Missing Growth from Creative Destruction

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[1]DISCLAIMER: Opinions and conclusions herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau or the Federal Reserve System. All results have been reviewed to ensure that no confidential information is disclosed.

Creative Destruction (CD)

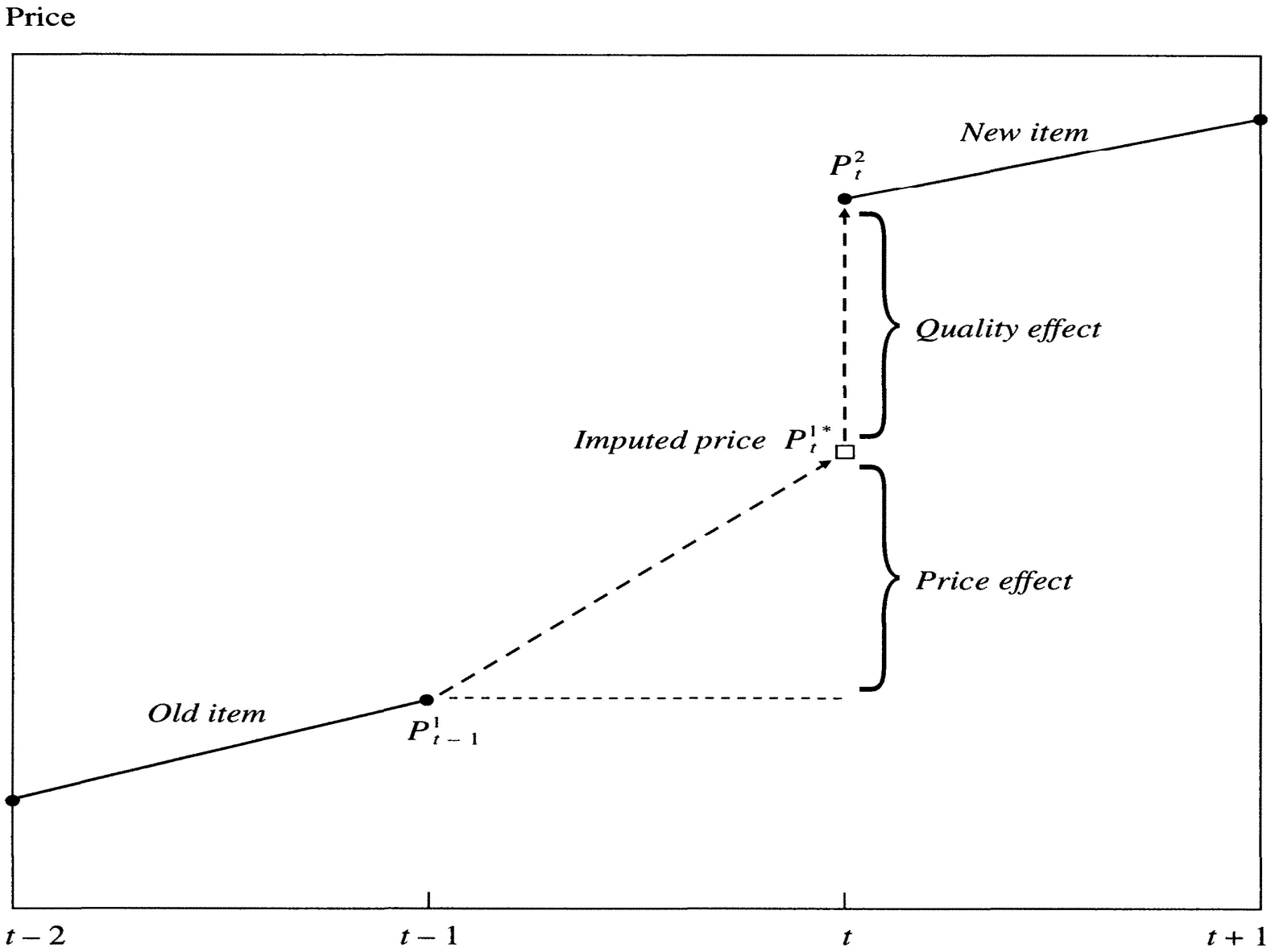
CD is a key source of growth in many models

- New producer of a product has higher quality or productivity, eclipsing incumbent producer
- See the survey by Aghion, Akcigit and Howitt (2014)

Does CD show up in measured growth?

- Standard measurement assumes new producers have same quality-adjusted price as products they replace
- But creative destruction $\Rightarrow$ new producers have *lower* quality-adjusted prices

Imputation


Price
New item
P_t^2
Quality effect
Imputed price P_t^{1*}
Price effect
Old item
P_{t-1}^1
$t-2$
$t-1$
t
$t+1$

Stylized 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 $= 2\%$
- Imputation for 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 imputation for creative destruction?

2. Has "missing growth" increased a lot in recent years?

Our Answers

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

   $\sim$ **0.6 ppt per year** between 1983–2013

2. Has "missing growth" increased a lot in recent years?

   No

Roadmap

Background: BLS imputation and previous lit

Model with exogenous innovation

- True growth
- Measured growth

Quantification with U.S. Census LBD

- Market share approach with plants
- Indirect inference on firms

BLS Procedures

CPI

- Boskin Commission (1996)
- Moulton and Moses (1997), GAO Report (1999)
- Klenow (2002), Bils (2009)
- Pakes (2003), Erickson and Pakes (2011)
- BLS Handbook of Methods (2015, ch. 17)

PPI

- Pakes (2003)
- BLS Handbook of Methods (2015, ch. 14)

Imputation in the CPI, 1988–2004

- $\sim$ 4% monthly exit rate of items
- $\sim$ 1/2 of the product substitutions "noncomparable"
- $\sim$ 20% annual "true" exit rate
- Noncomparable item substitutions:
  - $\sim$ 1/3 direct quality adjustments
  - $\sim$ 2/3 linking or class-mean imputation

Imputation in the PPI

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.

– BLS Handbook of Methods (2015, ch. 14, p. 10)

Relation to Boskin Commission

Focus of Boskin Commission:

Quality bias from incumbent own-product improvements

Focus of BLS quality adjustments:

Quality bias from incumbent own-product improvements

Our focus:

Quality bias from imputation in the event of CD

Broda and Weinstein (2010)

- AC Nielsen Scanner data 1994, 1999–2003
- Packaged consumer nondurables ($< 4\%$ of GDP)
  - Low rate of product turnover
- Assume BLS makes no quality adjustments

How we differ:

- Census LBD data 1983–2013
- All private nonfarm establishments ($> 80\%$ of GDP)
- Assume BLS captures quality improvements by incumbents on their own products

Erickson and Pakes (2011)

- BLS micro data + scanner data
- Televisions 2000–2003, 2005–2006
- Digital cameras 2007–2009
- Falling prices induce exit
- Correct hedonics for this selection

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Environment

Discrete time

Representative consumer with $C_t = Y_t$

Exogenous aggregate supply of labor L_t

M_t units of money, with $M_t = P_t Y_t$

Production

Aggregate

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

Product level

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

Product vs. process innovation

If all innovation is process innovation:

- Unit prices fall with innovation
- Easier to measure growth from CD (at least in CPI)

Data: elasticity of unit prices wrt revenue $\approx$ 0.

- e.g. Hottman, Redding and Weinstein (2015)

Consistent with product innovation.

Types of Innovation

	Creative destruction	New varieties	Incumbents on own products
Arrival rate	λ_d	λ_n	λ_i
Step size $\frac{q_{t+1}(j)}{q_t(j)}$	γ_d	γ_n	γ_i

Market structure and pricing

Competitive final goods (P_t) and labor (W_t/P_t) markets

Monopolistic competition in market for intermediate goods:

$$p_t(j) = \mu \cdot W_t$$

- $\mu = \frac{\sigma}{\sigma - 1}$ when $\sigma > 1$
- μ determined by limit pricing when $\sigma = 1$

True Inflation

Price level

$$P_t = \mu \cdot W_t \cdot \left(\int_0^{N_t} q_t(j)^{\sigma-1} \, dj \right)^{\frac{1}{1-\sigma}}$$

If the quality of new varieties is $q_t(j) = \gamma_n \, \bar{q}_t$ then

$$\frac{P_{t+1}}{P_t} = \frac{W_{t+1}}{W_t} \cdot \left[\underbrace{1 + \lambda_d \left(\gamma_d^{\sigma-1} - 1 \right)}_{\text{CD}} + \underbrace{(1-\lambda_d)\lambda_i \left(\gamma_i^{\sigma-1} - 1 \right)}_{\text{own innovation (OI)}} + \underbrace{\lambda_n \gamma_n^{\sigma-1}}_{\text{new varieties (NV)}} \right]^{\frac{1}{1-\sigma}}$$

True vs. Measured Growth

True

$$\frac{Y_{t+1}}{Y_t} = \frac{M_{t+1}}{M_t}\frac{P_t}{P_{t+1}}$$

Measured

$$\widehat{\left(\frac{Y_{t+1}}{Y_t}\right)} = \frac{M_{t+1}}{M_t}\widehat{\left(\frac{P_t}{P_{t+1}}\right)}$$

Missing growth $\Leftrightarrow$ overstated inflation

$$\log\frac{Y_{t+1}}{Y_t} - \log\widehat{\left(\frac{Y_{t+1}}{Y_t}\right)} = \log\widehat{\left(\frac{P_{t+1}}{P_t}\right)} - \log\frac{P_{t+1}}{P_t}$$

True vs. Measured Growth

True growth

$$\frac{Y_{t+1}}{Y_t} = \left[1 + \underbrace{\overbrace{\lambda_d \left(\gamma_d^{\sigma-1} - 1\right)}^{\text{impute}}}_{\text{CD}} + \underbrace{(1-\lambda_d)\lambda_i \left(\gamma_i^{\sigma-1} - 1\right)}_{\text{OI}} + \underbrace{\overbrace{\lambda_n \gamma_n^{\sigma-1}}^{\text{miss}}}_{\text{NV}}\right]^{\frac{1}{\sigma-1}}$$

Measured growth

$$\frac{\widehat{Y_{t+1}}}{Y_t} = \left[1 + \widehat{\lambda}_i \left(\widehat{\gamma}_i^{\sigma-1} - 1\right)\right]^{\frac{1}{\sigma-1}}$$

Cobb-Douglas case

True growth

$$\lambda_d \cdot \log \gamma_d \;\; + \;\; (1 - \lambda_d) \cdot \lambda_i \cdot \log \gamma_i$$

Measured growth

$$\underbrace{\lambda_d \; \widehat{\lambda}_i \; \log \widehat{\gamma}_i}_{\text{imputation for CD}} \quad + \quad \underbrace{(1 - \lambda_d) \, \widehat{\lambda}_i \; \log \widehat{\gamma}_i}_{\text{incumbent innovation}} \quad = \quad \widehat{\lambda}_i \log \widehat{\gamma}_i$$

Cobb-Douglas case

Missing growth:

$$\underbrace{\lambda_d \left(\log \gamma_d - \widehat{\lambda}_i \log \widehat{\gamma}_i \right)}_{\text{CD bias}} + \underbrace{(1 - \lambda_d) \left(\lambda_i \log \gamma_i - \widehat{\lambda}_i \log \widehat{\gamma}_i \right)}_{\text{quality bias}}$$

Cobb-Douglas case

Sources of bias from CD:

$$\underbrace{\lambda_d \left(1 - \widehat{\lambda}_i\right) \log \widehat{\gamma}_i}_{\text{not all incumbents innovate}} + \underbrace{\lambda_d \left(\log \gamma_d - \log \widehat{\gamma}_i\right)}_{\text{different stepsize for CD}}$$

Understated growth from CD:

- even if CD and own-innovation have the same step size
- but exacerbated by lower $\widehat{\lambda}_i$ and any quality bias

Roadmap

Model with exogenous innovation

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Relative prices $\Leftrightarrow$ market shares

CES $\Rightarrow$ market share isoelastic with respect to price

$$\text{Missing Growth} = \frac{\frac{Y_{t+1}}{Y_t}}{\widehat{\frac{Y_{t+1}}{Y_t}}} = \frac{\frac{P^S_{t+1}}{P_{t+1}}}{\frac{P^S_t}{P_t}} = \left(\frac{S_{I_t,t+1}}{S_{I_t,t}}\right)^{\frac{1}{1-\sigma}}$$

$S_{I_t,t}$ = market share in t of all goods sold in both t and $t+1$

$S_{I_t,t+1}$ = market share in $t+1$ of all goods sold in t & $t+1$

Shrinking share of non-CD goods $\Rightarrow$ missing growth

Going from model to data

IF existing plants carry out OI but not CD or NV:

$$\text{Missing Growth} = \frac{\frac{Y_{t+1}}{Y_t}}{\widehat{\frac{Y_{t+1}}{Y_t}}} = \frac{\frac{P^S_{t+1}}{P_{t+1}}}{\frac{P^S_t}{P_t}} = \left(\frac{S_{I_t,t+1}}{S_{I_t,t}}\right)^{\frac{1}{1-\sigma}}$$

$S_{I_t,t}$ = market share in t of all <u>establishments</u> operating in both t and $t+1$

$S_{I_t,t+1}$ = market share in $t+1$ of all <u>establishments</u> operating in both t and $t+1$

U.S. Census Data

- Longitudinal Business Database (LBD)
- all nonfarm private sector plants
- employment, wage bill, firm, industry
- results for 1983–2013

Some details

Use employment share; plant-level revenue is not available

In Census of Mfg, bigger MG with rev. than emp.

"Entrants" = plants who are 5 years old

$\sigma = 4$ based on Hottman, Redding and Weinstein (2016)

Missing Growth Implied by Survivor Market Shares

% points per year

1983–2013	**0.64**
1983–1995	0.66
1996–2005	0.55
2006–2013	0.74

Measured vs. True Growth

% points per year

	Measured	"True"
1983–2013	1.87	2.51
1983–1995	1.80	2.46
1996–2005	2.68	3.23
2006–2013	0.98	1.72

Robustness checks

	Lower $\sigma = 3$	Baseline $\sigma = 4$	Higher $\sigma = 5$
1983–2013	**0.96**	**0.64**	**0.48**

	Employment	Payroll
1989–2013	**0.70**	**0.72**

Missing Growth: 1 Sector vs. Weighted Sectors

	1-sector	2-digit	3-digit	4-digit	5-digit
1983–2013	**0.64**	**0.64**	**0.66**	**0.74**	**0.77**

And still no surge in missing growth

Contribution to Missing Growth

1.	Retail Trade	17.6%
2.	Restaurants & Hotels	17.4%
3.	Health Care	16.0%
4.	Admin support services	12.2%
5.	Professional services	8.1%
	⋮	
15.	Manufacturing	1.1%

Missing Growth vs. Declining Dynamism

	Plants	Firms	Net Entry	Gross Entry
1983–1995	0.66	0.33	0.54	0.70
1996–2005	0.55	0.17	0.40	0.06
2006–2013	0.74	0.09	0.06	-0.49

Net Entry assumes equal-sized firms

Gross Entry assumes equal-sized firms and a fixed exit rate

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Indirect inference on firms

Key advantage:

- Need not assume CD and NV come from new plants
- Bernard, Redding and Schott (2010) find that manufacturing plants do add SIC's

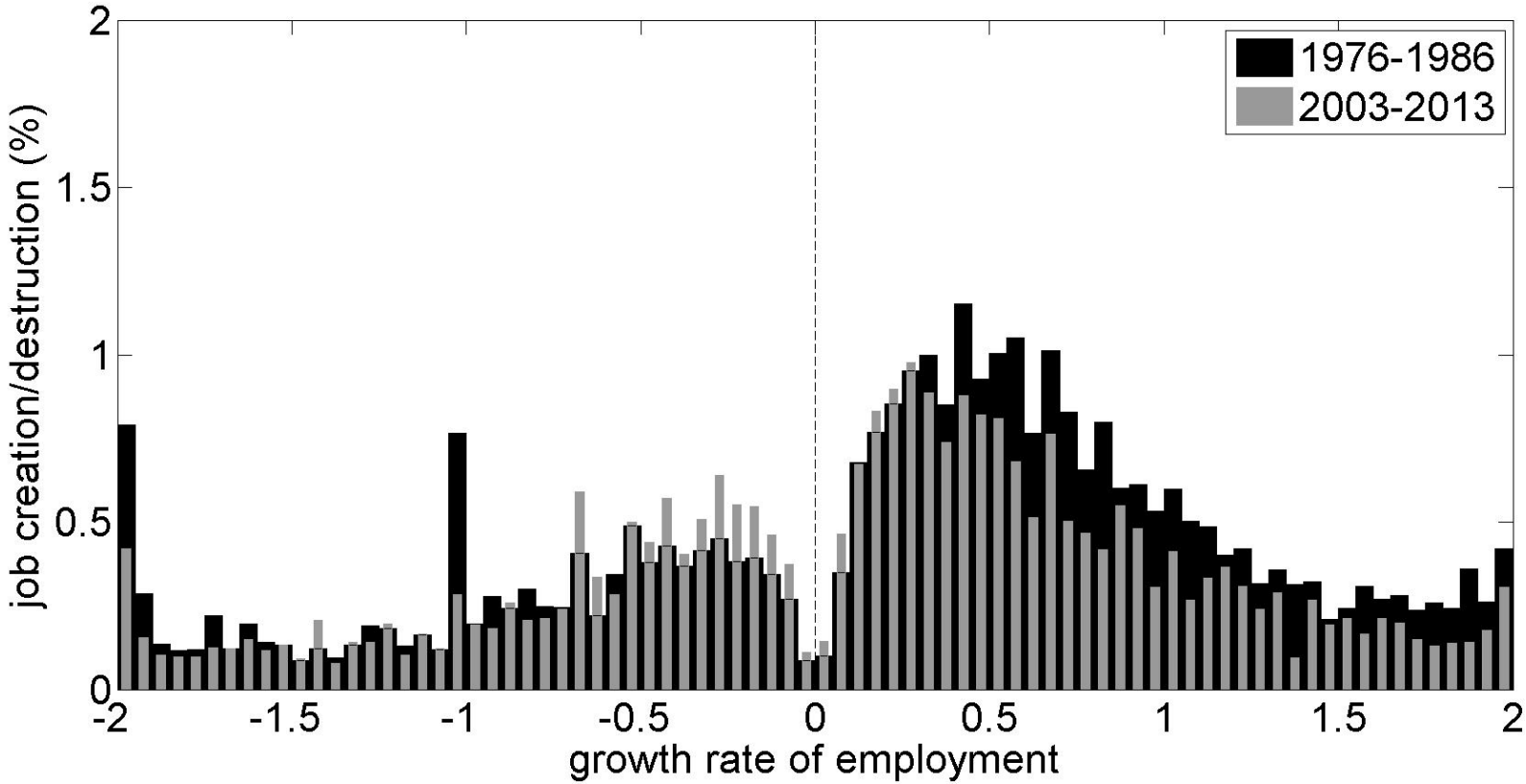
We extend Garcia-Macia, Hsieh and Klenow (2016)

- Infer arrival rates and step sizes to fit employment dynamics in LBD firms

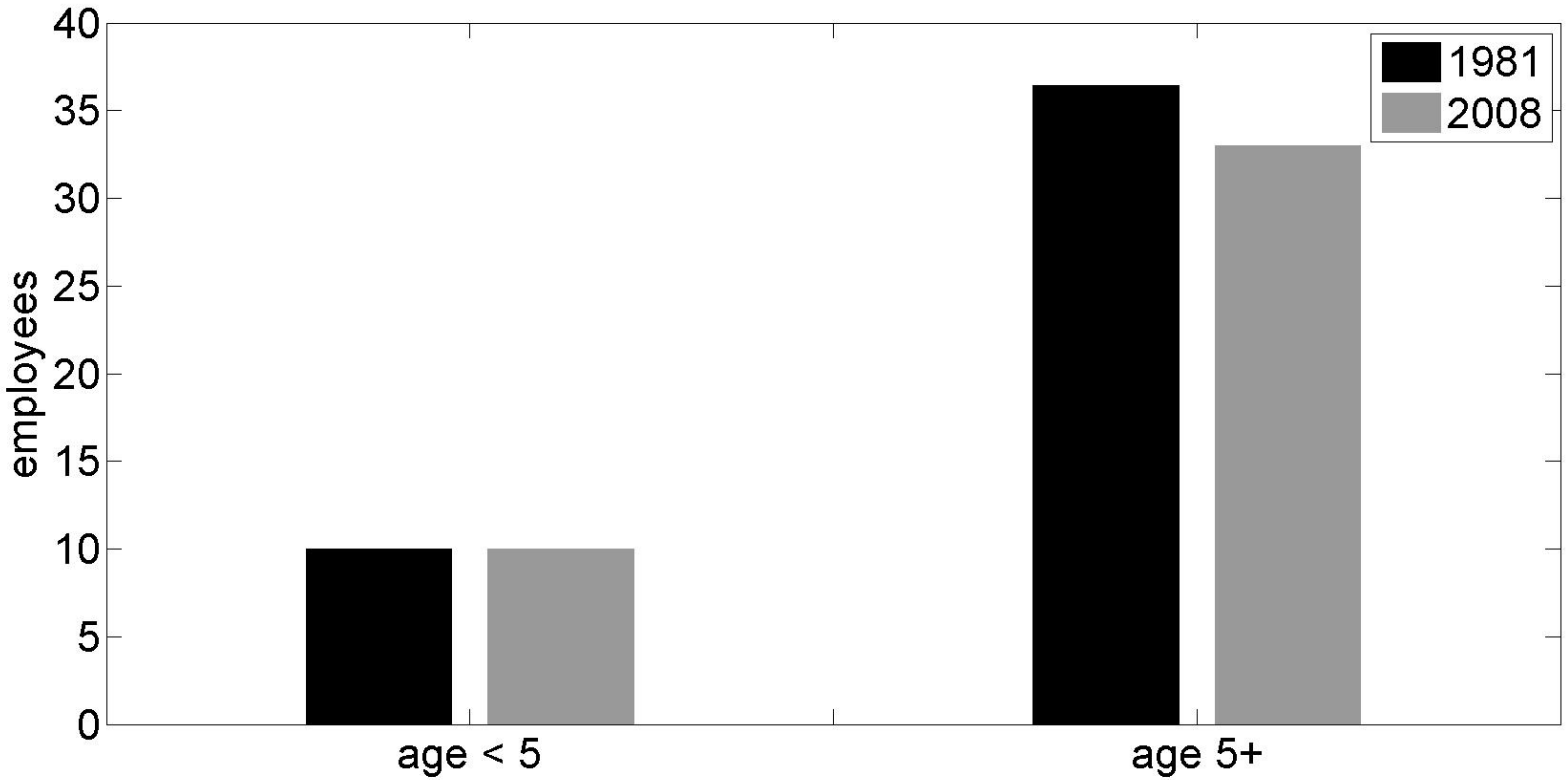
LBD Facts to Fit by Year

- Growth in the number of firms (tied to NV)
- Employment share of young firms (tied to NV, CD)
- Distribution of employment growth across firms
  - Job creation and destruction rates
    - CD shows up in the tails
    - OI shows up in the middle

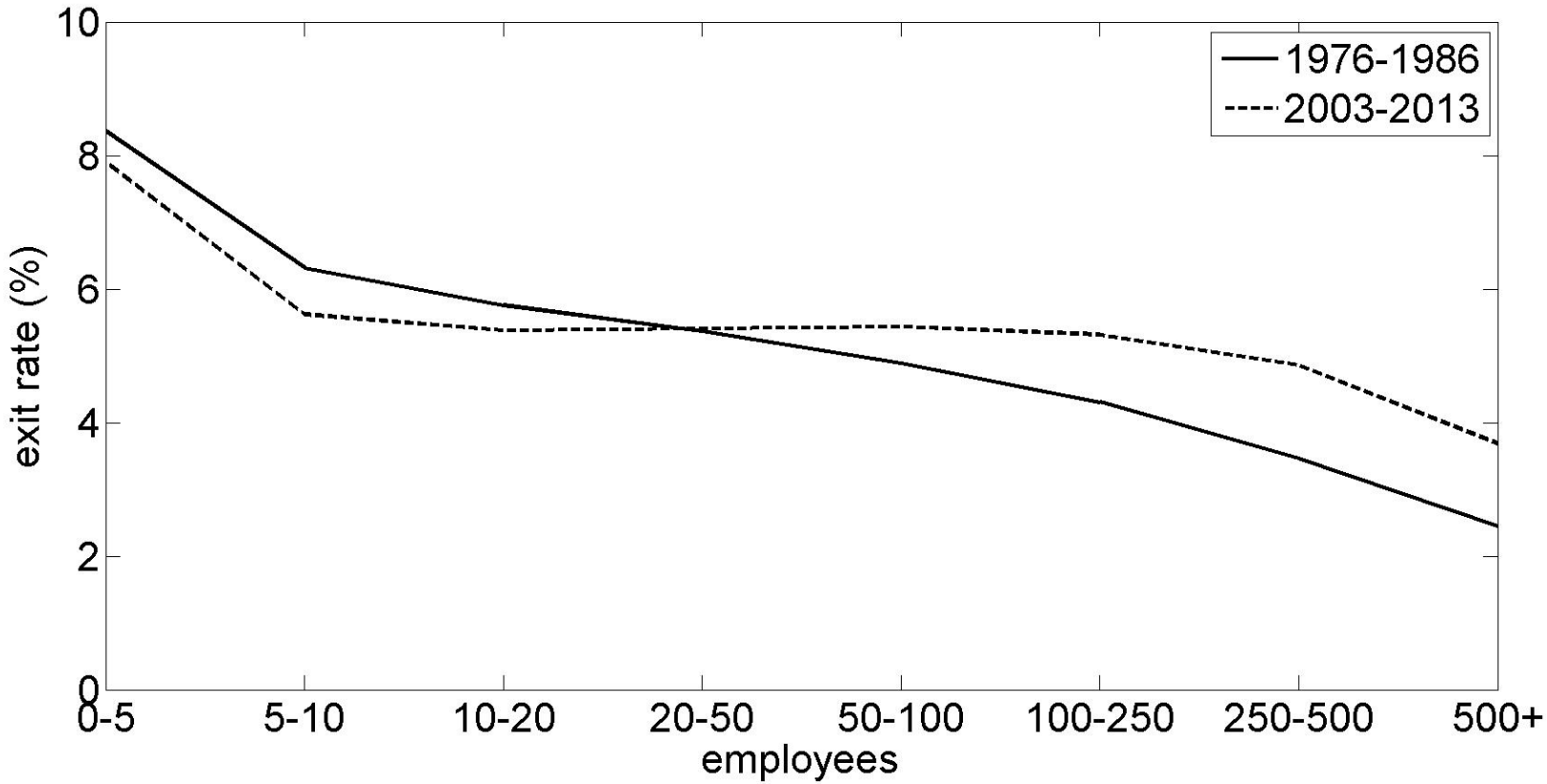
Job Creation and Destruction



Employment: young vs. old firms



Exit by size


10
8
6
4
2
0
exit rate (%)
1976-1986
2003-2013
0-5
5-10
10-20
20-50
50-100
100-250
250-500
500+
employees

How we deviate from GHK

- GHK assume measured growth = true growth

- 1) We argue CD and NV are missed;

  2) Set the combined arrival rates of CD and OI to match the CPI's noncomparable substitution rate

- We infer more true growth, higher step sizes

Indirect Inference

Parameter	1983–1993	1993–2003	2003–2013
CD arrival	0.014	0.011	0.010
OI arrival	0.024	0.027	0.027
NV arrival	0.004	0.002	0.002
Step size of CD, OI	1.106	1.125	1.074
Step size of NV	0.328	0.482	0.366

Note: These arrival rates are bimonthly

Missing growth from indirect inference

	1983–1993	1993–2003	2003–2013
Missing growth (ppt)	1.25	1.13	0.60
% of MG from CD	79%	80%	81%
% of growth missed	43%	33%	31%

Conclusions

Missing growth from CD and new varieties:

- at least 0.6% per year, mostly from CD

At least one-fourth of true growth is missed

No surge in missing growth since 2005

Why do we care?

1. Relating growth to policy

2. Gauging the proportional decline in growth / whether ideas are getting harder to find (Gordon, Jones)

3. Assessing how many people are better off than their parents (Chetty et al.'s Fading American Dream)

4. Setting the Fed's inflation target

5. Indexing Social Security and tax brackets