Emerging and Disappearing Work, Thriving and Declining Firms

Enghin Atalay (Federal Reserve Bank of Philadelphia)[1]
Sarada (University of Wisconsin School of Business)

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[1]Research results and conclusions expressed are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Philadelphia, the Federal Reserve System, or the Federal Reserve Board of Governors.

Digital Equipment Corporation and Nixdorf Computers

- Both founded in the 1950s as computer manufacturers, with initial commercial success in the 1960s
- Digital Equipment Corp's ads in the 1970s: *Engineer*, *Manager*, *Programmer*, *Programmer Analyst*
- Nixdorf: *Technical Typist*, *Field Service Engineer*, *Senior Cost Accounting Clerk*
- Comparing the two firms' job postings:
  - Jobs like *Programmer Analyst* are "newer" than jobs like *Technical Typist*

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- Comparing the two firms' job postings:
  - Jobs like *Programmer Analyst* are "newer" than jobs like *Technical Typist*
- Data Resources Inc, founded in 1969, has even newer vintage jobs (*Research Assistant, Market Research Manager)*

This paper

1. How do hiring decisions reflect new technology adoption?

- Explore firms' job vintages, in their vacancy postings, over 1940-2000.
  - 5.0 million ads from the *New York Times*, *Boston Globe*, and *Wall Street Journal*
- Job title vintages provide a new measure of firms' technology adoption
- There is substantial heterogeneity in the mix of job title vintages across firms.
  - Among publicly traded firms, newer job vintages correlated with R&D intensity, future growth.
  - Those posting for newer job vintages entered more recently, are more likely to survive

2. What are the sources of new technology adoption: entry/exit vs. incumbent tech updating?

Contribution

Measurement of innovation and technology adoption

- ... looks at adoption incentives within individual firms or industries (Griliches 1957, Henderson 1995, Arora and Gamberdella 1994)
- ... looks at aggregate technology adoption rates (Comin, Hobijn, and Rovito, 2008, Comin and Hobijn, 2010)

Our contribution: Present measurement of firm technology adoption across multiple industries, over a long time-period.

Models of firm technology updating

- Costly R&D $\rightarrow$ product innovation:(Klette and Kortum, 2004)
- Investment in vintage capital (Jovanovic and Yutsenko, 2012, Jovanovich and Rousseau, 2014)

Our contribution: New question

Outline

1. Data set and job vintage measures
2. Job title vintage is an indicator of innovative, high-skilled activity.
3. Job title is predictive of future firm performance
4. To what extent does vintage updating occur via entry and exit?

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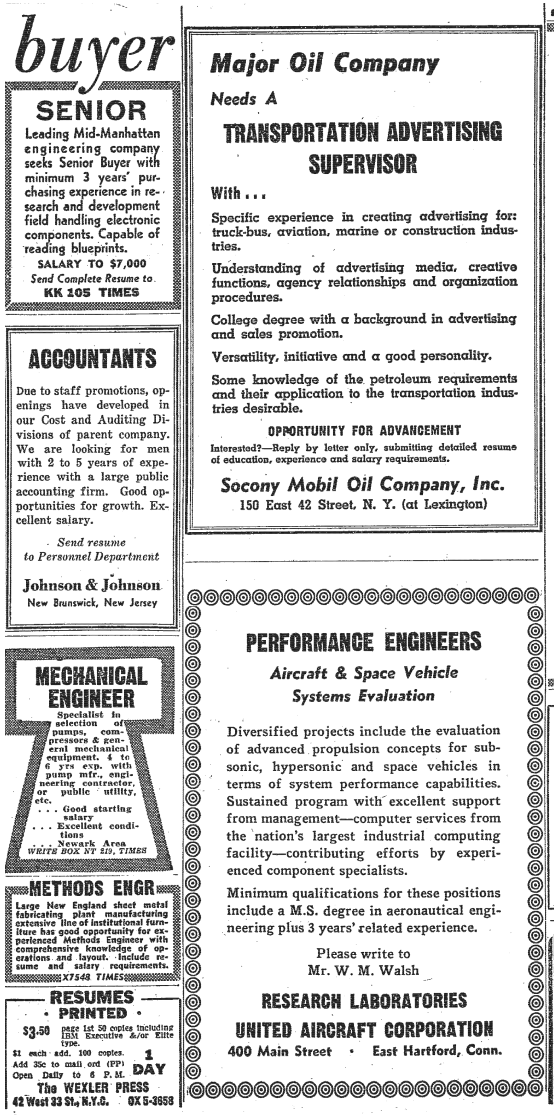
Unprocessed page of ads from the 1960 New York Times



buyer

SENIOR

Leading Mid-Manhattan engineering company seeks Senior Buyer with minimum 3 years' purchasing experience in research and development field handling electronic components. Capable of reading blueprints.

SALARY TO $7,000

Send Complete Resume to

KK 105 TIMES

ACCOUNTANTS

Due to staff promotions, openings have developed in our Cost and Auditing Divisions of parent company. We are looking for men with 2 to 5 years of experience with a large public accounting firm. Good opportunities for growth. Excellent salary.

Send resume to Personnel Department

Johnson & Johnson

New Brunswick, New Jersey

MECHANICAL ENGINEER

Specialist in selection of pumps, compressors & general mechanical equipment. 4 to 6 yrs exp. with pump mfr., engineering contractor, or public utility, etc.

. . . Good starting salary

. . . Excellent conditions

Newark Area

WRITE BOX XY 210, TIMES

METHODS ENGR

Large New England sheet metal fabricating plant manufacturing extensive line of institutional furniture has good opportunity for experienced Methods Engineer with comprehensive knowledge of operations and layout. Include resume and salary requirements.

X7548 *TIMES*

RESUMES

• PRINTED •

$3.50 page 1st 50 copies including IBM Executive &/or Elite type.

$1 each add. 100 copies.

Add 35c to mail ord (PP)

Open Daily to 6 P.M.

1 DAY

The WEXLER PRESS

42 West 33 St., N.Y.C. OX 5-3658

Major Oil Company

Needs A

TRANSPORTATION ADVERTISING SUPERVISOR

With . . .

Specific experience in creating advertising for: truck-bus, aviation, marine or construction industries.

Understanding of advertising media, creative functions, agency relationships and organization procedures.

College degree with a background in advertising and sales promotion.

Versatility, initiative and a good personality.

Some knowledge of the petroleum requirements and their application to the transportation industries desirable.

OPPORTUNITY FOR ADVANCEMENT

Interested?—Reply by letter only, submitting detailed resume of education, experience and salary requirements.

Socony Mobil Oil Company, Inc.

150 East 42 Street, N. Y. (at Lexington)

PERFORMANCE ENGINEERS

Aircraft & Space Vehicle Systems Evaluation

Diversified projects include the evaluation of advanced propulsion concepts for subsonic, hypersonic and space vehicles in terms of system performance capabilities. Sustained program with excellent support from management—computer services from the nation's largest industrial computing facility—contributing efforts by experienced component specialists.

Minimum qualifications for these positions include a M.S. degree in aeronautical engineering plus 3 years' related experience.

Please write to
Mr. W. M. Walsh

RESEARCH LABORATORIES

UNITED AIRCRAFT CORPORATION

400 Main Street • East Hartford, Conn.

TIMES ACCOUNTANTS Due to staff promotions, openings have developed in our Cost and Auditing Divisions of parent company. We are looking for men with 2 to 5 years of experience with a large public accounting firm. Good opportunities for growth. Excellent salary. Send resume to Personnel Department Johnson &Johnson. New Brunswick, New Jersey MECHANICAL ENGINEER Specialist In selection of pumps, compressors &general mechanical equipment. 4 te 6 yrs exp. with pump mfr.. engineering contractor. o or public utility, etc. o . . Good starting salary o . Ercellent conditions ark Area BOX 219, Large New England sheet metal fabricating plant manufacturing extensive line of InstItutional furniture has good opportunity for Methods Engineer with comprehensive knowledge of ope,ations and layout. Include resume and salary. requirements. X7548 TIMES u RESUMES PRINTED S3.50 lst5Goiviesfnciudiiw type. Si ch - add. 100 copIes. I Add 35c to mall ord (P1AE) Open DiSh td6 P.M. DAY The PRESS 42Wust 33 SI4E6Y.C. OX 5.3658 Major Oil Company Needs A TRANSPORTATION ADVERTISING SUPERVISOR With Specific experience in creating advertising for: truck-bus, aviation, marine or construction industries. Understanding of advertising media, creative functions, agency relationships and organization procedures. College degree with a background in advertising and sales promotion. Versatility, initiative and a good personality. Some knowledge of the, petroleum requirements and their application to the transportation industries desirable. OPPORTUNITY FOR ADVANCEMENT ? by letter only, submitting detailed resume of education, experience and salary requirements. Socony Mobil Oil Company, Inc. 150 East 42 Street, N. Y. (at Lexington) PERFORMANCE ENGINEERS Aircraft &Space Vehicle Systems Evaluation Diversified projects include the evaluation of advanced propulsion concepts for subsonic, hypersonic and space vehicles in terms of system performance capabilities. Sustained program with excellent support from services from the largest industrial computing efforts by experienced component specialists. Minimum qualifications for these positions include a M.S. degree in aeronautical engineering plus 3 related experience. UNITED AIRCRAFT CORPORATION 400 Main Street . East Hartford, Conn. Please write to Mr. W. M. Walsh RESEARCH LABORATORIES

Data Set

- In past work (Atalay, Phongtheingtham, Sotelo, Tannenbaum, 2019) we processed ads from the *New York Times*, *Boston Globe*, and *Wall Street Journal*
  - For each ad we identify the job title, educational requirements, sets of tasks workers perform, technologies they use.

- New, relative to earlier work, we identify the firm name and posted salary.

- For publicly-traded firms, we link firm names to Compustat
- For all firms we hand collect entry and exit dates.
- (In progress): Link firm names to patent grantees.

Processed page of ads from the 1960 New York Times

TIMES ACCOUNTANT [[132011]] Due to staff promotions, openings have developed in our Cost and Auditing Divisions of parent company. We are looking for men with 2 to 5 years of experience with a large public accounting firm. Good opportunities for growth. Excellent salary. Send resume to Personnel Department Johnson &Johnson. New Brunswick, New Jersey

MECHANICAL ENGINEER [[172141]] Specialist In selection of pumps, compressors &general mechanical equipment. 4 te 6 yrs exp. with pump mfr.. engineering contractor. o or public utility, etc. o . . Good starting salary o . Ercellent conditions ark Area BOX 219, Large New England sheet metal fabricating plant manufacturing extensive line of InstItutional furniture has good opportunity for Methods Engineer with comprehensive knowledge of ope,ations and layout. Include resume and salary. requirements. X7548 TIMES u RESUMES PRINTED S3.50 lst5Goiviesfnciudiiw type. Si ch - add. 100 copIes. I Add 35c to mall ord (P1AE) Open DiSh td6 P.M. DAY The PRESS 42Wust 33 SI4E6Y.C. OX 5.3658 Major Oil Company Needs A

TRANSPORTATION ADVERTISING SUPERVISOR [[531031]] With Specific experience in creating advertising for: truck-bus, aviation, marine or construction industries. Understanding of advertising media, creative functions, agency relationships and organization procedures. College degree with a background in advertising and sales promotion. Versatility, initiative and a good personality. Some knowledge of the, petroleum requirements and their application to the transportation industries desirable. OPPORTUNITY FOR ADVANCEMENT ? by letter only, submitting detailed resume of education, experience and salary requirements. Socony Mobil Oil Company, Inc. 150 East 42 Street, N. Y. (at Lexington)

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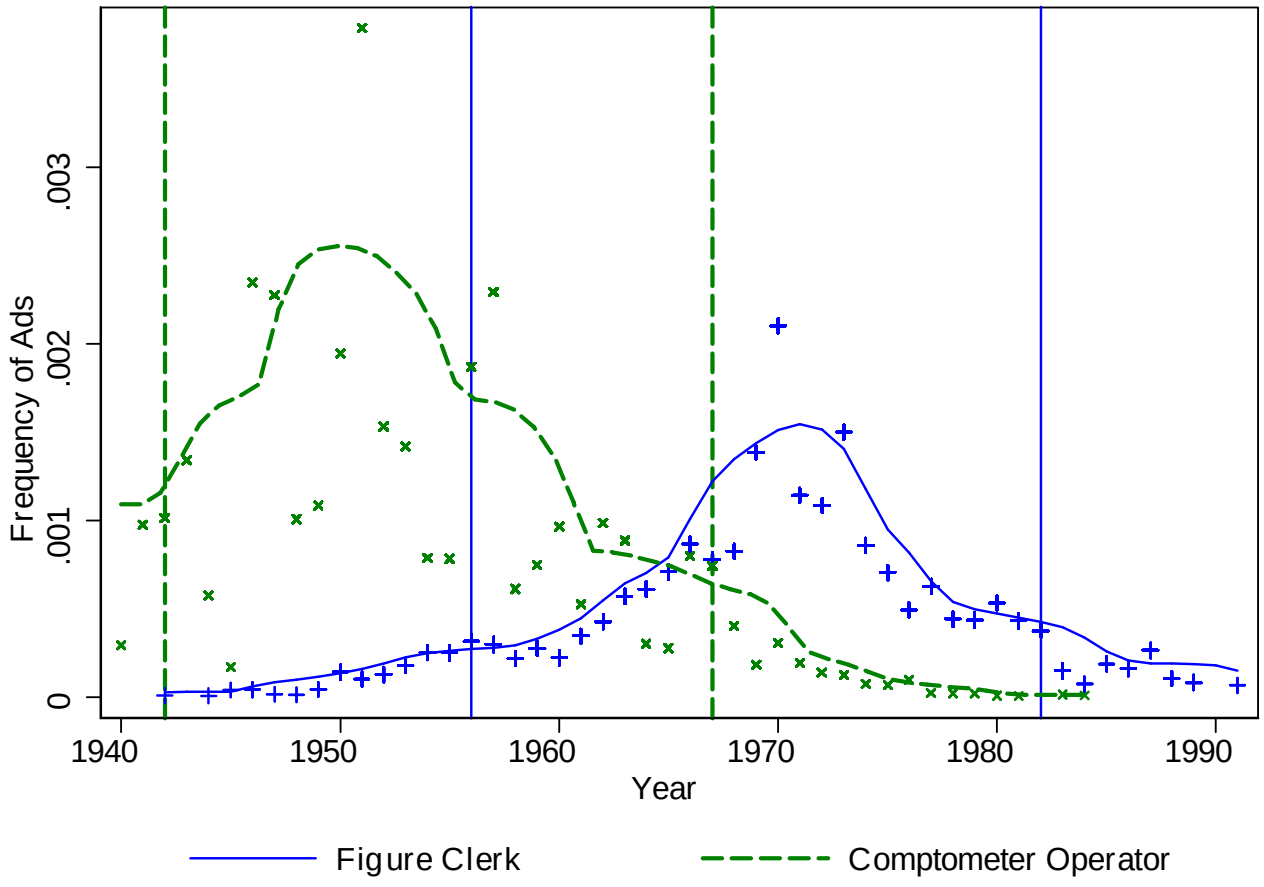
Defining Job Title Vintages



- Year of Emergence$_j$: 1st percentile of years in which j appeared
- Year of Disappearance$_j$: 99th percentile of years in which j appeared

Summary Statistics

- 5.0 million job ads for which we can identify the job title
  - 9 thousand unique job titles
  - 185 thousand ads for which identify the posted salary
  - 309 thousand ads for which identify the posting firm
    - Among these, 189 thousand ads correspond firms that are public at any point
- How much dispersion is job title vintages?
  - For each year of ads, compute average job title vintage. Relative to this average
  - Std. Dev.(Yr. of Emergence$_j$)$\approx$ 6.7 years;
  - Std. Dev.(Yr. of Disappearance$_j$)$\approx$ 6.5 years

Emerging Job Titles

Yr.	of Emergence$_j$ $\in$1950-1959	Yr.	of Emergence$_j$ $\in$1960-1969
1	administrative assistant	1	programmer analyst
2	programmer	2	computer operator
3	legal secretary	3	marketing manager
4	management trainee	4	product manager
Yr.	of Emergence$_j$ $\in$1970-1979	Yr.	of Emergence$_j$ $\in$1980-1989
1	paralegal	1	telemarketer
2	typesetter	2	hiv aid
3	word processing	3	line cook
4	word processor	4	broker trainee
Yr.	of Emergence$_j$ $\in$1990-2000		
1	power builder		
2	client server		
3	web developer		
4	web master		

Disappearing Job Titles

Yr. of Disappearance$_j$ $\in$1940-49		Yr. of Disappearance$_j$ $\in$1950-1959	
1	lens grinder	1	soda dispenser
2	radio instructor	2	millinery designer
3	christmas card salesperson	3	buyer wants contd
4	fluorescent salesperson	4	long distance telephone operator
Yr. of Disappearance$_j$ $\in$1960-1969		Yr. of Disappearance$_j$ $\in$1970-1979	
1	house worker	1	stenographer
2	bookkeeper stenographer	2	stenographer typist
3	dental mechanic	3	secretary stenographer
4	alteration hand	4	office boy
Yr. of Disappearance$_j$ $\in$1980-1989			
1	clerk typist		
2	draftsman		
3	statistical typist		
4	biller typist		

Comparison to Lin (2011)'s measure of new work

- Lin (2011) compares successive vintages of the Dictionary of Occupational Titles.
  $\Rightarrow$Four categories of job titles based on when they appeared ($\leq$1965, by 1977, by 1991, by 2000)
- For these four categories, plot the density of Yr. of Emergence$_j$

Comparison to Lin (2011)'s measure of new work

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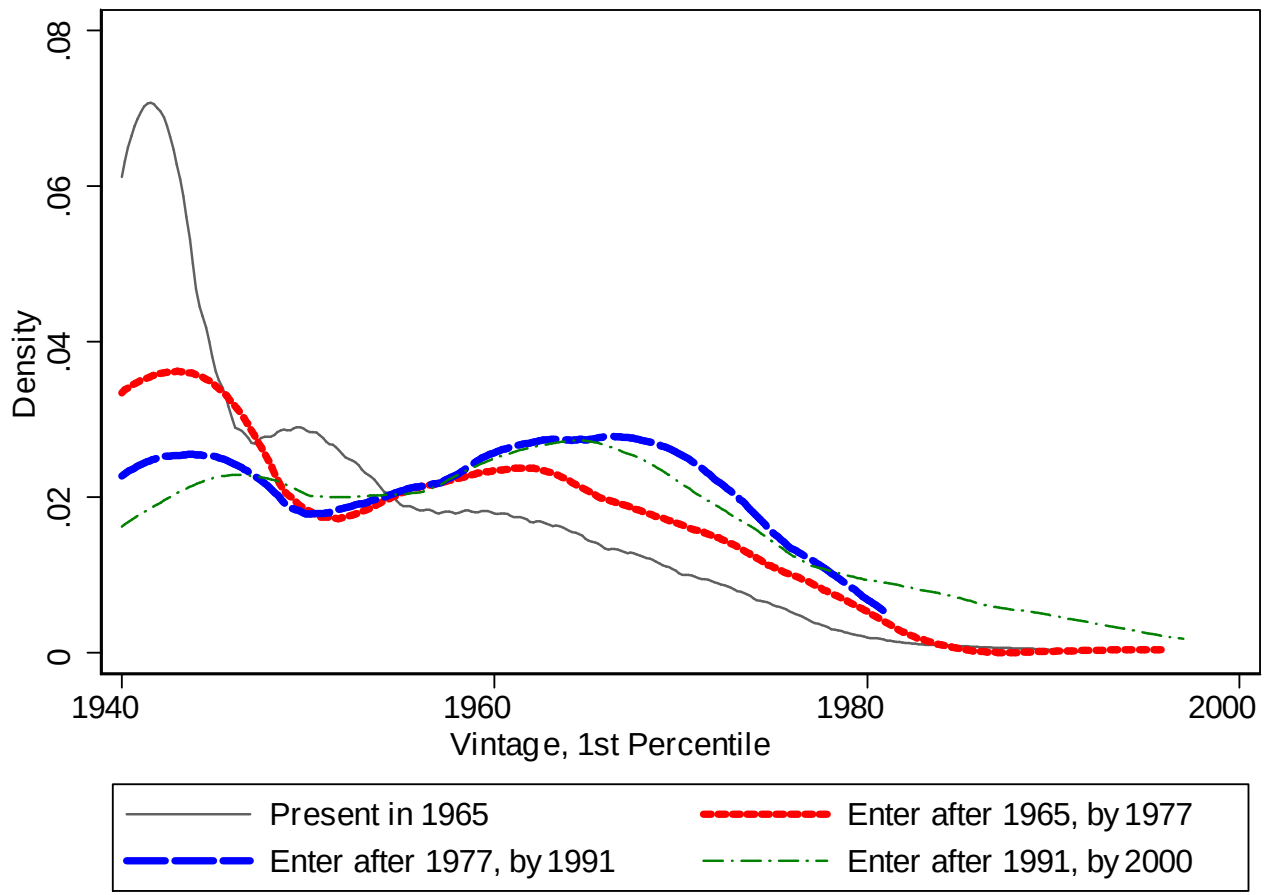

Outline

1. Data set and job vintage measures
2. **Job title vintage is an indicator of innovative, high-skilled activity.**
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4. To what extent does vintage updating occur via entry and exit?

Relating job vintages and other ad characteristics

$$y_{at} = \beta_t + \beta_o + \beta_1 \cdot v_{j(a)}^{0.01} + \beta_2 \cdot v_{j(a)}^{0.99} + \epsilon_a \quad (1)$$

- y_a: Characteristics of ad a:
  - posted salary
  - mentions of an undergraduate or graduate degree requirement
  - mentions of an ICT (EDP, Unix, Lotus 123, FORTRAN, 44 others)
- $v_{j(a)}^{0.01}$, $v_{j(a)}^{0.99}$: Year of Emergence and Disappearance of the job title.
- β_t, β_o: year and occupation fixed effects

Newer work is associated with human capital and technology usage

Dep. Variable	Log Salary	Undergrad Degree	Graduate Degree	Technology
Year of Emergence $_j$	0.0017	0.0061	-0.0079	0.044
	(0.0002)	(0.0029)	(0.0006)	(0.001)
Year of Disappearance$_j$	0.0010	0.0029	0.0099	0.052
	(0.0002)	(0.0003)	(0.0006)	(0.001)
Sample	——	1940-2000	——	1970-2000

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Year of Disappearance$_j$	0.0010	0.0029	0.0099	0.052
	(0.0002)	(0.0003)	(0.0006)	(0.001)
Sample	——	1940-2000	——	1970-2000

A decade increase in job vintage is associated with... :

- a 2.7 log point ($\approx (0.0017 + 0.0010) \cdot 10$) increase in salaries;
- a 0.02 standard deviation increase in the frequency of undergraduate degree mentions;
- a 0.11 standard deviation increase in the frequency of technology mentions.

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Job Vintage and Firm Characteristics

Compute the average job vintage of the ads that firm f places in year t:

$$\text{Year of Emergence}_{ft} = \frac{1}{|A_{ft}|} \times \sum_{a \in A_{ft}} \text{Year of Emergence}_j$$

$$\text{Year of Disappearance}_{ft} = \frac{1}{|A_{ft}|} \times \sum_{a \in A_{ft}} \text{Year of Disappearance}_j$$

$$\text{Median Vintage}_{ft} = \frac{1}{|A_{ft}|} \times \sum_{a \in A_{ft}} v_{j(a)}^{0.50}$$

- A_{ft} set of ads posted by firm f in year t

Empirical Setup

$$
\begin{aligned}
x_{ft} = \beta_t &+ \beta_1 \text{Year of Emergence}_{ft} + \beta_2 \text{Median Vintage}_{ft} \\
&+ \beta_3 \text{Year of Disappearance}_{ft} + \beta_n \\
&+ \beta_4 \log k_{ft} + \beta_5 \log l_{ft} + \beta_6 \log_t y_{ft} + \sum_o \beta_o S_{fto} + \epsilon_{ft}
\end{aligned}
$$

- x_{ft}: Firm-level characteristic
- β_t year fixed effects, β_n industry fixed effects
- k_{ft}, l_{ft}, y_{ft} : capital, labor, revenues,
- S_{fto}: share of firm f's ads in (2-digit) occupation o.

Newer work is not correlated with contemporaneous productivity

Dep. Variable	$\log(y_{ft}/l_{ft})$		
Year of Emergence $_{ft}$		-0.0002 (0.0022)	
Median Vintage$_{ft}$	0.0012 (0.0017)		–0.0018 (0.0020)
Year of Disappearance $_{ft}$		0.0107 (0.0037)	
Include occup. shares?	No	No	Yes

- No significant difference between contemporaneous productivity and job vintages

Newer work is not correlated with contemporaneous productivity... but is associated with R&D intensity

Dep. Variable	$\log(y_{ft}/l_{ft})$		$\log(R\&D_{ft}/y_{ft})$		
Year of Emergence $_{ft}$		-0.0002		0.028	
		(0.0022)		(0.007)	
Median Vintage$_{ft}$	0.0012		0.021		0.023
	(0.0017)		(0.006)		(0.006)
Year of Disappearance $_{ft}$		0.0107		-0.015	
		(0.0037)		(0.011)	
Include occup. shares?	No	No	No	No	Yes

- A decade difference in job vintage is associated with a 21 log point difference in R&D intensity

Newer work is also predictive of future growth

Dep. Variable	$\log(y_{f,t+5}/y_{ft})$			$\log(y_{f,t+10}/y_{ft})$		
Year of Emergence $_{ft}$		0.006			0.012	
		(0.003)			(0.004)	
Median Vintage$_{ft}$	0.010		0.009	0.016		0.014
	(0.002)		(0.002)	(0.003)		(0.003)
Year of Disappearance $_{ft}$		0.004			0.005	
		(0.003)			(0.004)	
Include occup. shares?	No	No	Yes	No	No	Yes

- A decade difference in job vintage is associated with 10 log points faster growth over 5 years, 16 log points over 10 years

New work is associated with young firms, firms that survive longer

Dep. Variable	Entry Year			Exit Year		
Year of Emergence $_{ft}$		0.384 (0.168)			0.482 (0.212)	
Median Vintage$_{ft}$	0.665 (0.123)		0.572 (0.119)	0.183 (0.114)		-0.005 (0.131)
Year of Disappearance$_{ft}$		0.385 (0.194)			-0.211 (0.158)	
Include occup. shares?	No	No	Yes	No	No	Yes

- Similar results (stronger for the exit margin, less so for the entry margin) when considering entry/exit from publicly traded status.

Summary so far

New work:

- is correlated with other innovative activities,
- predictive of survival and future growth,
- occurs in young firms

Other exercises

- Among all firms, new work is associated with being publicly traded, patenting more frequently, having more highly cited patents.

- Among privately held firms, firms posting ads for new work are more likely to go public in the future

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Model: Overview

- Goal: Decompose sources of new vintage job titles.
- Summary: Firms enter with new vintage technologies, can upgrade at a cost
  - Benefit of updating depends on competitive environment, marginal cost of producing
- Consistent with documented patterns
  - Little correlation between productivity and vintage
  - More recent entrants have newer vintage technologies
  - Firms with older vintage job titles are more likely to exit
- Result of estimated model: Only a small portion of technology updating occurs through the net entry margin.

Conclusion

This paper provides a new measure of adoption to new technologies

Our measure correlates with innovativeness and firm success

- Public firms which place ads for new work
  - are more R&D intensive
  - have faster future sales growth
- Among all firms, new work occurs in younger firms, firms likely to survive in the future.

Model: Firms

Monopolistic competition among heterogeneous firms:

- z: inverse marginal cost of production (permanent)
  - revenues, y, proportional to $z^{\eta-1}$
- v: vintage of the firm's technology (subject to change)
  - firms entering at time τ enter with $v \in [\tau, \tau+1]$
  - exit when their vintage is obsolete: $v < t$
  - incur $\frac{\kappa}{2}\lambda^2$ costs to update vintage (probabilistically) with rate λ.

Flow profits when in the industry

$$\alpha z^{\eta-1} - \frac{\kappa}{2}\lambda^2$$

- α is a constant
  - independent of z and v
  - pinned down by free entry condition (next slide)

Model: Free Entry and Stationary Equilibrium

- Let $V(k,z) \equiv$"value of having a vintage k units behind frontier" and productivity z.
- Free entry condition: firms pay sunk cost f to draw z and initial k

$$f = \int_0^\infty \left[\int_0^1 V(k,z)\, h(k)\, dk \right] g(z)\, dz$$

  - $h(k)$: distribution of entrants' distance to frontier: $h(k) = \beta \cdot (1-k)^{\beta-1}$ for $\beta \geq 1$ and $k \in [0,1]$
    - $\beta \to 1$: uniform between $k = 0$ and 1
    - $\beta \to \infty$: all mass at $k = 0$
    - $\mathbb{E}[k] = (1+\beta)^{-1}$
  - $g(z)$: distribution of entrants' productivity: Log Normal $\left(-\frac{1}{2}\sigma^2, \sigma^2\right)$

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- Stationary equilibrium: Set of prices, consumption choices, entry decisions:
  - Consumers' relative demand of each firm's product maximizes utility
  - Firms choose prices to maximize (static) flow profits
  - Firms choose innovation rates to maximize V
  - Distribution of (k,z) is constant over time
  - Free entry condition is satisfied

Model: Characterization

- Continuous time Bellman Equation:

$$r \cdot V(k,z) = \max_{\lambda} \alpha \cdot z^{\eta-1} - \frac{\kappa}{2}\lambda^2 + \lambda \cdot [V(0,z) - V(k,z)] + V'(k,z)$$

- FOC

$$\underbrace{\kappa \cdot \lambda}_{\text{marginal cost}} = \underbrace{V(0,z) - V(k,z)}_{\text{benefit from updating vintage}}$$

- Right-hand side increasing in z, increasing in $k \Rightarrow$ More innovation by high z firms, firms further behind the frontier.

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- Plug FOC into Bellam Equation

$$rV(k,z) = \alpha z^{\eta-1} + \frac{1}{2\kappa}[V(0,z) - V(k,z)]^2 + V'(k,z)$$

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$$r \cdot V(k,z) = \max_{\lambda} \alpha \cdot z^{\eta-1} - \frac{\kappa}{2}\lambda^2 + \lambda \cdot [V(0,z) - V(k,z)] + V'(k,z)$$

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- Right-hand side increasing in z, increasing in $k \Rightarrow$ More innovation by high z firms, firms further behind the frontier.
- Plug FOC into Bellam Equation

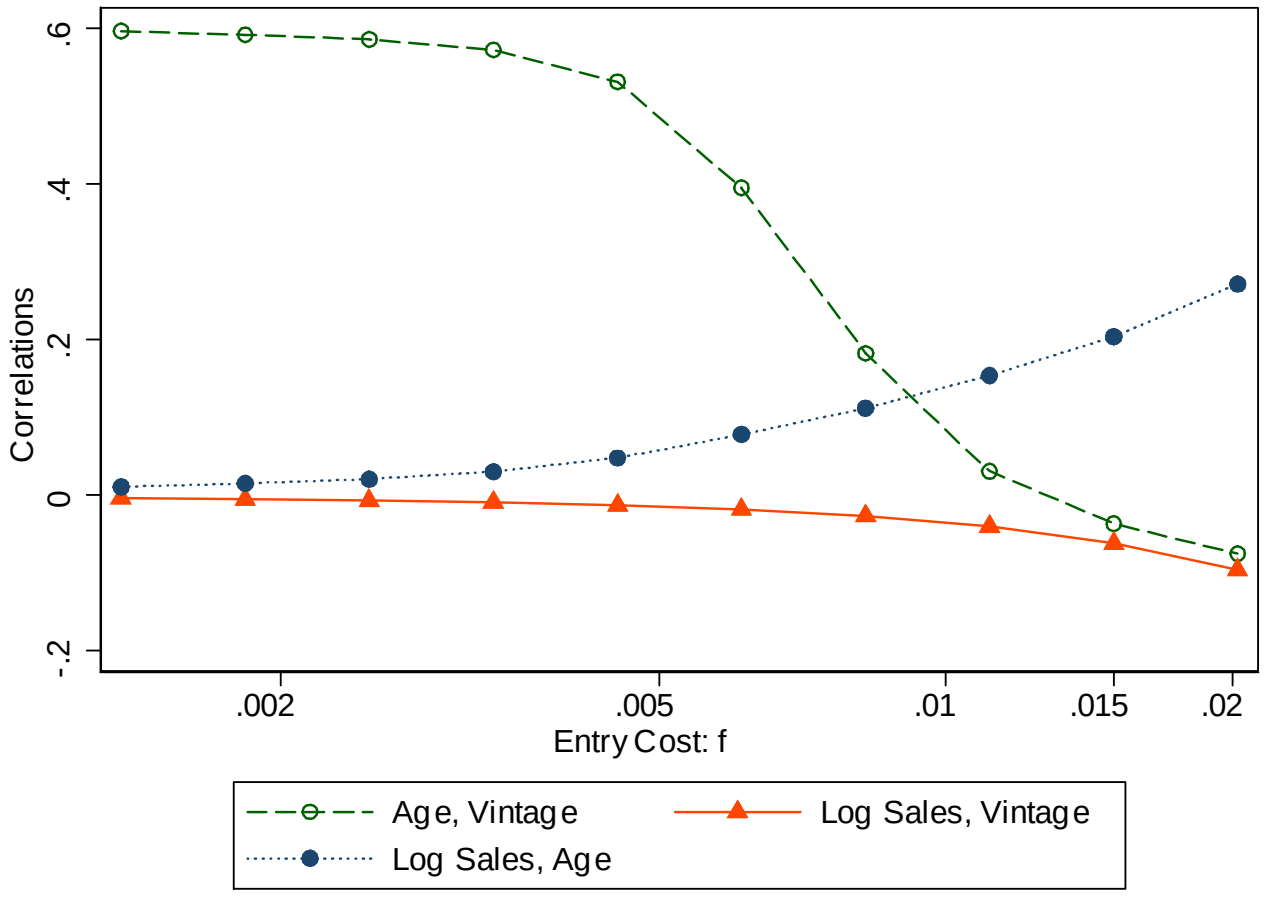
$$rV(k,z) = \alpha z^{\eta-1} + \frac{1}{2\kappa}\left[V(0,z) - V(k,z)\right]^2 + V'(k,z)$$

- "Convenient" solution to $V(k,z)$ exists

$$V(k,z) = V(0,z) + r\kappa - \varphi(z) \times \tan\left[\arctan\left[\left(V(0,z) + r\kappa\right)/\varphi(z)\right] - (1-k)\varphi(z)/(2\kappa)\right]$$

where $\varphi(z) = \left(2\alpha z^{\eta-1}\kappa - 2rV(0,z) + r^2\kappa\right)^{\frac{1}{2}}$

Correlations among vintage, age, and productivity help identify $\frac{f}{\kappa}$



- When f is high$\Rightarrow$ incumbents face less competition from entry$\Rightarrow$ more vintage updating (especially by high z firms)

Calibration and Estimation

- Set σ (elasticity of substitution in preferences) equal to 3; normalize $\kappa = 1$
- Relate model discount rate so that $(1 + r) = \left(1 + r^A\right)^T$
  - T: number of years per model period; r^A annual discount rate: 0.02
- θ, β, f, T are estimated via SMM:
  - Correlations among firm age, distance to the frontier, log sales
  - Standard deviation of log sales, age, distance to the frontier
  - Difference in distance to the frontier for entrants relative to all firms

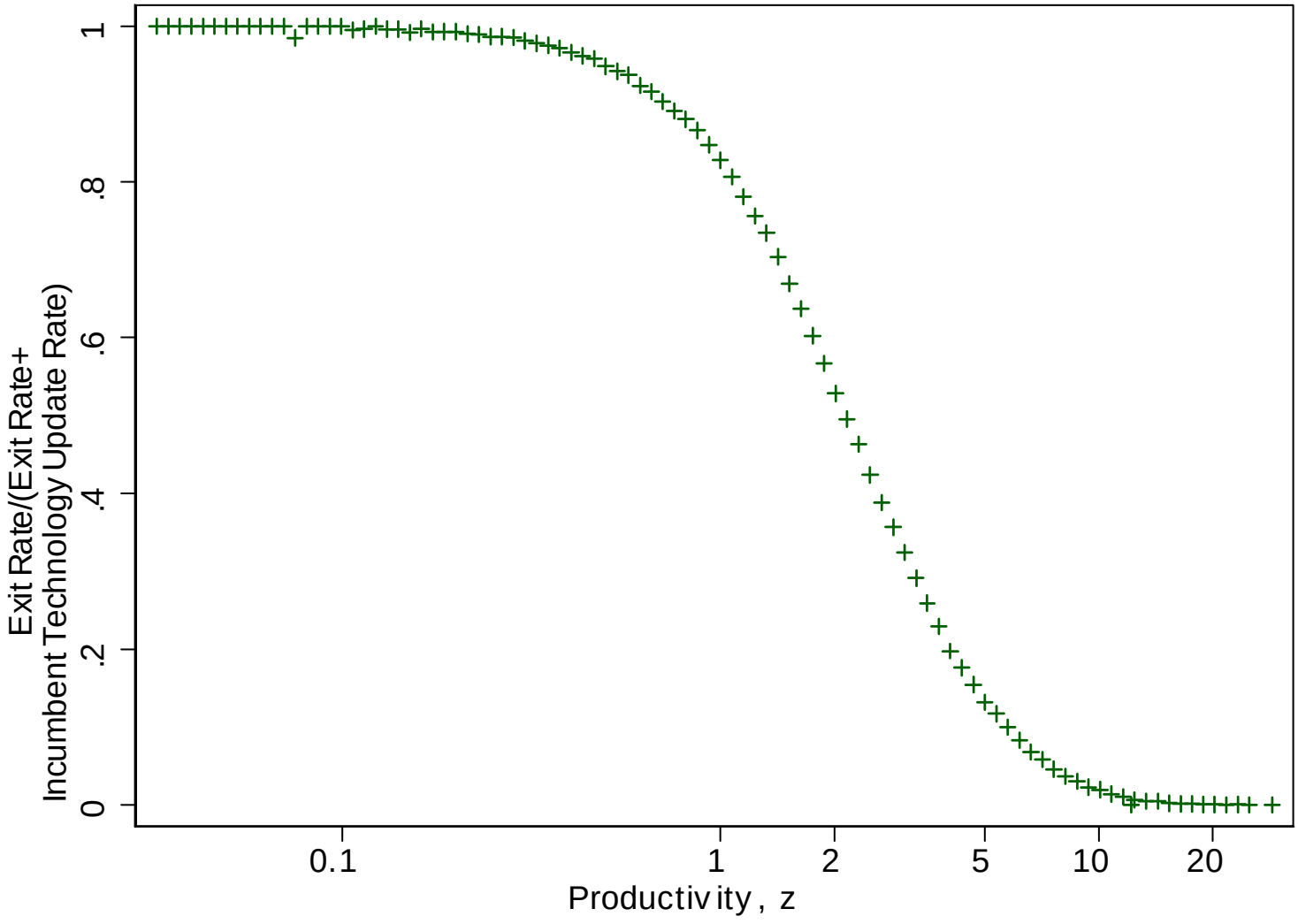
Calibration and Estimation

Panel A: Moments	Model	Data
St. Dev. $\log(y)$		1.384
St. Dev. a		24.942
St. Dev. k		3.641
Corr$(\log(y), a)$		0.094
Corr$(\log(y), k)$		-0.033
Corr(a, k)		0.134
Entrants k − Incumbents k		-3.564
Panel B: Parameter Estimates		
f: sunk cost of entry		
β: entrant dist. to frontier		
σ: entrant productivity sd		
T: years per model period		

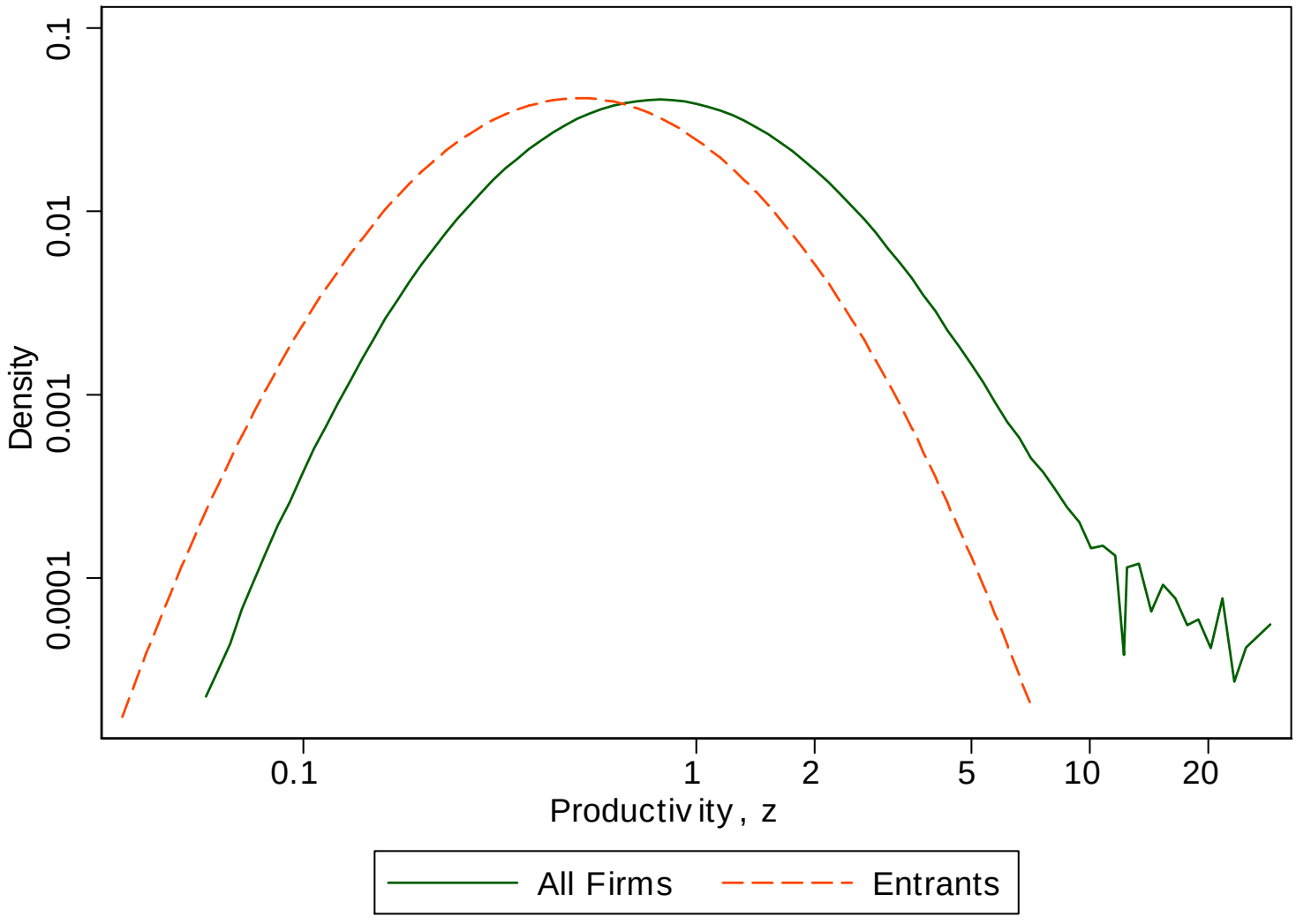
Calibration and Estimation

Panel A: Moments	Model	Data
St. Dev. $\log(y)$	1.400	1.384
St. Dev. a	22.592	24.942
St. Dev. k	3.759	3.641
Corr$(\log(y), a)$	0.204	0.094
Corr$(\log(y), k)$	-0.036	-0.033
Corr(a, k)	0.124	0.134
Entrants k − Incumbents k	-3.720	-3.564
Panel B: Parameter Estimates		
f: sunk cost of entry	0.012	
β: entrant dist. to frontier	1.536	
σ: entrant productivity sd	0.678	
T: years per model period	15.44	

Sources of Vintage updating



Productivity Distribution



Sources of Vintage updating: Summing Up Across Firms

- Integrate share of updating, summing over the (endogenous) productivity distribution:
  - Approximately 72 percent of vintage updating occurs through entry and exit
  - Approximately 13 percent when weighting by firm sales.