Firms and Growth

Pete Klenow

Stanford University

Kuznets Lecture

Yale University

April 2017
for his empirically founded interpretation of economic growth, which has led to new and deepened insight into the economic and social structure and process of development

– citation for the 1971 Nobel Memorial Prize in Economics
Modern revival of growth research

1980’s  Endogenous growth models (CRS)
   • Romer (1986), Lucas (1988)

1990’s  Endogenous growth models (IRS)
   • Romer (1990), Aghion-Howitt (1991), Kortum (1997)

1990’s  Cross-country empirics
   • Barro (1990), Mankiw-Romer-Weil (1992), Hall-Jones (1998)

Problem: Little interaction with micro data
More recent growth research

2000’s  Institutions, Directed Technological Change, Trade


2010’s  Firm Dynamics, Inequality, Trade


Fuel: Healthy interaction with micro data
Share of EconLit papers about "Growth"
Outline on Firms & Growth

1. Why firms and growth?

2. Which firms and how?
   - entrants vs. incumbents
   - own innovation vs. creative destruction vs. new varieties

3. Which contributions show up in official statistics?
BLS growth accounting

\[ Y = K^\alpha (A \cdot H)^{1-\alpha} \Rightarrow \frac{Y}{L} = \left( \frac{K}{Y} \right)^{\frac{\alpha}{1-\alpha}} \left( \frac{H}{L} \right) \cdot A \]

<table>
<thead>
<tr>
<th>Year Interval</th>
<th>( g_{Y/L} )</th>
<th>( g_A )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948–2016</td>
<td>2.36%</td>
<td>1.98%</td>
</tr>
<tr>
<td>1948–1973</td>
<td>3.28</td>
<td>3.20</td>
</tr>
<tr>
<td>1974–1995</td>
<td>1.55</td>
<td>0.84</td>
</tr>
<tr>
<td>1996–2005</td>
<td>3.10</td>
<td>2.69</td>
</tr>
<tr>
<td>2006–2016</td>
<td>1.19</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Possible drivers of residual TFP

Human capital?

BLS tries to net it out, but imperfectly

Allocative efficiency?

Evidence is limited to manufacturing (see next slide)

Firm-led innovation

This is promising and will be my focus
U.S. allocative efficiency

Source: Bils, Klenow and Ruane (2017)
Segue on allocative efficiency and development

Allocative efficiency *does* appear to be important for:

- levels of development
  - China, India, Mexico vs. the U.S.
- transitional growth
  - China, Spain, Eastern Europe

U.S. vs. Indian allocative efficiency

Source: Bils, Klenow and Ruane (2017)
Evidence on firm-level innovation

- Patents and R&D?
- Accounting decompositions \textit{a la} Haltiwanger?
- Indirect inference using firm employment
Manufacturing share of:

- Patents: 90%
- R&D: 69%
- GDP: 12%
- TFP growth: 11%

Sources: USPTO, NSF, BEA, BLS

Shares are in 2012 except for TFP growth (1987–2014)
Using plant-level or firm-level data:

$$g_{Y/L} = \text{Entrants} - \text{Exiters}$$

+ Reallocation among survivors

+ Growth within survivors

Atheoretical (both good and bad)

Limited to manufacturing because need output data
Longitudinal Business Database covers > 80% of employment

Employment as a proxy for market share and innovation:

- Entrant employment share reflects entrant innovation
- If survivors innovate, they add workers
- If creative destruction, thick tails for firm job growth
- If own innovation, modest employment gains
Klette and Kortum (2004)

Innovating Firms and Aggregate Innovation

Garcia-Macia, Hsieh and Klenow (2016)

How Destructive is Innovation?
own improvements

quality level

$q$

$M_t$

firm $j$ (3 initial varieties)
The diagram illustrates the relationship between quality level and the progression from initial varieties to new varieties through own improvements and creative destruction.

- **Quality Level (q)**: The vertical axis represents the quality level, indicating the progression of quality over time.

- **Firm j (3 Initial Varieties)**: The horizontal axis represents the firm j with three initial varieties, marked as $S_\lambda$, $S_\delta$, and $S_\kappa$.

- **Creative Destruction**: The process of new varieties replacing old ones, marked by $S_\kappa$, indicating the destruction of less efficient varieties.

- **Own Improvements**: The vertical bars $S_\lambda$ and $S_\delta$ indicate the improvements or innovations made by the firm itself, leading to the creation of new varieties.

The diagram shows how firms continuously innovate and improve their products, leading to the destruction of less efficient varieties and the introduction of new, more efficient varieties.
\[ Y = \left[ \sum_{j=1}^{M} \left( q_j y_j \right)^{1-\frac{1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \]

\[ y_j = l_j = \left( \frac{\sigma - 1}{\sigma} \right)^{\sigma-1} L W^{1-\sigma} q_j^{\sigma-1} \]

\[ L_f \equiv \sum_{j \in M_f} l_j = \left( \frac{\sigma - 1}{\sigma} \right)^{\sigma-1} L W^{1-\sigma} \sum_{j \in M_f} q_j^{\sigma-1} \]

\[ W \propto Y/L = M^{\frac{1}{\sigma-1}} \left[ \sum_{j=1}^{M} \frac{q_j^{\sigma-1}}{M} \right]^{\frac{1}{\sigma-1}} \]
Arrival rates of innovation

Own-variety improvements by incumbents \( \lambda_i \)
Creative destruction by entrants \( \delta_e \)
Creative destruction by incumbents \( \delta_i \)
New varieties from entrants \( \kappa_e \)
New varieties from incumbents \( \kappa_i \)

The average step size for quality improvements for own innovation and creative destruction, weighted by employment, is \( s_q = \left( \frac{\theta}{\theta-(\sigma-1)} \right)^{1/(\sigma-1)} \geq 1 \). New varieties are drawn from the quality distribution of existing products times \( s_\kappa \).
Firm-led innovation and growth

Two ways of decomposing the gross growth rate \((1 + g)\):

\[
\left( 1 + s_\kappa (\kappa_e + \kappa_i) + (s_q \sigma^{-1} - 1) \lambda_i + (s_q \sigma^{-1} - 1) \left( \tilde{\delta}_e + \tilde{\delta}_i \right) - \delta_o \psi \right)^{\frac{1}{\sigma - 1}}
\]

\[
\text{new varieties} \quad \text{own innovation} \quad \text{creative destruction}
\]

\[
\left( 1 + s_\kappa \kappa_e + (s_q \sigma^{-1} - 1) \tilde{\delta}_e + s_\kappa \kappa_i + (s_q \sigma^{-1} - 1) \left( \lambda_i + \tilde{\delta}_i \right) - \delta_o \psi \right)^{\frac{1}{\sigma - 1}}
\]

\[
\text{entrants} \quad \text{incumbents}
\]
Model JC/JD with only Creative Destruction
Model exit by size with *only* Creative Destruction
Model JC/JD with *only* Own Innovation
Data JC/JD in the U.S. LBD

![Graph showing job creation/destuction vs growth rate of employment](image-url)
Employment per firm, young vs. old – in the U.S. LBD

Bar chart showing employment per firm for age groups in 1981 and 2008. The y-axis represents employees and the x-axis represents age groups: age < 5 and age 5+. The chart compares employment levels between the two time periods for each age group.
Exit rate, small vs. large firms – in the U.S. LBD
Sources of Product Innovation, 2003–2013

Incumbents’ product improvements: 76.7%

Creative destruction by entrants: 12.5%

Creative destruction by incumbents: 6.4%

New varieties entrants and incumbents: 4.4%
## Sources of growth

<table>
<thead>
<tr>
<th></th>
<th>Entrants</th>
<th>Incumbents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1976–1986</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative destruction</td>
<td>19.1%</td>
<td>8.2%</td>
<td>27.3%</td>
</tr>
<tr>
<td>New varieties</td>
<td>0.0%</td>
<td>7.6%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Own-variety improvements</td>
<td>-</td>
<td>65.1%</td>
<td>65.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19.1%</td>
<td>80.9%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Entrants</th>
<th>Incumbents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2003–2013</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative destruction</td>
<td>12.5%</td>
<td>6.4%</td>
<td>18.9%</td>
</tr>
<tr>
<td>New varieties</td>
<td>0.3%</td>
<td>4.1%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Own-variety improvements</td>
<td>-</td>
<td>76.7%</td>
<td>76.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12.8%</td>
<td>87.2%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Why do we care which firms drive growth?

- spillovers may be bigger from entrants
- entrants may face financial constraints
- business stealing from creative destruction

▶ see Atkeson and Burstein (2016)
Rest of presentation builds on three papers

Broda and Weinstein (2010)

Product Creation and Destruction

Erickson and Pakes (2011)

An Experimental Component Index for the CPI

Aghion, Bergeaud, Boppart, Klenow and Li (2017)

Missing Growth from Creative Destruction
CD is a key source of growth in many models

- See the survey by Aghion, Akcigit and Howitt (2014)
- Yet GHK find a modest role for CD

Does CD show up in measured growth?

- standard measurement assumes new producers have the same quality-adjusted price as producers they replace
- but creative destruction ⇒ new producers have a lower quality-adjusted price
Numerical example

- 80% of items: 4% inflation (no innovation)
- 10% of items: −6% inflation (innovation w/o CD)
- 10% of items: −6% inflation (CD)

True inflation = 2%, True growth = 2%

Imputed inflation due to CD = \( \frac{8}{9} \cdot 4\% + \frac{1}{9} \cdot (-6\%) = 2.9\% \)

Measured growth= 1.1%, Missing Growth = 0.9%
Our questions

1. How much is U.S. growth understated, on average, because of creative destruction?

2. Has such “missing growth” increased in recent years?
3.9% monthly exit rates of products

48% of the product substitutions “noncomparable”

So 22.5% average annual “true” exit

Noncomparable item substitutions:

- 31% direct quality adjustments (mostly same producer products)
- 69% linking or class-mean forms of imputation
2.3% monthly exit rate (Nakamura & Steisson 2008)

**Missing prices**

*If no price report from a participating company has been received in a particular month, the change in the price of the associated item will, in general, be estimated by averaging the price changes for the other items within the same cell (i.e., for the same kind of products) for which price reports have been received.*

Sources of bias from CD:

\[ \lambda_d \left(1 - \hat{\lambda}_i\right) \log \hat{\gamma}_i + \lambda_d \left(\log \gamma_d - \log \hat{\gamma}_i\right) \]

not all incumbents innovate

different stepsize for CD
GHK assume measured growth = true growth

We argue that CD and NV are missed

Our indirect inference differs as a result

We infer more true growth, higher step sizes
Percentage points per year

1976–1986 0.52%
  from CD 0.41%

2003–2013 0.42%
  from CD 0.33%
## Measured vs. True growth

<table>
<thead>
<tr>
<th></th>
<th>Measured</th>
<th>“True”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976–1986</td>
<td>1.03%</td>
<td>1.55%</td>
</tr>
<tr>
<td>2003–2013</td>
<td>1.44%</td>
<td>1.86%</td>
</tr>
</tbody>
</table>
Why do we care if some growth is missed?

- business stealing
- relating growth to policy
- whether ideas are getting harder to find (Gordon, Jones)
- how many people are better off than their parents (Chetty et al.’s Fading American Dream)
- setting the Fed’s inflation target
- indexing Social Security and tax brackets
Focused on U.S. growth today

But issues are just as relevant for other countries:

- Firms everywhere are innovating / imitating / adopting
  - See India and Mexico vs. the U.S.

- Same issues arise with growth statistics in OECD and beyond
Growth in Average Plant Employment over the Life Cycle

Open questions

- How big are externalities?
  - entrants vs. incumbents
  - domestic vs. international

- Sources of firm-level innovation outside the U.S.?

- Reasons for declining dynamism and growth?

- Creative destruction, trade, and inequality?

- Missing growth outside the U.S.?