Market Power and Innovation in the Intangible Economy

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University of Cambridge

Concordi 2019 - Seville
Recent macroeconomic trends

- **Productivity growth** has been sluggish
  - High growth in the 1990s, low growth since 2005
    - United States
    - France

- Business dynamism has declined
  - Entry rate from 16 to 8%
  - Reallocation rate from 30 to 25%
- Market power is increasing
  - Markups are increasing
  - Product market concentration is rising
  - United States
  - France
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- Literature Review
Productivity growth

- Ideas are getting harder to find (Bloom et al. 2017)

U.S. Investments in Intellectual Property excluding Software

Source: BEA, Fernald (FRBSF)
Productivity growth

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![Graph showing productivity growth and innovative investments as a percentage of GDP over time.]

**U.S. Investments in Intellectual Property excluding Software**

Source: BEA, Fernald (FRBSF)
My explanation: intangible inputs

U.S. Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016)
My explanation: intangible inputs

U.S. Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016)
Intangible inequality

![Graph showing the standard deviation of software investments per employee from 1995 to 2005. The graph compares firms with and without controls. Controls include industry-trend, 5-digit f.e., and size. Source: EAE (14,000 French firms).]
Macroeconomic model

- Macroeconomic model with the following features:
  - Endogenous growth: R&D increases quality (creative destruction)
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- Some firms have a talent for adopting digital/intangible technologies

Mechanism:
- Paradox: small group of innovative high-intangible firms firms can reduce creative destruction and innovation after causing a boom
- High-intangible firms with low marginal costs undercut innovative competitors on price and dominate sectors, which deters entry
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Intangibles reduce marginal costs, raise fixed costs

If the framework is accurate, we should see that:

- Ratio of fixed to variable costs increases over time
- Ratio of fixed to variable costs increases when adopting technologies
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A new measure of fixed costs derived from operating profits and markups:

\[ \pi_{it} = (p_{it} - mc_{it}) \cdot y_{it} - \underbrace{S(\phi_{it}, s_{it}) - \eta_{it}}_{\tilde{S}_{it}} \]
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\[
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\]

\[
\frac{\tilde{S}_{it}}{p_{it} \cdot y_{it}} = \left(1 - \frac{1}{\mu_{it}}\right) - \frac{\pi_{it}}{p_{it} \cdot y_{it}}
\]
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Data

Balance sheet and income statement data from French Census and DGFiP

- Universe of firms from 1994-2016 from merging FARE and FICUS
- Production and employment data from tax and social security files
- Merge with representative surveys on software investments (EAE), IT-systems (TIC), research and development (CIS)

Treatment

Drop financial, insurance and real estate (FIRE) firms
Firms without employees, zero/negative sales, wage bill, capital
Nominal variables are deflated with EU-KLEMS sector-level deflators

Result: 9.5 million firm-years across 572 NACE industries
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Fixed costs as a share of total cost (sales-weighted)

Source: Own calculations based on universe of French firms (FARE-FICUS)
Industries

Fixed costs as a share of total cost, sales-weighted average within NACE sections and major 2-digit industries.

Source: Own calculations based on universe of French firms (FARE-FICUS)
Fixed costs and intangibles

\[
\frac{\tilde{S}_{it}}{TC_{it}} = \beta \cdot Adoption_{it} + \gamma'X_{it} + \varepsilon_{it}
\]

<table>
<thead>
<tr>
<th>Fixed Cost Share</th>
<th>ERP</th>
<th>CRM</th>
<th>CAO</th>
<th>RFID</th>
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<tr>
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<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
<td>0.39</td>
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Data: FARE-FICUS merged with TIC 2006-2016, observations weighted with TIC sample weights. Firm-clustered standard errors in brackets. All dep. variables are binary.
Innovation in the macroeconomic model

Standard models of economic growth:

- Firms expand the range of products they can produce through R&D

If a firm innovates it becomes the market leader

Incumbent firm loses market leadership: creative destruction

This model: high-IT firms have lower marginal production costs

Trade-off consumers: high-cost innovative good vs low cost incumbent

Greater chance that innovator does not become market leader

Discourages entry and innovative investments by low-IT firms
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- Discourages entry and innovative investments by low-IT firms
## Growth and innovation

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<th>R&amp;D Intensity</th>
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<tr>
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</tbody>
</table>

Data: FARE-FICUS income statement data, CIS innovation data.
Firm-clustered standard errors in brackets.

🔗 [Full table](#)
Structural estimation

- Assume all firms have equal intangible productivity $\phi$
- Simulated method of moments: 32,000 firms for 50 years

<table>
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<tr>
<th>Parameter</th>
<th>Model</th>
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<th>Model</th>
<th>Data</th>
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<td>1.3%</td>
<td>1.3%</td>
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<tr>
<td>$\phi$</td>
<td>Fixed costs (%)</td>
<td>9.5%</td>
<td>9.5%</td>
<td>12.0%</td>
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<tr>
<td>$\sigma$</td>
<td>Gibrat’s Law</td>
<td>-0.035</td>
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<tr>
<td>$\eta$</td>
<td>Entry rate</td>
<td>10.0%</td>
<td>9.9%</td>
<td>13.8%</td>
</tr>
<tr>
<td>$\eta$</td>
<td>R&amp;D intensity</td>
<td>3.1%</td>
<td>2.6%</td>
<td>2.5%</td>
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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Moment</th>
<th>France Data</th>
<th>France Model</th>
<th>U.S. Data</th>
<th>U.S. Model</th>
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<tr>
<td>$\lambda$</td>
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<td>2.5%</td>
<td>2.5%</td>
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Experiment

Introduce group firms with higher intangible-efficiency:
  - Match increase in fixed costs and decline in entry
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<th>Variable</th>
<th>France</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\Delta$ model</td>
<td>$\Delta$ data</td>
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<tr>
<td><strong>Targeted</strong></td>
<td></td>
<td></td>
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<tr>
<td>Avg. fixed cost share</td>
<td>4.5 pp</td>
<td>4.5 pp</td>
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<tr>
<td>Entry rate</td>
<td>-3.6 pp</td>
<td>-3.6 pp</td>
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<tr>
<td><strong>Untargeted</strong></td>
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<tr>
<td>Productivity growth</td>
<td>-0.2 pp</td>
<td>-1.3 pp</td>
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<tr>
<td>Reallocation rate</td>
<td>-24 %</td>
<td>-23 %</td>
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<tr>
<td>Avg. markup</td>
<td>10 pt</td>
<td>11 pt</td>
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</tbody>
</table>
Transition: productivity growth

- Transitory boom due to intangibles
- Long-term decline due to concentration and entry

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![Graph showing productivity growth rates with black-dashed original steady state and red-dashed new steady state.]

Transition: intangibles contribution

- Transitory effect intangibles wears off as firms fully adopt

Contribution of intangible adoption to growth. Red-dashed: steady state.
Transition: entry rate

- Entry declines as probability of successful innovation declines

Transition: markups and wages

- Markups up: decoupling of wages and productivity

(a) Avg. Markup

(b) Wage Rate


French calibration
Conclusion

Three macroeconomic trends:

- Low productivity growth despite high R&D, fall in business dynamism, rise of market power/concentration

Propose unequal rise of intangibles as common explanation:

- Intangible inputs reduce marginal costs, raise fixed costs
- Firms with low adoption costs can reduce aggregate growth

Results:

- Endogenous growth model with intangibles, entry/exit dynamics, variable markups: explains significant part of slowdown
Appendix
Productivity growth

Total Factor Productivity between 1975 and 2016.

Data: Fernald/FRSF
Productivity growth (France)

Total Factor Productivity between 1975 and 2016.
Data: Penn World Tables
Start-ups as percentage of firms (solid) and employment (dash)

Data: Business Dynamics Statistics, U.S. Census
Business dynamism: entry rate (France)

Percentage of employment by new firms ($\leq 1$yr) in private sector employment (HP).

Source: own calculations based for universe of French firms (FARE-FICUS)
Business dynamism: reallocation rate

Sum of job destruction and creation rate (%)

Data: Business Dynamics Statistics, U.S. Census
Business dynamism: reallocation rate (France)

Sum of job creation and job destruction rates across companies (HP).
Source: own calculations based for universe of French firms (FARE-FICUS)
Business dynamism: skewness of growth (France)

(c) 90-10 Difference
(d) 90-50 Difference
(e) 50-10 Difference

Difference (perc. point) in growth between percentiles of the employment-growth distribution.

Source: own calculations based for universe of French firms (FARE-FICUS)
Firm concentration

Fraction of sales and employment by top 4 or 20 firms by 4-digit industry.

Source: Autor et al (2017) based on U.S. Census Data
Firm concentration

Panel C: Services

Fraction of sales and employment by top 4 or 20 firms by 4-digit industry.

Source: Autor et al (2017) based on U.S. Census Data
Firm concentration (France)

Average Herfindahl Index at 4-digit NACE level, weighted by value added (HP).
Source: own calculations based for universe of French firms (FARE-FICUS)
Markups

Average markup weighted by sales (solid) and costs (dashed)

Source: Own calculations based on Compustat Data
Markups (France)

Average markup weighted by sales (solid) and costs (dashed)

Source: Own calculations based on Compustat Data
Markups

Hall (1988): Markup $\mu$ of firm $i$ in year $t$ can be written as:

$$\mu_{it} = \theta_{it}^{m} \cdot \left( \frac{p_{it} \cdot y_{it}}{p_{it}^{m} \cdot m_{it}} \right)$$

- $p_{it} \cdot y_{it}$: Revenue (sales)
- $p_{it}^{m} \cdot m_{it}$: Expenditure on variable input $m$ (materials)
- $\theta_{it}^{m}$: Elasticity of output $y_{it}$ with respect to input $m$
  - Estimation: iterative GMM as in De Loecker & Warzynski (2012)
Markups Estimation

Assume a translog production function:

\[
\ln y_{it} = \ln a_{it} + \sum_{h \in \{k,l,m\}} \left( \beta^h \cdot \ln h_{it} + \beta^{hh} \cdot [\ln h_{it}]^2 \right)
\]

- \(a\): productivity (hicks-neutral)
- \(k\): capital
- \(l\): labor input (wage bill)
- \(m\): intermediate inputs and materials

\[
\mu_{it} = (\beta^m + 2 \cdot \beta^{mm} \cdot \ln m_{it}) \left( \frac{p_{it}y_{it}}{p^m m_{it}} \right)
\]

Productivity \(a\) might depend on factor usage \((k,l,m)\), \(\Rightarrow\) OLS invalid
- Estimate \(\beta^h\) and \(\beta^{hh}\) per sector using iterative GMM procedure
- De Loecker & Warzynski (2012) and De Loecker and Eeckhout (2017)
Markup Estimation

Find sales of function of production factors including technology, to purge sales from unexpected demand shocks:

\[
\ln y_{it} = \sum_{x=0}^{3} \sum_{y=0}^{3} \sum_{z=0}^{3} \gamma_{xyz} \ln k_{it}^z \ln l_{it}^y \ln m_{it}^z + \Psi_t + \varepsilon_{it} \tag{1}
\]

Causal production function’s parameters follow from log TFP:

\[
\ln a_{it} = \phi_{it} - \sum_{h \in \{k, l, m\}} \left( \beta^h \cdot \ln h_{it} + \beta^{hh} \cdot [\ln h_{it}]^2 \right) \tag{2}
\]

where log TFP follows AR(1) process:

\[
\ln a_{it} = g(\ln a_{it-1}) + \xi_{it} \tag{3}
\]

where \(\xi_{it}\) is estimated by an iterative GMM with moment condition:

\[
E \left( \xi_{it} \begin{bmatrix} k_{it} & l_{it-1} & m_{it-1} & k_{it}^2 & l_{it-1}^2 & m_{it-1}^2 \end{bmatrix}' \right) = 0 \tag{4}
\]
Fixed costs as a share of total cost (sales-weighted), derived from markups and profit rate. Solid line: average across 2-digit industries. Dashed line: average across Compustat firms.

Source: Own calculations based on Compustat data
Literature

Rise of corporate profits:

- **Concentration**, Autor et al. (2017), Gutierrez and Philippon (2017, 2018)
- **Misallocation**: Peters (2016), Baqee and Farhi (2017), Midrigran (2018)
- **Intangibles**: Crouzet and Eberly (2018), Criscuolo et al. (2018)

Fall of business dynamism:

- **Decline in reallocation rates**:
  - Davis et al (2006), Decker et al. (2014), Haltiwanger et al. (2014)
- **Decline in entry rates**:
Fixed costs and communication technology

\[
\text{Communication}_{it}^x = \beta^x \cdot \frac{F_{it}}{TC_{it}} + \gamma^x'X_{it} + \varepsilon^x_{it}
\]

<table>
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<tr>
<th>Technology:</th>
<th>Videoconferencing</th>
<th>Internal soc. med.</th>
<th>Remote access</th>
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<td>0.118***</td>
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<td>(0.012)</td>
<td>(0.016)</td>
<td>(0.040)</td>
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<td>(R^2)</td>
<td>0.243</td>
<td>0.056</td>
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Data: FARE-FICUS merged with TIC 2006-2016, observations weighted with TIC sample weights. Firm-clustered standard errors in brackets. All dep. variables are binary.
Fixed costs and online sales and marketing

\[ Adoption_{it}^x = \beta \cdot \frac{F_{it}}{TC_{it}} + \gamma^{x'} X_{it} + \varepsilon_{it}^x \]

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Market power and intangibles:

- Brynjolfsson et al. (2008), Bessen (2017) at US industry level:
  - IT-intensive industries have greatest level + increase concentration
  - IT-intensity (IV'ed) explains most of increase in concentration (Bessen)
  - also have largest increase profit margin, productivity (Bessen)

- Firm level:
  - Bijnens and Konings (2018): Belgium census data ⇒ larger decline in business dynamism in high ICT intensity industries (also within manufacturing, services).
  - OECD (2017), Calligaris et al. (2018): increase in markups larger in industries with high digital intensity
  - Crouzet and Eberly (2018), Bessen and Righi (2019): Firm-level relationship between intangibles, markups, productivity
Aghion et al. ‘A Theory of Rising Rents and Falling Growth’

Explains productivity slowdown through lack of R&D

Summary:

- Productive firms stop growing because of span of control
- IT increases span of control
- Lowers expected markup ⇒ productive firms more likely to compete with productive firms ⇒ less R&D

Main differences:

- Have a 50% drop in R&D intensity
- This paper: R&D intensity increases (quantitatively matching the data)

- No entry and exit
- This paper: Decline in entry (quantitatively matching the data)
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Recent related papers

Rise of concentration and fall in entry:
- Demographics: Hopenhayn, Neira and Singhania (2018)
- Scalable IT: Lashkari and Bauer (2018), Bessen and Righi (2019), Korinek and Ng (2019)
  \Rightarrow Contribution: also explain productivity growth, markups

Two-firm models of growth, dynamism, concentration:
- Low interest rates: Liu, Mian and Sufi (2019)
  - Low interest rates increase firm patience
  - Leader and follower have greater incentive to invest, but incentive increases more for leader (because they are more likely to win)
  - Strategic interaction: follower invests less, so both end up investing less
  - Decline in knowledge transfusion form leader to follower firms, potentially driven by change in patenting behavior
What is $\phi$?

Extensive literature shows heterogeneous effect of IT on productivity

Recent evidence: efficient management practices are a key determinant:
- Bloom et al. (2012): Americans do IT better
  - European establishments have smaller productivity boost from IT expense
  - IT productivity increases when establishment becomes US-owned (!)
- Schivardi and Schmitz (2019): IT (..) and Southern Europe's Lost Decades
  - Productivity effect of IT is entirely conditional on WMS management score -
    Existing differences across firms start to 'matter'
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Intangibles as productivity-enhancements

Example 1: Enterprise Resource Planning (ERP)

- Automate **business processes** like supply chain, inventory management
- Receive an order: software orders components, allocates production time, invoices customer
- Lower marginal costs, higher fixed costs

Example 2: Software behind Tesla's autopilot

- Costly initial development, independent of sales
- Software can be installed in all cars that are sold
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Equilibrium

Definition:

- \( w, Y, \pi \) grow at constant rate \( g \)
- \( r, e, L^p, s(\phi_i, \lambda_{ij}), x(n_i, \phi_i) \mu(\phi_i, \lambda_{ij}), \tau(\phi_i), M(\phi_i), \) and \( K(\phi_i) \) are constant
- Firms obey static first order condition for pricing and intangibles, dynamic first order condition for innovation and entry, consumption grows along the Euler equation.
- The labor and goods markets clear:

\[
1 = L^p + L^{rd} + L^s
\]

\[
Y = C
\]
Dynamic optimization

Incumbents choose rate of innovation $x_i$ to maximize firm value:

$$rV_t(\phi_i, \bar{J}_i) - \dot{V}_t(\phi_i, \bar{J}_i) =$$

\[
\begin{align*}
&\sum_{j \in \bar{J}_i} \pi_t(\phi_i, \lambda_{ij}) \\
&+ \sum_{j \in \bar{J}_i} \tau(\phi_i) \left[ V_t(\phi_i, \bar{J}_i \setminus \{\lambda_{ij}\}) - V_t(\phi_i, \bar{J}_i) \right] \\
&+ \max_{x_i \geq 0} \left\{ x_i \cdot \Pr \left( \lambda_{ij} \geq \frac{p_{choke}(\phi_i)}{p_{choke}(\phi_i)} - 1 \right) \cdot \mathbb{E} \left[ V(\phi_i, \bar{J}_i \cup + \lambda_{ij}) - V_t(\phi_i, \bar{J}_i) \right] - w_n x_i \psi x n^{-\sigma} \right\} - F_x(\phi_i, n_i)
\end{align*}
\]

Following Akcigit and Kerr (2018), assume a value function linear in $n$ by equating $F_x$ to external R&D option value.
Transition: productivity growth

Transition: productivity growth

Transition

Contribution of intangible adoption to growth. Red-dashed: steady state.
Entry Rate (%) vs. Year

Transition

Black dash-dotted line: fraction produced by high-intangible firms.

Blue-dashed line: fraction produced by other firms.

U.S. calibration
Transition

(a) Research Intensity

(b) Research Productivity

Transition

(a) Avg. Markup

(b) Wage Rate

## Growth and innovation

### Sales growth

<table>
<thead>
<tr>
<th>Fixed Cost Share</th>
<th>0.129***</th>
<th>0.396***</th>
<th>0.445***</th>
<th>0.105***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.005)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>N</td>
<td>7,895,588</td>
<td>7,895,588</td>
<td>7,895,588</td>
<td>7,895,588</td>
</tr>
<tr>
<td>R²</td>
<td>0.115</td>
<td>0.221</td>
<td>0.250</td>
<td>0.110</td>
</tr>
</tbody>
</table>

### R&D Intensity

<table>
<thead>
<tr>
<th>Fixed Cost Share</th>
<th>0.014***</th>
<th>0.013***</th>
<th>0.022***</th>
<th>0.012**</th>
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<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.005)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>N</td>
<td>85,566</td>
<td>85,566</td>
<td>85,566</td>
<td>85,566</td>
</tr>
<tr>
<td>R²</td>
<td>0.084</td>
<td>0.093</td>
<td>0.002</td>
<td>0.011</td>
</tr>
</tbody>
</table>

- Year F.E.: ✓ ✓ ✓ ✓
- Industry F.E.: ✓ ✓ ✓ ✓
- Firm F.E.: ✓ ✓ ✓ ✓
- Size Poly.: ✓ ✓ ✓ ✓

Data: FARE-FICUS income statement data, CIS innovation data. Firm-clustered standard errors in brackets.
Ideas are getting harder to find

- Low growth but high innovative investments: hard to rationalize

French. Investments in Intellectual Property excluding Software

Source: BEA Fixed Private Investments, Fernald (FRBSF)
Intangible inputs

- Intangible investments now exceed capital investments

French. Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016)
Intangible inputs

- Intangible investments now exceed capital investments

French Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016)
Aggregate variables

Equilibrium wage $w$:

$$w = \exp\left(\int_0^1 \ln \left[ \frac{q_{ij}}{1 - s_{ij}} \right] dj \right) \cdot \exp\left(\int_0^1 \ln \left[ \frac{1 - s_{ij}}{1 + \lambda_{ij}} \right] dj \right)$$

- **CES Productivity**
- **Avg. Inverse Markup**

Gross domestic product $Y$:

$$Y = \underbrace{L^p}_{\text{production labor}} \cdot \exp\left(\int_0^1 \ln \left[ \frac{q_{ij}}{1 - s_{ij}} \right] dj \right) \cdot \frac{\exp \left(\int_0^1 \ln \mu_{ij}^{-1}dj\right)}{\int_0^1 \mu_{ij}^{-1}dj}$$

- **CES productivity**
- **efficiency wedge**
Static optimization

Setting: innovator $i$ and incumbent $-i$ play two-stage simul. move game

Stage 1: firms choose marginal cost reduction $s_{ij}$ and pay fixed costs

Stage 2: firms choose optimal price $p^*_ij$

\[
p^*_ij = \begin{cases} 
mc_{ij} - \lambda_{ij} 
& \text{if } mc_{ij} - \lambda_{ij} > mc_{ij} \\
mc_{ij} \cdot \lambda_{ij} - 1 
& \text{if } mc_{ij} - \lambda_{ij} < mc_{ij} \\
mc_{ij} 
& \text{otherwise (no sales)} 
\end{cases}
\]
Static optimization

Setting: innovator \( i \) and incumbent \(-i\) play two-stage simul. move game

Stage 1: firms choose marginal cost reduction \( s_{ij} \) and pay fixed costs

Stage 2: firms choose optimal price \( p_{ij}^* \)

Solve for optimal static decisions through backward induction:

\[
p_{ij}^* = \begin{cases} 
  mc_{-ij} \cdot (1 + \lambda_{ij}) & \text{if } mc_{-ij} \cdot (1 + \lambda_{ij}) > mc_{ij} \\
  mc_{ij} & \text{otherwise (no sales)}
\end{cases}
\]

\[
p_{-ij}^* = \begin{cases} 
  mc_{ij} \cdot (1 + \lambda_{ij})^{-1} & \text{if } mc_{-ij} \cdot (1 + \lambda_{ij}) < mc_{ij} \\
  mc_{-ij} & \text{otherwise (no sales)}
\end{cases}
\]
Static optimization

Best response by incumbent given optimal pricing is:

\[ 1 - s^*_i = \begin{cases} 
(1 + \lambda_{ij}) \cdot (1 - s^*_{-ij}) \cdot \psi \cdot \frac{w}{Y} \cdot (1 - \phi_i) \cdot \frac{1}{\psi + 1} & \text{if } (1 - s_{-ij}) \cdot (1 + \lambda_{ij}) > 1 - s_{ij} \\
0 & \text{otherwise (no sales)}
\end{cases} \]

\[ 1 - s^*_{-ij} = \begin{cases} 
(1 + \lambda_{ij})^{-1} \cdot (1 - s^*_i) \cdot \psi \cdot \frac{w}{Y} \cdot (1 - \phi_i) \cdot \frac{1}{\psi + 1} & \text{if } (1 - s_{-ij}) \cdot (1 + \lambda_{ij}) < 1 - s_{ij} \\
0 & \text{otherwise (no sales)}
\end{cases} \]

Nash equilibrium:

- Firm that charges marginal cost in stage 2 must have \( s = 0 \)
- Firm with lowest quality-adjusted choke price always has \( s > 0 \) best response