A Theory of Falling Growth and Rising Rents

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October 2019
Motivation

The U.S. economy over the past 30+ years has been characterized by the following patterns:

1. Falling “long run” growth (after a burst of growth)
2. Falling labor share (due to composition)
3. Rising (national) concentration
Our goal

Provide a theoretical framework that speaks to these facts.

Calibrate our model to gauge potential magnitudes.

Use our theory to discuss policy questions (*not yet done*).
Our story

Theory of endogenous growth with heterogeneous firms.

Source of the change since the 1990s: IT improvements extending the boundary of high-productivity firms.

High-productivity firms (with high markups) expand in response; aggregate labor share falls.

Expansion of high productivity firms deters innovation and undermines long-run growth (after initial burst of growth).
Related literature

Declining growth and rising concentration:
Akcigit and Ates (2019), Liu, Mian and Sufi (2019)

Rising concentration:
Chatterjee and Eyigungor (2019), Hsieh and Rossi-Hansberg (2019),
Hopenhayn et al. (2019)

Declining labor share:
Koh et al. (2016), Kehrig & Vincent (2017), Autor et al. (2017), Barkai
(2017), De Loecker & Eeckhout (2018), Eggertsson et al. (2018),
Farhi & Gourio (2018), Karabarbounis & Neiman (2018)

Our contribution: a model generating all three patterns in response
to increased span of control
Roadmap

Motivating facts

Theoretical framework

Quantification
  - Steady state
  - Transition dynamics
Rise and decline in TFP growth

1.82%  
1949 - 1995

2.88%  
1996 - 2005

1.10%  
2006 - 2018

BLS TFP growth + R&D and IP contribution; labor augmenting.
Relative price of IT

BEA. Average annual growth rate of IT price relative to GDP deflator.
TFP growth by IT intensity

Update of Fernald (2015) Figure 6A; 5-year moving average.
Labor share by IT intensity

1987 = 1

IT producing
IT intensive
Others

BLS
Declining labor share (mostly due to composition)

Cumulative change over specified period (ppt)

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<td></td>
<td>MFG</td>
<td>RET</td>
<td>WHO</td>
<td>SRV</td>
<td>FIN</td>
<td>UTL</td>
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<td>( \Delta \frac{\text{Payroll}}{\text{Sales}} )</td>
<td>-6.73</td>
<td>-0.85</td>
<td>-0.08</td>
<td>0.23</td>
<td>3.25</td>
<td>-1.83</td>
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<tr>
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<td>-1.71</td>
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<td>-5.44</td>
<td>-4.59</td>
<td>-0.76</td>
<td>-0.75</td>
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</table>

Autor et al. (2019) Table 5.
Labor share declines with firm size

Autor et al. (2019), Figure 5.
## Rising national concentration

Cumulative change over specified period (ppt)

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<td>(\Delta) Top 4 firms sales share</td>
<td>6.0</td>
<td>14.0</td>
<td>4.7</td>
<td>4.5</td>
<td>7.2</td>
<td>4.6</td>
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<td>(\Delta) Top 20 firms sales share</td>
<td>5.2</td>
<td>16.3</td>
<td>10.1</td>
<td>6.1</td>
<td>13.3</td>
<td>4.7</td>
<td></td>
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Autor et al. 2019 Table 1. Sales-weighted average across 4-digit industries.
Rising concentration in services

Panel D: Services

Autor et al. (2019).
Declining local concentration

Establishments growth by firm size

U.S. Census Bureau's *Business Dynamics Statistics*

Rise and decline in employment-weighted plant entry rate

Source: U.S. Census Bureau’s Business Dynamics Statistics. Job creation by birth over total employment by firm size bins. 5-year centered moving average.
Roadmap

Motivating facts

Theoretical framework

Quantification

- Steady state
- Transition dynamics
Representative household maximizing

\[ U_0 = \sum_{t=0}^{\infty} \beta^t \log C_t \]

subject to \( a_{t+1} = (1 + r_t)a_t + w_tL - C_t \) and a nPg-condition.

Resulting in the standard Euler equation

\[ \frac{C_{t+1}}{C_t} = \beta(1 + r_{t+1}) \]
Production

Final output competitively produced with

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

where intermediates differ in quality \( q(i) \) and price \( p(i) \).

Resulting demand:

\[ y(i) = \frac{YP}{p(i)}, \]

where \( P \) is the price index.
Firm heterogeneity

There are $J$ firms.

Exogenous, permanent differences in the level of process efficiency across firms.

Endogenous, evolving differences in the level of product-specific quality across firms.
Process efficiency across firms:

share $\phi$ with high productivity $\varphi^H$
share $1 - \phi$ with low productivity $\varphi^L$

Production of product $i$ by firm $j$ is linear in labor

$$y(i, j) = \varphi(j) \cdot l(i, j)$$

Productivity differential $\Delta = \frac{\varphi^H}{\varphi^L} > 1$
Product quality

Firm $j$ owns patent to produce $i \in [0, 1]$ at quality $q(i, j)$.

Spending $\psi_r \cdot Y$ units of final output on R&D increases the frontier quality of a randomly drawn line by factor $\gamma > 1$.

Firms choose R&D investment to maximize profits.

This leads to an endogenous rate of “creative destruction” $z_{t+1}$ and is the source of growth.
**Market structure**

Bertrand competition within each product line \( i \in [0, 1] \).

In each line \( i \) the leading firm \( j(i) \) sets

\[
p(i, j(i), j'(i)) = \frac{q(i, j(i))}{q(i, j'(i)) \varphi(j'(i))} w,
\]

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

We assume \( \gamma > \Delta \) so the highest quality producer is active.

Price is constrained by the second-best quality.
Markup

Markup is endogenously determined by the relative quality and process efficiency of the best and second-best firms.

The markup factor $\mu(i) = \frac{p(i, j(i), j'(i))}{w/\varphi(j(i))}$ is given by

$$
\mu(i, j(i), j'(i)) = \begin{cases} 
\gamma \Delta, & \text{if } j = H\text{-type}, j' = L\text{-type} \\
\gamma, & \text{if type of } j = \text{type of } j' \\
\gamma / \Delta, & \text{if } j = L\text{-type}, j' = H\text{-type}
\end{cases}
$$
Boundary of the firm

Per-period overhead cost for firm $j$ with $n(j)$ products

$$\psi_o \cdot \frac{1}{2} n(j)^2 \cdot Y$$

Convexity yields a well-defined boundary of the firm.

High productivity firms operate more lines but not all lines.
**Profits**

Period profits of an $H$-type firm producing in $n(j)$ lines and facing a share $s(j)$ of $H$-type competitors:

$$\Pi(j) = \left[ n(j)s(j) \left( 1 - \frac{1}{\gamma} \right) + n(j)[1 - s(j)] \left( 1 - \frac{1}{\Delta \gamma} \right) - \psi_o \frac{1}{2} n(j)^2 \right] Y$$

Period profits of an $L$-type firm producing in $n(j)$ lines and facing a share $s(j)$ of $H$-type competitors:

$$\Pi(j) = \left[ n(j)s(j) \left( 1 - \frac{\Delta}{\gamma} \right) + n(j)[1 - s(j)] \left( 1 - \frac{1}{\gamma} \right) - \psi_o \frac{1}{2} n(j)^2 \right] Y$$
Firm problem

Each firm decides how much to invest in R&D, \( x_t(j) \), to maximize the net present value of its profits.

This leads to an endogenous rate of creative destruction \( z_{t+1} \) and is the source of growth.

For ease of exposition, we will only formally specify the firm problem in steady state here.
Firm problem in steady state

Focus on steady state where the fraction of lines served by high productivity firms \( S^* \in (0, 1) \) and the rate of creative destruction \( z^* \) and hence \( g^* \) are both constant over time.

For \( H \)-type and \( L \)-type firms, respectively:

\[
\nu_H(n) = \max_{n'} \{ \pi_H(n, S^*) - [n' - n(1 - z^*)] \psi_r + \beta \nu_H(n') \}
\]

\[
\nu_L(n) = \max_{n'} \{ \pi_L(n, S^*) - [n' - n(1 - z^*)] \psi_r + \beta \nu_L(n') \}
\]

subject to

\[
n' \geq n(1 - z^*)
\]
Resource constraints, aggregates

\[ Y_t = C_t + O_t + R_t \]

\[ a_t = \int_0^J V_t(j) dj \]

\[ L = \int_0^1 l_t(j, i) di \]

\[ z_{t+1} = \int_0^J x_t(j) \, dj \]

\[ O_t = \int_0^J \psi_o \cdot \frac{1}{2} n_t(j)^2 \cdot Y_t \, dj \]

\[ R_t = \int_0^J \psi_r \cdot x_t(j) \cdot Y_t \, dj \]
Steady state characterization

\((S^*, z^*, n_{H}^*, n_{L}^*)\) can be determined analytically from

\[
\psi_r = \frac{1 - S^* \frac{1}{\gamma} - (1 - S^*) \frac{1}{\gamma} - \psi_o n_{H}^*}{1/\beta - 1 + z^*}
\]

\[
\psi_r = \frac{1 - S^* \Delta \frac{1}{\gamma} - (1 - S^*) \frac{1}{\gamma} - \psi_o n_{L}^*}{1/\beta - 1 + z^*}
\]

\[
\phi J n_{H}^* = S^*
\]

\[
(1 - \phi) J n_{L}^* = 1 - S^*
\]

\[
\phi J n_{H}^* = S^*
\]

\[
(1 - \phi) J n_{L}^* = 1 - S^*
\]
Steady state implications

Proposition 1

In steady state, \( H \)-type firms have lower labor share and higher average markup than \( L \)-type firms. Furthermore, \( n^*_H > n^*_L \).

Intuition: Higher expected profit per line for \( H \)-type \(\rightarrow\) they push higher up their overhead cost schedule.

Corollary 1

The fraction of \( H \)-type lines exceeds the fraction of \( H \)-type firms, i.e., \( S^* > \phi \).
Steady state comparison: \( \psi_0 \) drops

Recall overhead cost is \( \psi_0 \frac{1}{2} n^2 Y \). Suppose \( \psi_0 \) drops permanently to a lower level.

How does the new steady state compare to the old one?

 Particularly interested in effects on

- Concentration \( S^* \)
- Labor income share \( \lambda^* \) (within firm and overall)
- Growth rate \( g^* \) and the rate of creative destruction \( z^* \)
Steady state effect of lower $\psi_o$ on concentration

Proposition 2

$S^*$ rises monotonically as $\psi_o$ falls.

Intuition:
A larger size gap $n^*_H - n^*_L$ is needed to yield a given difference in their marginal overhead costs.
Labor income share

R&D and overhead cost both denominated in final output.

No physical capital.

Aggregate labor income share is the inverse of the average cost-weighted markup:

$$\lambda_t = \int_0^1 \mu_t(i) \frac{l_t(i)}{L} di = \int_0^1 \frac{1}{\mu_t(i)} di.$$

Thus, labor share depends on the distribution of markups, and in turn the joint distribution of leader and follower.
Steady state effect of lower $\psi_o$ on the labor income share

$$d \lambda^* = \phi d \lambda^*_H + (1 - \phi) d \lambda^*_L + d (S^* - \phi)(\lambda^*_H - \lambda^*_L)$$

**within** component *increases*

Intuition: lower $\psi_o$ raises $S^*$ and hence the share of lines with a $H$-type follower $\rightarrow$ lower markup.

**between** component *declines*

Intuition: lower $\psi_o$ raises $S^*$, the share of products by $H$-types who have higher markups.

Overall effect: lower $\psi_o$ reduces the aggregate labor share as long as initial $S^* > 1/2$. 
Steady state effect of lower $\psi_o$ on the growth rate

Two opposing effects as $\psi_o$ falls:

**Direct effect**: more incentive to innovate.
Intuition: lower $\psi_o$ raises the marginal value of innovating on an additional line.

**GE effect**: less incentive to innovate
Intuition: lower $\psi_o$ raises $S^*$ and reduce expected markup within a product line.

For a range of parameter values, the GE effect dominates and growth slows as $\psi_o$ falls.
Roadmap

Motivating facts

Theoretical framework

**Quantification**

- Steady state
- Transition dynamics
Quantification

Overall strategy:

- Calibrate baseline parameter values to initial period.
- Change $\psi_0$ to match the change in the price of IT.
- How big is the resulting change in the growth rate, concentration, and aggregate labor share?

Generalizations:

- CRRA preferences with IES of $1/\theta$
- CES aggregation across products with elasticity $\sigma$
Baseline Calibration

Assigned: $\sigma = 4, \theta = 2$

Calibrated:

$\psi_0^0 = 0.002, \phi = 0.006, \gamma = 1.335, \psi_r = 1.694, \beta = 0.976, \Delta = 1.194.$

<table>
<thead>
<tr>
<th>Target</th>
<th>Model</th>
</tr>
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<tbody>
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<td>1. top 10% concentration 1987–1992</td>
<td>64.0</td>
</tr>
<tr>
<td>2. productivity growth 1949–1995</td>
<td>1.82</td>
</tr>
<tr>
<td>3. aggregate markup 1988–2015</td>
<td>1.27</td>
</tr>
<tr>
<td>4. real interest rate 1980–1995</td>
<td>6.1</td>
</tr>
<tr>
<td>5. intangible share 1995</td>
<td>10.4</td>
</tr>
<tr>
<td>6. labor share and size relation 1982–2012</td>
<td>-1.1</td>
</tr>
</tbody>
</table>

Effect of decline in $\psi_o$ on untargeted moments

$\psi_o$ falls 35.4% to match the decline in the relative price of IT goods over 1996–2005.

% of growth slowdown explained: **55.6%**

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<thead>
<tr>
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<tbody>
<tr>
<td>1. 2006–18 productivity growth rate (ppt)</td>
<td>1.10</td>
<td>1.42</td>
</tr>
<tr>
<td>2. change in aggregate labor share (%)</td>
<td>-8.1</td>
<td>-1.5</td>
</tr>
<tr>
<td>3. within change in labor share (%)</td>
<td>4.5</td>
<td>3.9</td>
</tr>
<tr>
<td>4. between change in labor share (%)</td>
<td>-12.5</td>
<td>-5.4</td>
</tr>
<tr>
<td>5. change in concentration (ppt)</td>
<td>4.8</td>
<td>19.6</td>
</tr>
<tr>
<td>6. change in intangible share (ppt)</td>
<td>1.5</td>
<td>0.2</td>
</tr>
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</table>

## Initial vs. new steady state

<table>
<thead>
<tr>
<th>Description</th>
<th>Initial</th>
<th>New</th>
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</thead>
<tbody>
<tr>
<td>1. creative destruction rate in % ($z^*$)</td>
<td>4.07</td>
<td>3.16</td>
</tr>
<tr>
<td>2. % of H-type products ($S^*$)</td>
<td>47.9</td>
<td>73.4</td>
</tr>
<tr>
<td>3. % of H-type sales ($\tilde{S}^*$)</td>
<td>54.0</td>
<td>75.7</td>
</tr>
<tr>
<td>4. markup of H-type firms</td>
<td>1.33</td>
<td>1.33</td>
</tr>
<tr>
<td>5. markup of L-type firms</td>
<td>1.19</td>
<td>1.15</td>
</tr>
<tr>
<td>6. aggregate markup</td>
<td>1.27</td>
<td>1.28</td>
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<tr>
<td>7. R&amp;D/PY (%)</td>
<td>6.9</td>
<td>5.4</td>
</tr>
<tr>
<td>8. overhead/PY (%)</td>
<td>3.4</td>
<td>5.1</td>
</tr>
<tr>
<td>9. rent/PY (%)</td>
<td>10.7</td>
<td>11.7</td>
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<tr>
<td>10. real interest rate (%)</td>
<td>6.2</td>
<td>5.4</td>
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</table>
Markup distribution

% of employment

<table>
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<th>firm markup</th>
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<th>new</th>
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<tr>
<td>1.15</td>
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<td>0.7</td>
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Robustness: alternative decline in $\psi_o$

<table>
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<th>Decline in $\psi_o$</th>
<th>New growth rate</th>
<th>% of decline explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>1.62</td>
<td>27.8%</td>
</tr>
<tr>
<td>35.4% (Baseline)</td>
<td>1.42</td>
<td>55.6%</td>
</tr>
<tr>
<td>50%</td>
<td>1.17</td>
<td>90.4%</td>
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</table>
Transition dynamics

Initially, as $S$ has not increased yet, incentive to do R&D increases.

And static process efficiency gains are realized during the transition as $S$ increases.

Both effects will contribute to a **burst of growth** during the transition.
Cobb-Douglas Calibration

Assigned: $\sigma = 1, \theta = 1$

Calibrated:

$\psi^0_o = 0.026, \phi = 0.010, \gamma = 1.273, \psi_r = 1.006, \beta = 0.956, \Delta = 1.182.$

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Cobb-Douglas: effect of decline in $\psi_o$

$\psi_o$ falls 35.4% to match the decline in the relative price of IT goods over 1996–2005.

% of growth slowdown explained: **103.9%**

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<td>-1.4</td>
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Transition after $\psi_0 \downarrow$
Firm level new product innovation rate after $\psi_0 \downarrow$
Share of lines with a $H$-type follower after $\psi_o \downarrow$

- $h_{Ht}$
- $h_{Lt}$

The graphs show the share of lines with a $H$-type follower over time ($t$) for both $h_{Ht}$ and $h_{Lt}$, with a new steady state indicated by the red line.
Labor share & markup after $\psi_0$ ↓

- **ppt change in labor share**
  - aggregate (blue)
  - within (red)
  - between (black)

- **firm-level labor share**
  - H-type (red)
  - L-type (black)
Change in output components after $\psi_0 \downarrow$
Output and consumption: $\psi_{o} \downarrow$ vs. no decline

![Graphs showing output and consumption with and without decline in $\psi_{o}$](image)

- **Output**: Comparison between $\psi_{o}$ drops and constant $\psi_{o}$.
- **Consumption**: Comparison between $\psi_{o}$ drops and constant $\psi_{o}$.
- **Output Growth**: Comparison between $\psi_{o}$ drops and constant $\psi_{o}$.
- **Consumption Growth**: Comparison between $\psi_{o}$ drops and constant $\psi_{o}$.
Utility from a consumption path:

\[ U(\{C_t\}_{t=0}^{\infty}) = \sum_{t=0}^{\infty} \beta^t \ln C_t \]

Consumption equivalence \( \xi \)

\[ U(\{(1 + \xi) C_{old}^t\}_t) = \frac{\ln(1 + \xi)}{1 - \beta} + U(\{C_{old}^t\}_t) = U(\{C_{new}^t\}_t) \]

\( \xi = -1.04\% \Rightarrow \text{the decline in } \psi_0 \text{ reduced welfare} \)
**Theory extensions**

CRRA preferences, CES technology, physical capital

Allowing for M&A activity

Case with $\Delta > \gamma$ or more realistic distribution in $\varphi(i)$

Endogenous entry and exit of *firms* (to be done)

Endogenous number of products (to be done)
Changing other parameters

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>$\psi_0 \downarrow$</th>
<th>$\Delta \uparrow$</th>
<th>$\gamma \downarrow$</th>
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<td>↑</td>
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How our story is distinct

Closest papers in the literature:

- Akcigit and Ates (2019)
- Liu, Mian and Sufi (2019)

We differ in

- our driving force
- generating opposite trends for labor’s share (and markups) within versus across firms
- generating/emphasizing an initial burst of growth before the growth slowdown
A complementary paper

Hsieh and Rossi-Hansberg (2019):

- IT lowers marginal costs, raises fixed costs
- firms expand into more locations
  - document this for Services, Retail, Wholesale
- raises concentration
- boosts productivity (transitional growth)

We differ in having:

- markup dispersion
- within and between markup changes
- falling long run growth
Conclusion

We provide an endogenous growth theory built around firms with heterogeneous quality, productivity and markups.

As firm span of control increases, the theory predicts:

- Rising concentration
- A decline in the labor income share (driven by composition as opposed to a decline within firms)
- A fall in TFP growth after an initial burst

Theory allows us to analyze the consequences of alternative comparative statics through firm composition.
Next steps

Solving numerically for the transition outside Cobb-Douglas case

More welfare analysis

Antitrust policy: how to deal with FAMANG?
Appendix
Rise and decline in TFP growth

Source: BLS multifactor productivity series + R&D and IP contribution in labor augmenting form.
Falling Labor Income Share

Source: BLS
Falling entry and exit rate

Source: BDS
Falling job reallocation

Annual Rates of Job Reallocation Across Firms and Establishments, U.S. Nonfarm Private Sector

Source: Decker et al. (2014)
Non-rising investment rate

Source: BEA. Nominal investment over nominal GDP
“Big Business Is Too Big” David Leonhardt, New York Times, April 2 2018

The United States has an oligopoly problem—a concentration of corporate power that has been building for years but is only now starting to receive serious attention from policymakers, think tanks and journalists...This consolidation has helped hold down wages, raise prices and reduce job growth—while lifting corporate profits...The Democrats have put antitrust policy at the center of their economic agenda.
cost of IT, intangibles

- Falling cost of IT
  - BEA IT deflator / GDP deflator

- Rising intangibles investment of large vs. small firms
  - Lashkari and Bauer (2018)
  - Crouzet and Eberly (2018)
• Small (young) firms appear more innovative
  - Akcigit and Kerr (2018)

• Small (young) firms grow faster
  - Haltiwanger, Jarmin and Miranda (2013)
Firm markup persistence

- Revenue/Inputs
  - Hsieh and Klenow (2009)
  - David and Venkateswaran (2018)

- Labor shares
  - De Loecker and Eeckhout (2018)
  - Gouin-Bonenfant (2018)
Why not trade?

- labor’s share has fallen in U.S. non-manufacturing
  - Autor et al. (2017)

- labor’s share has fallen in many developing countries
  - Karabarbounis and Neiman (2013)
Why not competition policy?

• labor’s share has fallen in many countries
  ○ Karabarbounis and Neiman (2013)

• local concentration has not risen
  ○ Rossi-Hansberg, Sarte, and Trachter (2018)
Within firm markups

Within firm markups

Source: Baqaeer and Farhi (2018).
Dynamic firm problem

A firm with \( n_t(j) \) highest quality patents and facing a share \( s_t(j) \) of high-productivity competitors solves

\[
V_t(n_t(j), s_t(j), S_t, \alpha_t, j) = \max_{x_t(j), n_{t+1}(j), s_{t+1}(j)} \{ \Pi_t(n_t(j), s_t(j), \alpha_t, j) \\
- x_t(j) \psi_r Y_t P_t \\
+ \frac{1}{1 + r_t} V_{t+1}(n_{t+1}(j), s_{t+1}(j), S_{t+1}, \alpha_{t+1}, j) \}
\]

s.t.

\[
x_t(j) = n_{t+1}(j) - n_t(j)(1 - z_{t+1})
\]

\[
n_{t+1}(j)s_{t+1}(j) = s_t(j)n_t(j)(1 - z_{t+1}) + x_t(j)S_t
\]

and

\[
x_t(j) \geq 0
\]