Good Rents versus Bad Rents: R&D Misallocation and Growth

Philippe Aghion (LSE) Antonin Bergeaud (BdF) Timo Boppart (IIES)

Peter J. Klenow (Stanford) Huiyu Li (Fed SF)

NBER SI Macroeconomics and Productivity

Boston, July 2022

The views presented here should not be interpreted as reflecting the views of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System, the Banque de France, or the Eurosystem.

Overview

In this paper, we...

- investigate the effect of markup dispersion on R&D misallocation across firms
- develop a model of endogenous growth where markup dispersion arises from *two sources*: differences in process efficiency and the step size of quality innovations
- compare the decentralized equilibrium with the planner's solution
- quantify the importance of the two sources of markups in French manufacturing

Key assumption

- Process efficiency has less knowledge spillover than quality improvements do

"*The tendency to regard secrecy as more effective than process patents...probably reflects the greater ease and desirability of maintaining secrecy about process technology...Maintaining secrecy about product innovations is thus likely to be both difficult and undesirable.*" — Levin, Klevorick, Nelson and Winter (1987)

See also Arundel and Kabla (1998), Cohen, Nelson and Walsh (2000), Arundel (2001), and Brownyn Hall and Sena (2017).

What we find

- Planner endeavors to reallocate research labor toward firms with big quality steps.
- We infer firm-level process efficiencies and quality step sizes from price and revenue productivity data in French manufacturing.
- $\sim$ 30 basis points lower growth in the decentralized equilibrium than socially optimal.
- Planner also wishes to undo the static misallocation (which has a small level effect).

Roadmap

Theoretical framework

Decentralized equilibrium

Planner's solution

Calibration and quantitative results

Preferences and resource constraint

Representative household with utility $U_0 = \sum_{t=0}^{\infty} \beta^t \log C_t$.

Final output is produced using a Cobb-Douglas aggregator of intermediate goods:

$$Y = \exp\left(\int_0^1 \log\left[q(i)y(i)\right] di\right),$$

where $q(i)$ denotes the quality of good i and $y(i)$ its quantity.

Final output can be used for consumption or to cover production overhead: $Y = C + O$.

Fixed Z units of R&D labor, fixed L units of production labor in the aggregate.

Intermediate Goods Production

Produced by a fixed measure J of firms.

Firm j has the knowledge to produce variety i at quality $q(i, j)$ and process efficiency φ_j

$$y(i, j) = \varphi_j \cdot l(i, j).$$

φ_j is exogenous and permanent. Spending ψ_z units of research labor increases the frontier quality of a randomly drawn line by factor $\gamma_j > 1$.

Per-period overhead costs for firm j "active" in $n(j)$ product lines is $\psi_o \cdot \frac{1}{2}n(j)^2 \cdot Y$.

Firm market share and growth on the BGP

We analyse the Balanced Growth Path (BGP) in which quantities grow at constant rates.

Consider high (H) vs. low (L) process efficiency and big (B) vs. small (S) step sizes
$\rightarrow$ 4 firm types $k \in \{HB, HS, LB, LS\}$.

Let ϕ_k denote the fraction of firms and $\overline{S}_k$ the share of lines operated by firms of type k.

The growth rate is the sales-weighted geometric mean of the step sizes raised to Z/ψ_z:

$$1 + \bar{g} = \left(\prod_k \gamma_k^{\overline{S}_k} \right)^{\frac{Z}{\psi_z}} .$$

We will compare the planner's $\overline{S}_k$ with the decentralized equilibrium values.

Roadmap

Theoretical framework

Decentralized equilibrium

Planner's solution

Calibration and quantitative results

Market structure

Both the final goods market and the labor market are competitive.

Bertrand competition within each intermediate product line $i \in [0, 1]$.

We assume $\gamma_S > \Delta \equiv \frac{\varphi_H}{\varphi_L}$ so the highest quality producer is always active in each line.

In each line i the leading firm $j(i)$ sets markup

$$\mu = \frac{\varphi_{j(i)}}{\varphi_{j'(i)}} \cdot \frac{q(i, j(i))}{q(i, j'(i))}$$

where $j'(i)$ indexes the next highest quality firm.

Firm's problem

Due to the Cobb-Douglas structure of final output production, sales in each product line are given by Y and independent of the quality and price levels.

A firm of type k active in n lines and facing high productivity firms in $n \cdot h$ lines has per-period profit (relative to Y):

$$n \cdot h \cdot \left(1 - \frac{\varphi_H}{\varphi_k \cdot \gamma_k}\right) + n \cdot (1 - h) \cdot \left(1 - \frac{\varphi_L}{\varphi_k \cdot \gamma_k}\right) - \frac{1}{2} \cdot \psi_o \cdot n^2$$

Each period, loses $\frac{Z}{\psi_z} n$ products to creative destruction.

Maximizes PDV of profits by hiring $\psi_z x$ R&D labor each period to takeover x new lines.

The BGP of the decentralized equilibrium

Along the BGP, $x_k = \frac{Z}{\psi_z} n_k$ and $h = \overline{S}_{HB} + \overline{S}_{HS} \equiv \overline{S}$.

From the firm's FOC for R&D, any two n_k and $n_{k'}$ satisfy

$$n_k - n_{k'} = \frac{1}{\psi_o}\left[\overline{S} \cdot \varphi_H \cdot \left(\frac{1}{\varphi_{k'} \cdot \gamma_{k'}} - \frac{1}{\varphi_k \cdot \gamma_k}\right) + (1 - \overline{S}) \cdot \varphi_L \cdot \left(\frac{1}{\varphi_{k'} \cdot \gamma_{k'}} - \frac{1}{\varphi_k \cdot \gamma_k}\right)\right]$$

- Firm size depends **only** on the level of markups $\mu_k \propto \varphi_k \cdot \gamma_k$
- Firms with higher markups are larger (more products, sales, and production labor)

Roadmap

Theoretical framework

Decentralized equilibrium

Planner's solution

Calibration and quantitative results

Planner's problem

Planner maximizes household utility subject to resource constraints and laws of motion.

Planner can change the distribution of products across firms by the way it allocates R&D.

Features of the BGP of the planner's solution:

- The planner equalizes employment across product lines: $L = l(i)$
- Any two n_k and $n_{k'}$ satisfy

$$n_k - n_{k'} = \frac{1-\bar{o}}{\psi_o}\left[\log\left(\frac{\varphi_k}{\varphi_{k'}}\right) + \left(1 + \frac{Z/\psi_Z}{1/\beta - 1}\right)\log\left(\frac{\gamma_k}{\gamma_{k'}}\right)\right]$$

- **The planner puts greater weight on the γ differences because of spillovers**

Roadmap

Theoretical framework

Decentralized equilibrium

Planner's solution

Calibration and quantitative results

Datasets

- A representative sample of French manufacturing firms over 2012–2019 with
  - Firm-level value added, wage bill and asset value (FARE)
  - Firm-level hours (DADS)
  - Product-level price and quantity (EAP)
- 128,485 firm-year observations and 32,641 firms

Properties of the BGP in the decentralized equilibrium

- High φ_j and big γ_j firms have higher markups

$$\text{TFPR}_j \equiv \frac{\text{Revenue}_j}{\text{Inputs}_j} \propto \gamma_j \cdot \varphi_j$$

- Big γ_j firms have higher sales-weighted average prices (not quality adjusted)

$$p_j \propto \gamma_j$$

- High φ_j firms have lower marginal cost (not quality adjusted)

$$\text{TFPQ}_j \equiv \frac{\text{TFPR}_j}{p_j} \propto \varphi_j$$

Calibration results

Targets	Data	Model
1. Dispersion in firm-level prices, $Var_j(\log \hat{p})$	1.74	1.72
2. Dispersion in firm-level TFPQ, $Var_j(\log \widehat{\text{TFPQ}})$	1.88	1.86
3. Dispersion in firm-level TFPR, $Var_j(\log \widehat{\text{TFPR}})$	0.15	0.15
4. Within firm dispersion in product prices, $Var_{j(i)}(\log \widehat{p(i,j)})$	0.98	0.97
5. Dispersion in firm sales shares (StDev/Mean)	4.97	1.28
6. Skewness in firm sales shares (Median/Mean)	0.19	0.21
7. Semi-elasticity of firm employment share wrt firm price, $\hat{\beta}_{l,p}$	0.04	0.04
8. Semi-elasticity of firm employment share wrt firm TFPQ, $\hat{\beta}_{l,\text{TFPQ}}$	-0.03	0.00
9. Aggregate price-cost markup ratio	1.50	1.48
10. Productivity growth rate (ppt year)	2.3	2.3
11. Interest rate (ppt/year)	5.2	5.2

Parameter values

ϕ_{HB}	Share of firms with high process efficiency and big step size	0.01
ϕ_{HS}	Share of firms with high process efficiency and small step size	0.28
ϕ_{LB}	Share of firms with low process efficiency and big step size	0.20
ϕ_{LS}	Share of firms with low process efficiency and small step size	0.51
γ_S	Small step size	1.30
γ_B	Big step size	1.56
$\Gamma \equiv \gamma_B/\gamma_S$	Step size gap	1.20
$\Delta \equiv \varphi_H/\varphi_L$	Process efficiency gap	1.02
ψ_o/J	Overhead cost	0.04
β	Discount factor	0.97
ψ_Z/Z	R&D cost relative to R&D labor	18.4

Planner reallocates toward big step size firms

Recall growth is given by

$$1+\overline{g} \quad = \quad \left(\prod_k \gamma_k^{\overline{S}_k}\right)^{\frac{Z}{\psi_Z}}$$

Product shares (in ppt)

	$\overline{S}_{HB}$	$\overline{S}_{HS}$	$\overline{S}_{LB}$	$\overline{S}_{LS}$	high proc. eff.	big step size
Decentralized	3.8	16.6	68.8	10.9	20.4	72.5
Planner	5.2	0.0	94.8	0.0	5.2	100.0
Difference	$\uparrow$ 1.4	$\downarrow$ 16.6	$\uparrow$ 26.0	$\downarrow$ 10.9	$\downarrow$ 15.2	$\uparrow$ 27.5

Biggest growth effect comes from reallocation of R&D towards firms with big γ but low φ.

Welfare gains along the BGP mostly come from eliminating R&D misallocation

Welfare along the BGP:

$$\frac{1}{1-\beta}\left(\log(c_0) + \frac{\beta}{1-\beta}\log(1+\overline{g})\right)$$

Planner has ∼30 bps higher growth rate ($\overline{g}^P = 2.6\%$, $\overline{g}^D = 2.3\%$)

Planner has similar detrended consumption per capita $c_0 \equiv (1+\overline{g})^{-t} C_t / L$

$$\underset{1.004}{\frac{c_0^P}{c_0^D}} = \underset{0.995}{\overbrace{\frac{1-o^P}{1-o^D}}^{\text{Overhead}}} \cdot \underset{0.997}{\overbrace{\frac{\Phi^P}{\Phi^D}}^{\text{Process efficiency}}} \cdot \underset{1.003}{\overbrace{\frac{\mathcal{M}^P}{\mathcal{M}^D}}^{\text{Allocative efficiency}}} \cdot \underset{1.051}{\overbrace{\frac{Q_0^P}{Q_0^D}}^{\text{Quality}}}$$

Concluding remarks

Studied R&D allocation in an economy where markup heterogeneity arises from differences in the step size of quality innovations and process efficiency across firms.

- Calibrated model using French manufacturing firms
- Planner tilts innovation toward big quality step firms to enhance spillovers and growth

Next steps:

- Actual policies (e.g. size-dependent R&D subsidies)
- Impact of transition dynamics on welfare gains
- Evidence on spillovers (e.g. propensity to patent for process vs. product innovation)