Innovative Growth Accounting

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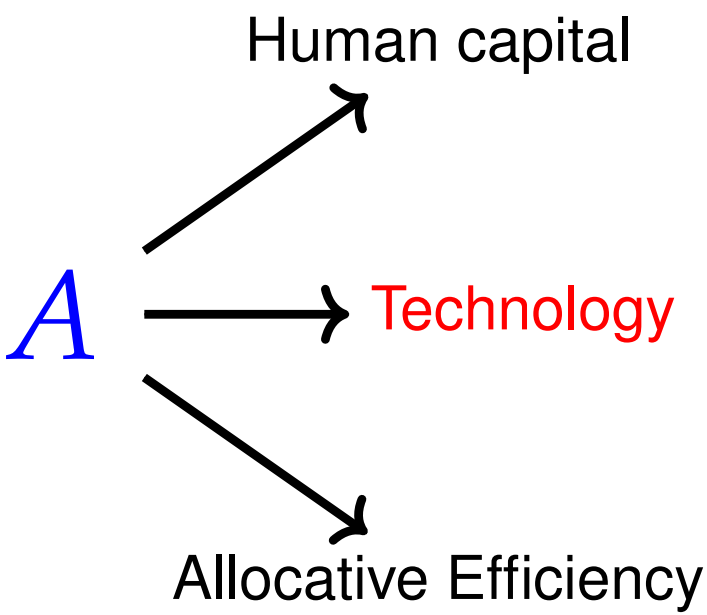
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Macro growth accounting

$$\frac{Y}{L} = A^{\frac{1}{1-\alpha}} \times \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$$



- A accounts for almost all of growth of Y/L
- Technology accounts for bulk of growth in A

Innovative growth accounting

We decompose the technology term into contribution from

- innovation types:
  - creative destruction (CD)
  - new varieties (NV)
  - own-innovation (OI)
- firm types:
  - young vs old
  - small vs large

Motivation

The U.S. economy over the past 30 years:

1. Falling growth (interrupted by a 10-year burst of growth)
2. Falling rates of firm entry, exit and job reallocation
3. Rising firm concentration within industries

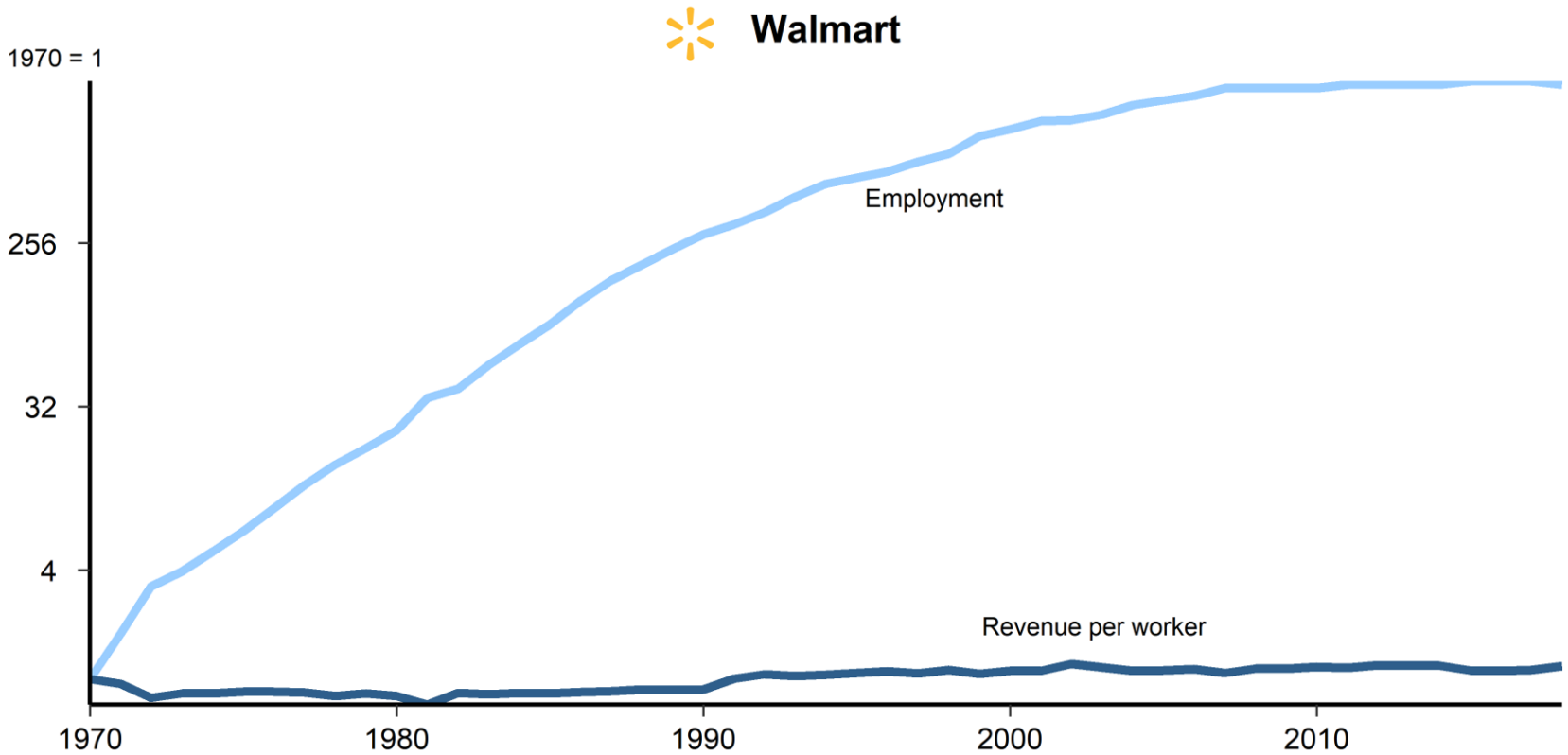
Intuition for our method

Model-based accounting: silent on determinants of arrival rates and step sizes of innovation

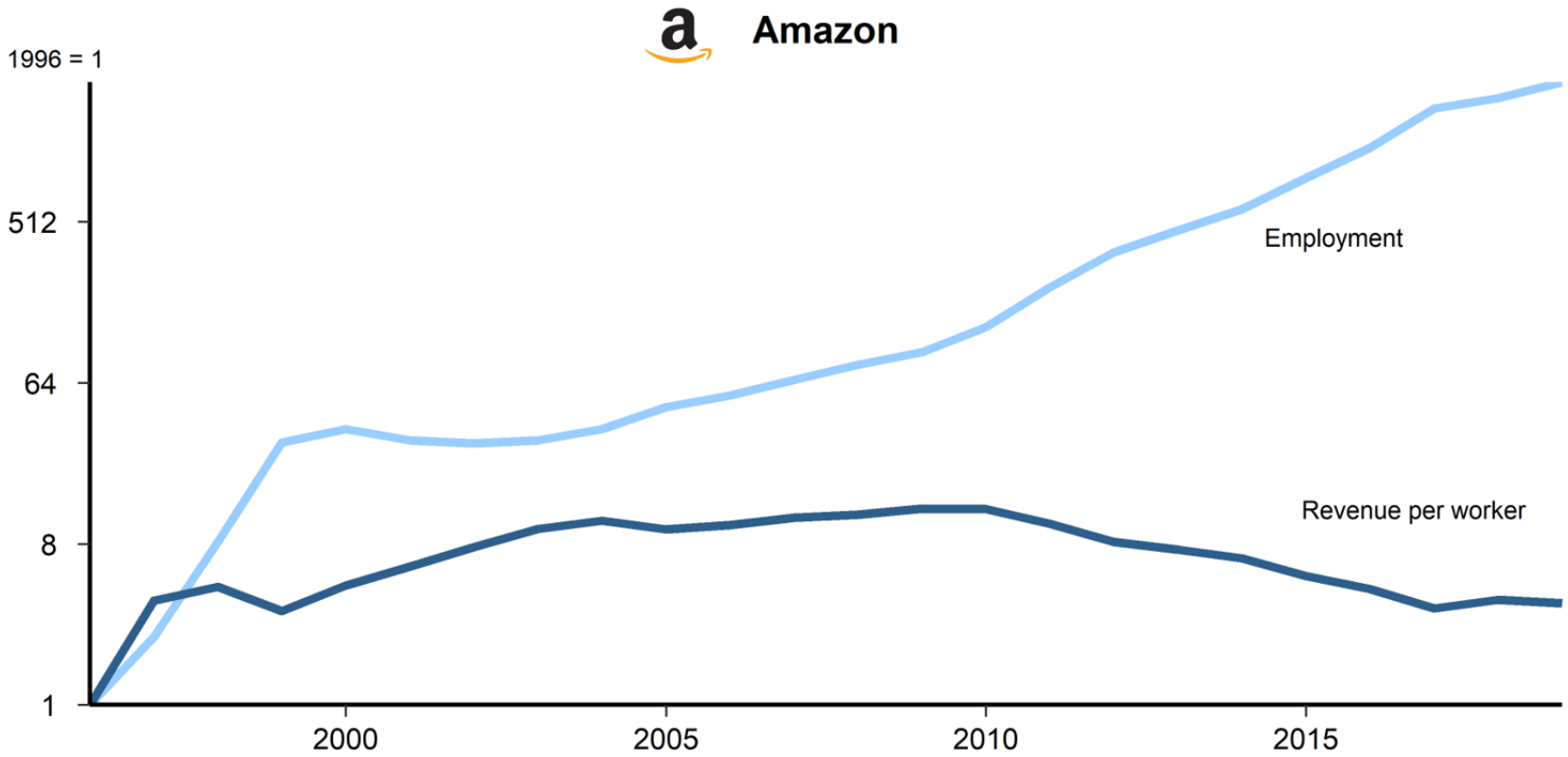
Feenstra (1994): changes in market share reflect changes in relative prices and productivity

Garcia, Hsieh and Klenow (2020): compared to NV and OI, CD generates more job reallocation than innovation

Why not revenue productivity?



Why not revenue productivity?



Method: Environment

Aggregate output:

$$Y = \left[\int_0^N \left[q(j)\, y(j) \right]^{1-1/\sigma} dj \right]^{\frac{\sigma}{\sigma-1}}$$

Product-level output:

$$y(j) = l(j)$$

Aggregate productivity:

$$Q \equiv \frac{Y}{L} = \left[\int_0^N q(j)^{\sigma-1} dj \right]^{\frac{1}{\sigma-1}}$$

Arrival rates and step sizes of innovation

	Creative destruction	New varieties	Incumbents on own products
Arrival rate	δ	ν	o
Step size $\frac{q_{t+1}(j)}{q_t(j)}$	Δ	V	O

Timing: obsolescence $\rightarrow$ CD and NV $\rightarrow$ OI

A firm's contribution to growth

$$
\begin{aligned}
g_f \;&:=\; \nu_f V_f^{\sigma-1} + \delta_f(\Delta_f^{\sigma-1}-1) && \text{NV, CD}\\
&+\; o_f(O_f^{\sigma-1}-1)\frac{\mathbb{E}_{G_{f,t-1}}(q^{\sigma-1})}{\mathbb{E}_{G_{t-1}}(q^{\sigma-1})} && \text{OI}\\
&+\; \left(\int_j \nu_j V_j^{\sigma-1} + \delta_j(\Delta_j^{\sigma-1}-1)\,dj\right)\left(\left(\frac{\widehat{Q}}{Q}\right)^{\sigma-1}-1\right)\frac{G_{f,t-1}(\kappa_t)N_{f,t-1}}{G_{t-1}(\kappa_t)N_{t-1}}\\
&+\; o_f(O_f^{\sigma-1}-1)\left(\frac{\mathbb{E}_{G_{f,t-1}}(q^{\sigma-1}|q\geq\kappa_t)}{\mathbb{E}_{G_{t-1}}(q^{\sigma-1})}-1\right) && \text{Selection}\\
&-\; \mathbb{E}_{G_{f,t-1}}[s_{t-1}\,|\,q<\kappa_t]G_{f,t-1}(\kappa_t)N_{f,t-1}, && \text{Variety loss}
\end{aligned}
$$

Growth from each type of firm

Aggregate growth

$$g = \frac{1}{\sigma - 1} \ln \left[1 + \int_f g_f \, df \right] \approx \frac{1}{\sigma - 1} \int_f g_f \, df$$

Contribution of a firm group

$$\frac{\int_{f \in \mathcal{F}} g_f \, df}{\int_{f'} g_{f'} \, df'}$$

Growth from each type of innovation

Creative destruction:

$$\frac{\int_f \delta_f (\Delta_f^{\sigma-1} - 1)\ df}{\int_f \ g_f \ df}$$

New variety:

$$\frac{\int_f \nu_f V_f^{\sigma-1}\ df}{\int_f \ g_f \ df}$$

Own innovation:

$$\frac{\int_f o_f (O_f^{\sigma-1} - 1) \frac{\mathbb{E}_{G_{f,t-1}}(q^{\sigma-1})}{\mathbb{E}_{G_{t-1}}(q^{\sigma-1})}\ df}{\int_f \ g_f \ df}$$

U.S. Census Data

- Longitudinal Business Database (LBD)
- all nonfarm private sector plants
- employment, wage bill, firm, industry
- results for 1982–2013
  - subperiods 1982–1995, 1996–2005, 2006–2013

Mapping to Moments

Choose arrival rate and step size to fit entry and exit rate and changes in market share of surviving plants

Assume existing plants carry out OI but not CD or NV
$\Rightarrow$ plant entry and exit reflects arrival of NV, CD, and obsolescence

CES implies a plant's market share is isoelastic wrt to its quality
$\Rightarrow$ change in market share reflects relative quality growth

Data Target Moments

For each firm group $\mathcal{F}$

$\mathcal{E}_{\mathcal{F}t}/N_{t-1}$	# of new plants
$\mathcal{X}_{\mathcal{F},t-1}/N_{t-1}$	# of exiting plants
$S_{\mathcal{E}_{\mathcal{F}t}}$	employment share of new plants
$S_{\mathcal{X}_{\mathcal{F},t-1}}$	employment share of exiting plants
$S_{C_{\mathcal{F}t}}/S_{C_{\mathcal{F}t-1}}$	growth in employment share of continuing plants
$S^{\{2\}}_{\mathcal{E}_{\mathcal{F}t}}$	2nd moment of employment share of new plants
$S^{\{3\}}_{\mathcal{E}_{\mathcal{F}t}}$	3rd moment of employment share of new plants

Aggregate moments

$S^{\{k\}}_{\mathcal{N}_{t-1}}$	kth moment of employment share of all plants, $k = 1, 2, 3$
g	TFP growth rate

Notes: $S^{\{k\}}_{\mathcal{P}t} := \int_{\mathcal{P}} s^k_t(i)di$, where s denotes employment share.

Growth by innovation type, 1982–2013

g	CD	NV	OI
1.64	0.21	0.38	1.06
Baseline	13.0%	27.2%	59.8%
(Entrants age 0)			
Alternative	17.1%	40.2%	42.7%
(Entrants age 0–5)			

Growth speedup and slowdown by innovation type

Own innovation drove the speedup and slowdown

Period	Δg	CD	NV	OI
1982–1995	**1.67**	9.8%	-0.5%	90.8%
vs 1996–2005				
1996–2005	**-1.79**	11.0%	7.1%	81.9%
vs 2006–2013				

Growth by age group, 1982–2013

New firms' contribution to growth exceeded their employment share

	Age 0	Age 1–5	Age 6–10	Age 11+
% of growth	30.3%	18.9%	9.7%	41.1%
% of employment	3.3%	13.4%	11.2%	72.1%
% of firms	10.7%	31.1%	18.5%	39.6%

Growth speedup and slowdown by age group

Older firms were most important for the speedup and slowdown

Period	Δg	Age 0	Age 1–5	Age 6–10	Age 11+
1982–1995 vs 1996–2005	**1.67**	4.4%	13.4%	12.6%	69.6%
1996–2005 vs 2006–2013	**-1.79**	11.8%	17.0%	12.3%	58.9%

Growth by size group, 1982–2013

Small firms' contribution to growth exceeded their employment share

	Small (0–19)	Medium (20–249)	Large (250–4999)	Mega (5000+)
% of growth	62.2%	15.0%	12.2%	10.7%
% of employment	21.4%	26.3%	26.9%	25.4%
% of firms	88.0%	11.2%	0.8%	0.03%

Growth speedup and slowdown by size group

All size groups were important for the speedup and slowdown

Period	Δg	Small (0–19)	Medium (20–249)	Large (250–4999)	Mega (5000+)
1982–1995 vs 1996–2005	1.67	27.0%	24.7%	25.5%	22.7%
1996–2005 vs 2006–2013	-1.79	37.5%	22.2%	20.2%	20.1%

Contribution of superstar firms not so super?

- U.S. Census Bureau forbids us from disclosing identity of firms
- Apply our method to NETS data to estimate the contribution of Walmart and Amazon to fast growth from 1996–2005

	Walmart	Amazon
% of growth	0.80%	0.0041%
% of employment	0.41%	0.0013%

Growth by age and innovation type, 1982–2013

New firms contribute via NV, incumbent firms through OI

Age	CD	NV	OI	Total
0	7.2	23.0	0.0	30.3
1–5	0.7	1.2	17.1	18.9
6–10	0.7	0.9	8.1	9.7
11+	4.4	2.1	34.6	41.1

Growth by size and innovation type, 1982–2013

All size groups contribute through OI, small firms also do CD and NV

Size	CD	NV	OI	Total
Small (0–19)	8.5	23.6	30.0	62.2
Medium (20–249)	0.1	2.8	12.1	15.0
Large (250–4999)	1.2	0.6	10.4	12.2
Mega (5k–10k+)	3.1	0.2	7.4	10.7

Growth by age-size group, 1982–2013

New firms and small firms are particularly important

	New	Young small	Old small
% of growth	29.9	14.1	11.6
% of employment	3.3	6.1	8.3
% of firms	10.7	28.8	32.0

Conclusion and future research

We provide a method to decompose aggregate productivity growth into contributions from firms and innovation types.

Many caveats that we hope future studies can address:

- Plants as proxies for products
- Plant employment shares instead of sales shares
- CES demand
- Untargeted creative destruction
- No misallocation (!)