $\chi = \infty$, firms become financially unconstrained.

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:

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

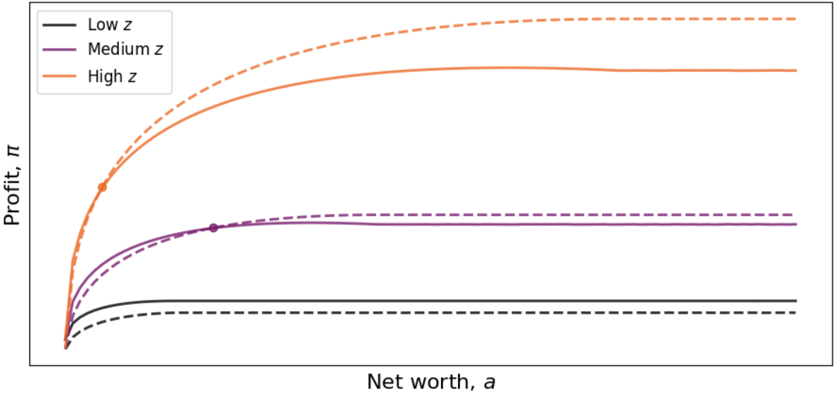
$$V^{\tau}(a,z) = \max_{c,a'}\{u(c) + \beta\mathbb{E}V(a',z')\}$$

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

$$V^{\kappa}(a,z) = \max_{c,a'}\{u(c) + \beta\mathbb{E}V(a',z')\}$$

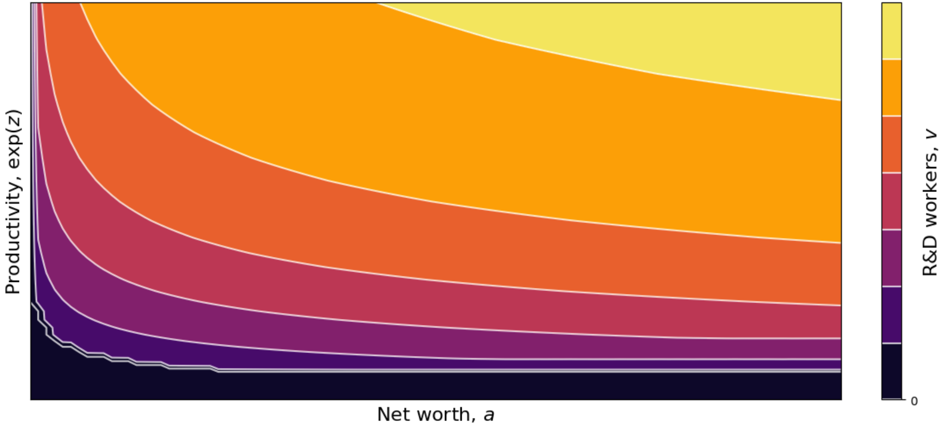
$$\begin{aligned}
\text{s.t.:}\quad & c + a' = \pi + (1+r)a \\
& \pi = \max_{k,l,\nu\leqslant l}\{py - (r+\delta)k - wl - c_f\} \\
& y = \exp\left(z + \xi\log\nu\right)\, k^{\alpha}\, (l-\nu)^{1-\alpha} \\
& p = \Upsilon'\left(\frac{y}{Y}\right) \\
& k \leqslant \lambda a
\end{aligned}$$

Technology Choice



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.

R&D-Intensity Choice



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.

Calibration

Target	Data	Model	Parameter	Value
Exogenously Calibrated				
Risk aversion			γ	1.50
Discount factor			β	0.87
Depreciation rate			δ	0.06
Capital share			α	0.33
Interest rate			r	0.05
Endogenously Calibrated				
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

Quantitative Fit

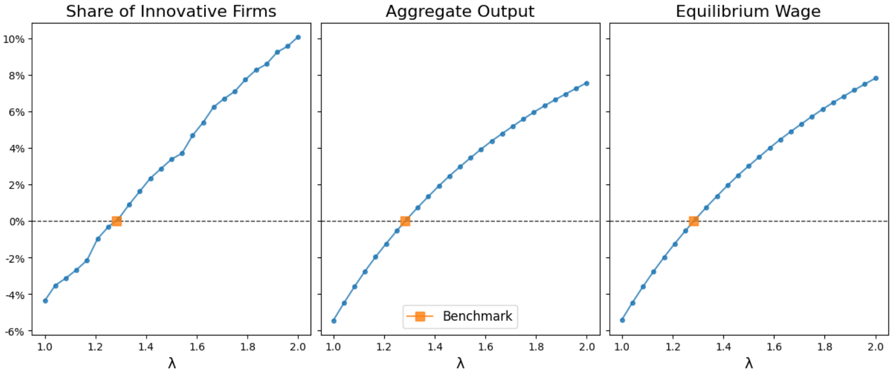
Untargeted Moments	Data	Model
Share R&D Firms	0.115	0.105
Elasticity of Market Share wrt R&D	0.539	1.434
Elasticity of Markup wrt R&D	0.022	0.620

Next: Policy Counterfactuals

- **Policy I:** Financial Development
- **Policy II:** Reforming Competition Policy

Policy I: Financial Development

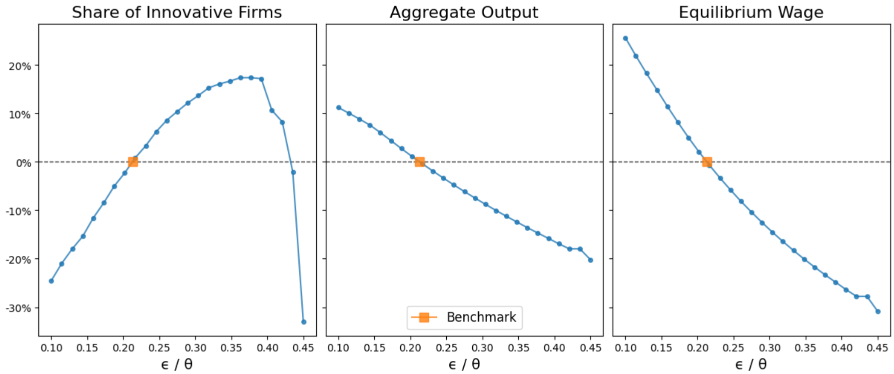
- In the model, the tightness of the borrowing constraint and therefore the level of financial development is governed by the parameter λ. (improving financial development $\Rightarrow \uparrow \lambda$)



- 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.

Policy II: Competition Policy Reforms

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



- Policies that intensify competition among firms can come at a cost of lower innovation if borrowing constraints are sufficiently severe.
- But the incentive to invest in costly innovation dissipates if firms are able to quickly accumulate market power.

Related Literature

- Macroeconomic impact of financial frictions: Buera et al. (2011), Midrigan and Xu (2014), Moll (2014), Gopinath et al. (2017), Itskhoki and Moll (2019), among others.
  - These papers assume an exogenous distribution of productivity, so the costs of financial frictions only arise from distortions to capital decisions.
  - **This paper:** Financial frictions also distort the distribution of productivity by affecting innovation decisions.
- Impact of financial frictions on innovation: Buera and Fattal-Jaef (2018) and Ottonello and Winberry (2023).
  - These papers abstract from the role of market power.
  - **This paper:** Market power plays a key role in both investment and innovation decisions.

Conclusion

- Using a comprehensive firm-level dataset from Portugal, I show that:
  - At the extensive margin, firms with higher market shares in their respective industries are more likely to have workers allocated to R&D and operate using intangible capital.
  - At the intensive margin, a higher intensity of R&D labor and intangible capital is associated with higher market shares and markups.
  - Innovation spells are accompanied by large and persistent increases in both markups and market shares.
- Motivated by the empirical evidence, I augmented a framework of heterogeneous producers with an innovation decision and variable markups.
  - In the model, financial frictions constrain productive capacity, distort innovation decisions, and reduce competition.
  - Policies that improve a country's financial development allow small firms to expand and engage in innovation, improving aggregate output and wages.
  - Policies that intensify competition between firms may come at a cost of lower innovation and aggregate output if borrowing constraints are sufficiently severe.
- These findings underscore the importance of tailoring a country's competition policy to its level of financial development.