Factories of Ideas?

Big Business and the Golden Age of American Innovation

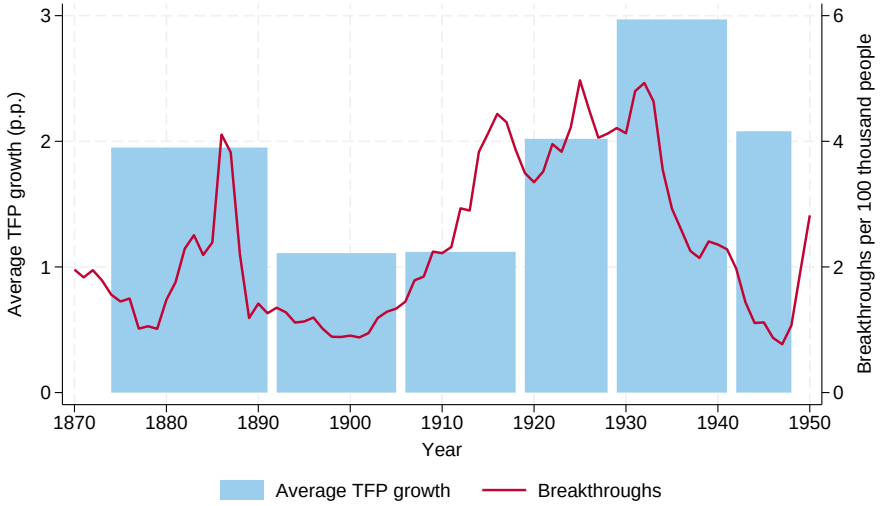
Pier Paolo Creanza

Princeton → Swarthmore

NBER Summer Institute

July 15, 2026

The Most Technologically Progressive Decade (Field 2003)



Did Big Business Power the Golden Age of U.S. Innovation?

- A common narrative credits the **modern corporation and its industrial research lab** for U.S. technological & economic development
  (Schumpeter 1942; DeLong 2022)
  - "Big Businesses" like DuPont, GE and RCA as key innovation drivers before WW2

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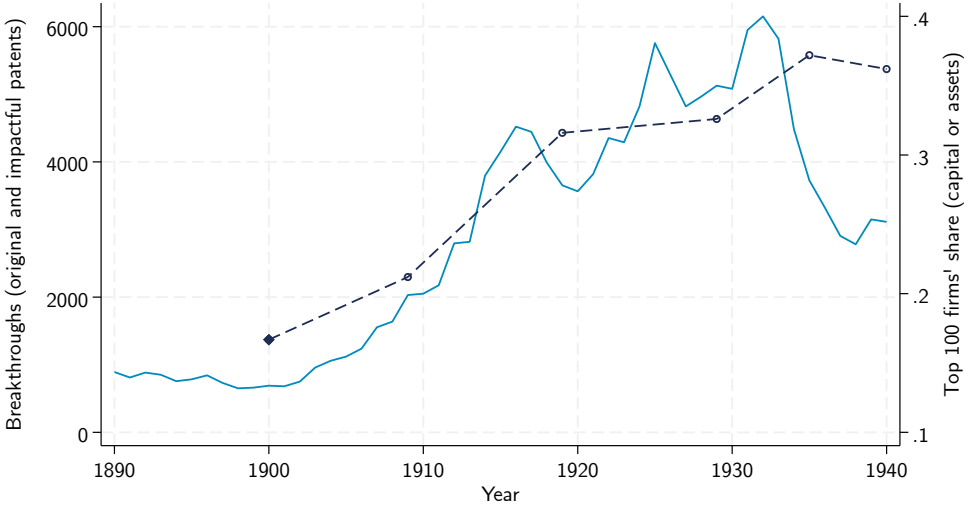
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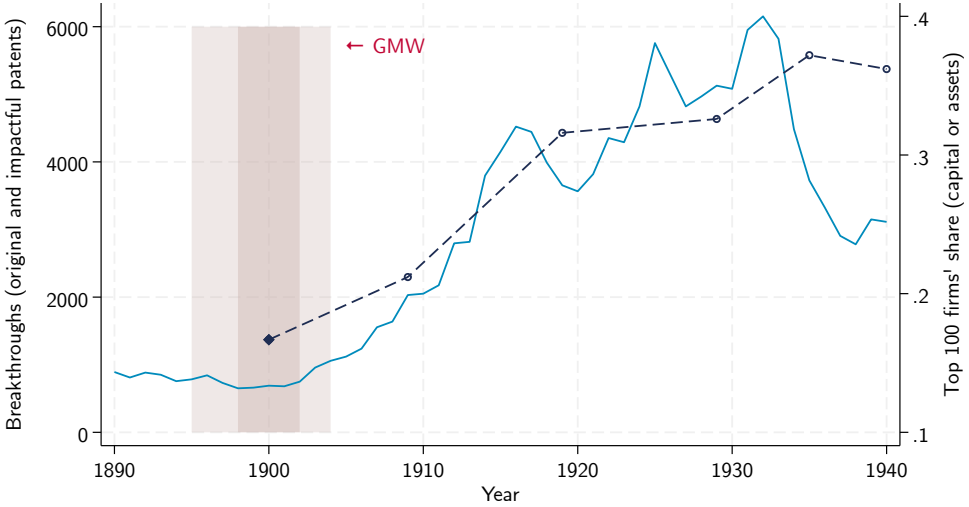
- **This paper**: study the effects of increased bigness through **consolidation** during the Great Merger Wave (1895-1904)

Big Business and Innovation Rose Together



Patent share

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The Great Merger Wave as an Antitrust Experiment

- Largest M&A event in U.S. history: **2,600+ firms** consolidated, 1895–1904
  - Peak-year merged assets = 12.5% of GNP
  - Avg. 10 medium-sized rivals $\rightarrow$ one "big" firm; overwhelmingly horizontal

Context Timeline

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- **Legal shocks** opened and closed the wave
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- Firms merged to increase **market power** and escape competition
  - Stigler (1950), Lamoreaux (1985), and Ahumada (2025)
  - *"Elimination of competition . . . the most important motive of the merger"* Kramer (1964, p. 301)

Context Timeline

This Paper: New Data, Three Questions

0 **New data on U.S. innovation, 1875–1955**: firms, patents, inventors, labs

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Preview of Results

1. Merging firms' patenting rose $\sim$**4**$\times$, breakthroughs $\sim$**6**$\times$ (intensive margin)

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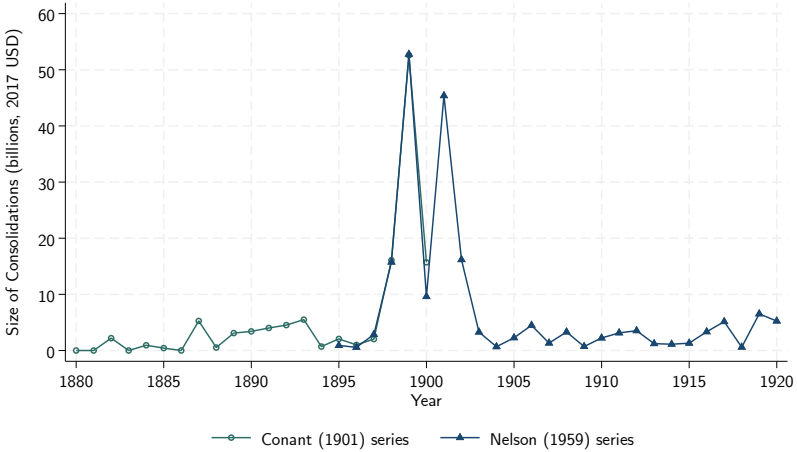
3. Spillovers: $+$**13%** more breakthroughs, but:
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In an era of weak public science, big business became a central engine of technological progress, where systematic R&D mattered most.

Outline

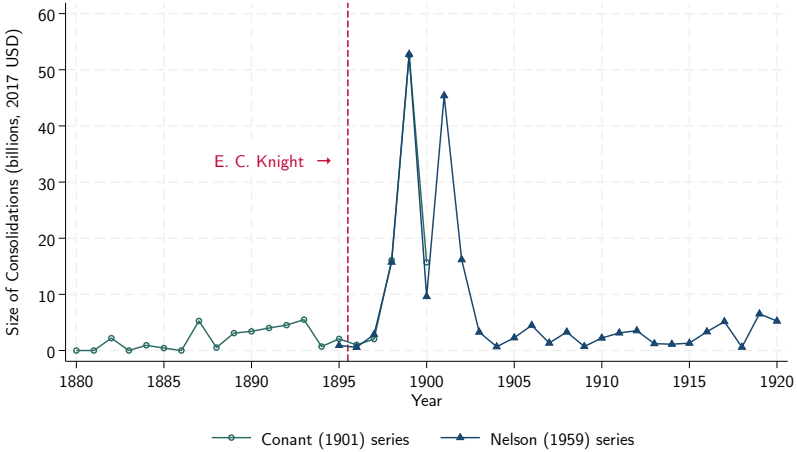
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Merger Activity Spiked Before an Antitrust Reversal



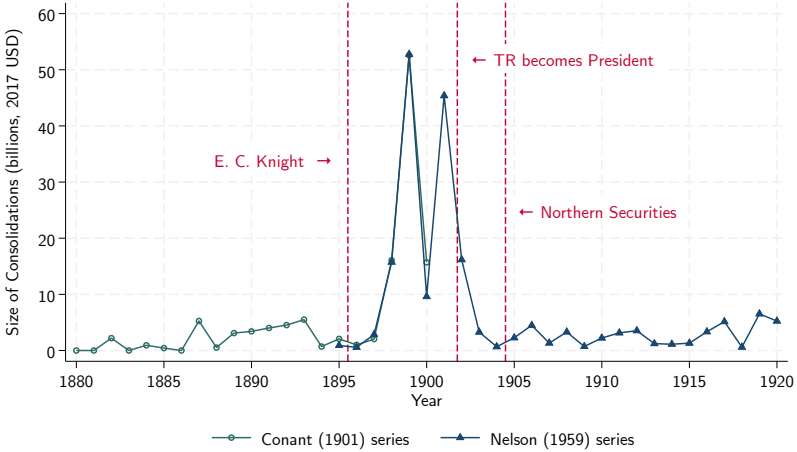
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International Harvester: Five Rivals → One Big Business

- Formed 1902 to end the "Harvester War"

International Harvester: Five Rivals → One Big Business

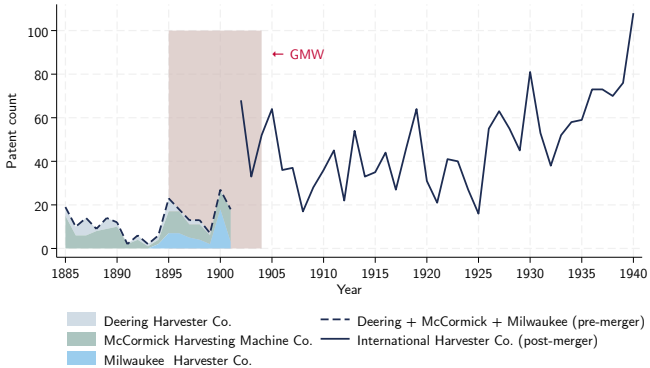
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- Controlled **90% of binders**, 80% of mowers
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Tracking Firms Before Compustat

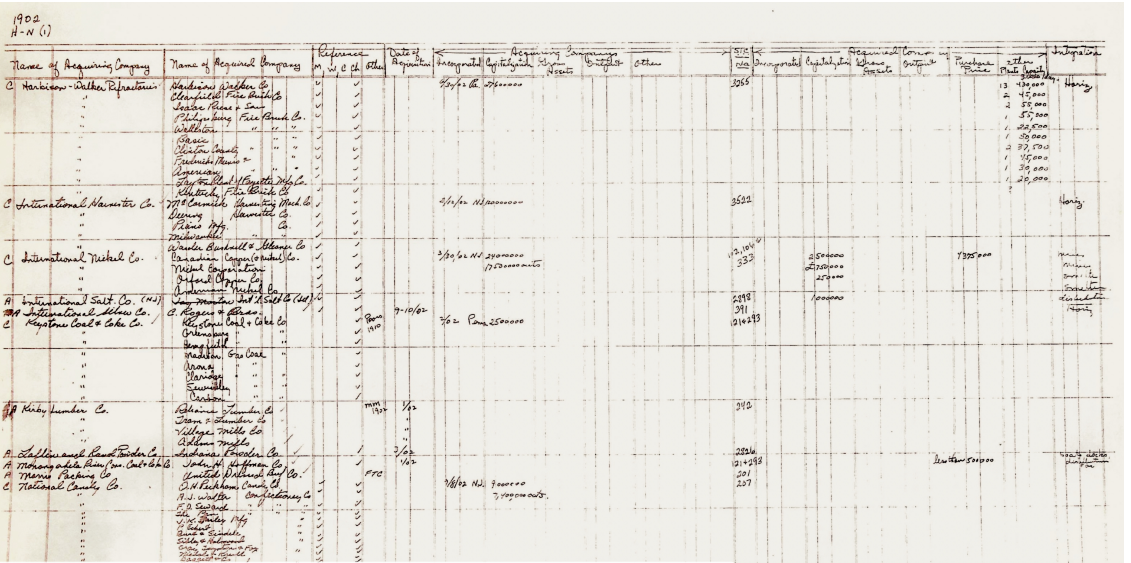
- **Corporate identities change**—names, aliases, M&A, breakups, subsidiaries
- Solution: harmonize and link six data sources into one annual firm panel
  - Dictionary of 1,500+ aliases and name changes, collected by hand
- Highlights:
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Sources Firm links Diagram

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  - Digitize **Nelson's (1959) hand-collected merger records**, 1895–1930

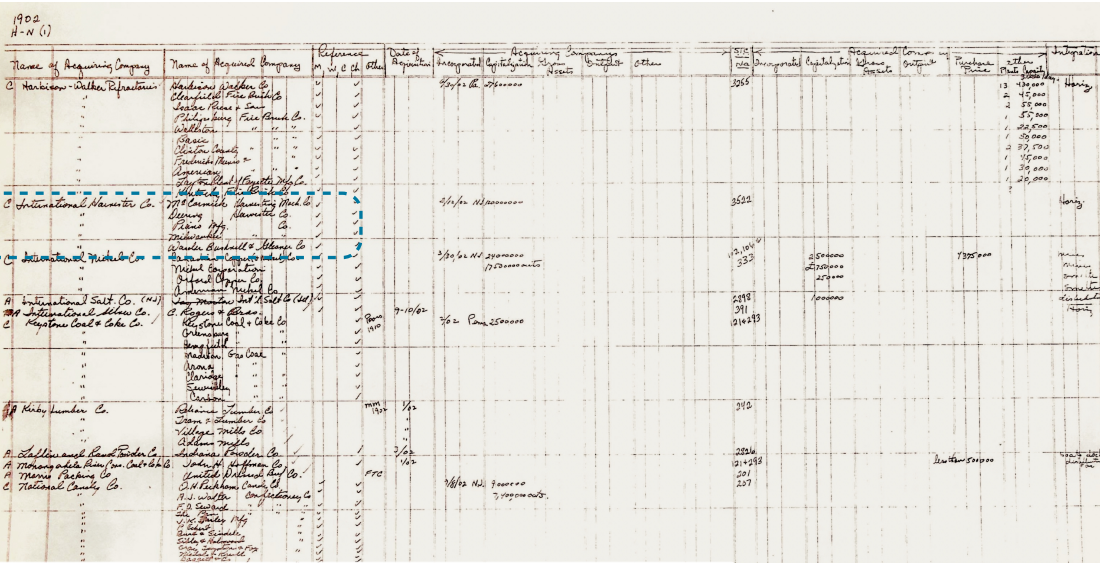
Sources Firm links Diagram



1902
H-N (1)

Name of Acquiring Company	Name of Acquired Company	Reference M	W	C	Ch	Other	Date of Acquisition	Amalgamated	Capitalized	Acquiring Company Shares	Acquiring Company Bonds	Other	Total	Amalgamated	Capitalized	Acquiring Company Shares	Acquiring Company Bonds	Other	Purchase Price	Other (Date & Amount)	Integrated
C Harbison-Walker Refractories	Harbison Walker Co							2/20/02 Cl. 35,000,000					3065							13 430,000	Horiz.
"	Clearfield Fire Brick Co																			2 45,000	
"	Sesame Fire Brick Co																			2 55,000	
"	Philipsburg Fire Brick Co.																			1 55,000	
"	Wellsboro " " "																			1 22,500	
"	Beaver " " "																			1 29,000	
"	Mentor Canada " "																			2 37,500	
"	Fredericks Mexico "																			1 15,000	
"	Aspercamp " "																			1 30,000	
"	Clay Fire Brick & Tile Co.																			1 20,000	
"	Gilbert " " "																				
C International Nickel Co.	McCormick Harvesting Mach Co.							2/26/02 NJ 20,000,000					3522								Horiz.
"	Keystone Nickel Co.																				
"	Deering Harvester Co.																				
"	Plano Mfg. Co.																				
"	McCormick " "																				
C International Nickel Co.	Orford Copper Co							3/30/02 NJ 20,000,000					172.184								Horiz.
"	Canadian Copper Co (Nickel) Co.							17,500,000 cash					333		2,500,000						Horiz.
"	Nickel Corporation														2,000,000						Horiz.
"	Belgian Copper Co														250,000						Horiz.
"	Lydenburg Nickel Co.																				Horiz.
A International Salt Co. (NJ)	Ivory Mountain Salt & Coal Co (Ltd)	C											2998		100,000						Horiz.
MA International Silver Co.	A. Rogers & Bros.						9-10/02						291								
C Keystone Coal & Coke Co.	Keystone Coal & Coke Co					Penn 1910		3/02 Penn 2,500,000					1210+93								
"	Greensburg " "																				
"	Youngstield " "																				
"	Madden Gas Coal "																				
"	Irons " "																				
"	Harvey " "																				
"	Saundlin " "																				
"	Carbon " "																				
A Kirby Lumber Co.	Edwin Hamber Co						mid 1902	1/2					340								
"	Dean & Hamber Co							"													
"	Village Mills Co							"													
"	Eddy Mills "							"													
A Lallance & Grosvenor Co	Indiana Veneer Co							2/02					2836								
A Mahoning Sales Co	John A. Hoffman Co							1/2					1210+293						Dec 1902 $80,000		Horiz.
A Morris Packing Co	Louisville Provision Co.					FPC							291								
C National Carbon Co.	D.W. Feltman Carbon Co							7/8/02 NJ. 9,000,000					227								
"	N.J. Wafer Confectionery Co							7,000,000 cash.													
"	F.D. Seward " " "																				
"	The Purity Mfg " "																				
"	J.C. Parker " "																				
"	Bunte & Schmidt " "																				
"	Gillis & Belmont " "																				
"	Chas. Symington & Co "																				
"	Wilbert F. Wheeler "																				
"	Standard " "																				

Nelson's original worksheets: every consolidation, firm by firm



1902
H-N (1)

Name of Acquiring Company	Name of Acquired Company	Reference M	W	C	Ch	Other	Date of Acquisition	Consolidated	Capitalized	Acquiring Company Bonds	Acquiring Company Stock	Other	Stock	Consolidated	Capitalized	Acquired Company Bonds	Acquired Company Stock	Other	Purchase Price	Plant & Equip.	Integrated
C Harbison-Walker Refractories	Harbison-Walker Co				✓			2/20/02 Pa	15,000,000				3065							13	439,000
	Clearfield Fire Brick Co				✓															2	45,000
	Swissvale Fire Brick Co				✓															2	55,000
	Philipsburg Fire Brick Co.				✓															1	55,000
	Wellsboro " " "				✓															1	25,500
	Beaver " " "				✓															1	39,000
	Mexico Canada " "				✓															2	37,500
	Fredericks Mexico "				✓															1	15,000
	Anderson " "				✓															1	30,000
	Clay Fire Brick Mfg Co.				✓															1	20,000
	Mt. Savage Fire Brick Co				✓																
C International Harvester Co.	McCormick Harvesting Mach Co				✓			2/12/02 NJ	20,000,000				3522								Horiz.
	Deering Harvester Co				✓																
	Plano Mfg Co				✓																
	Milwaukee "				✓																
C International Nickel Co	Orford Copper Co				✓			3/30/02 NJ	25,000,000				121,184								Horiz.
	Canada Copper Co Ltd				✓				17,500,000 com				333		2,500,000						Horiz.
	Nickel Corporation				✓										2,000,000						Horiz.
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A International Salt Co. (NJ)	Ivory Mountain Salt & Coal Co (Va)				✓								2998								Horiz.
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C Keystone Coal & Coke Co.	Keystone Coal & Coke Co				✓			Penn 1910	3/02 Penn 2,500,000				121,283								
	Greensburg "				✓																
	Youngfield "				✓																
	Madden Gas Coal "				✓																
	Stoney "				✓																
	Harvey "				✓																
	Sewickley "				✓																
	Carbon "				✓																
A Kirby Lumber Co.	Edwin Hines Lumber Co				✓			Miss 1904	1/02				340								
	Dean & Chamberlain Co				✓																
	Village Mills Co				✓																
	Eddy Mills "				✓																
A Lalley-Waugh Road Tractor Co	Indiana Tractor Co				✓		2/02						2836								
A Mahoning Valley Iron Coal & Coke Co	John A. Hoffman Co				✓		1/02						121,283						Dec 1901 $50,000		
A Morris Packing Co	Kansas City Dressed Beef Co.				✓		FTC						221								
C National Candy Co.	D.M. Ketchum Candy Co				✓				1/6/02 NJ 900,000				227								
	N.J. Wotten Confectionery Co				✓				7,100,000 com.												
	F.D. Seward " "				✓																
	The Morley Mfg				✓																
	J. Paul "				✓																
	Bunte & Brandt "				✓																
	Gillett & Eaton "				✓																
	Wm. Symington Co				✓																
	Wilbur F. Wood "				✓																
	Chandler Co				✓																

Nelson's original worksheets: every consolidation, firm by firm

Outline

1. Introduction
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5. Technology-level Analysis
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Empirical Strategy: Merger Effects on Firm Innovation

- **Treatment** = **enterprises consolidating 1895–1904** (232 consolidations)
  - Pre-merger outcome = **sum across constituent firms**; post = the combine
- Event time t_0 = each deal's **earliest public announcement**
  - Newly collected from the *Commercial & Financial Chronicle*

Descriptives Chart Method

No Perfect Control Group: Three Complementary Approaches

Benchmark post-merger patenting output against:

1. the firms' **own pre-period**
2. **abandoned consolidations** ("paper mergers")
3. **matched non-merging firms**

Selection Probit Pre-trends Designs

No Perfect Control Group: Three Complementary Approaches

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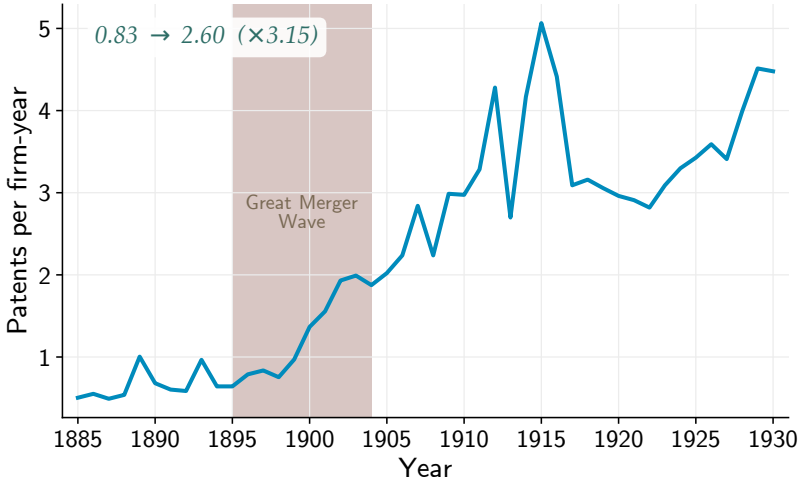
1. the firms' **own pre-period**
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- Central concern is **selection on unobservables**
- Historical record and my tests agree: firms selected on **price competition and cost structure**, not innovative potential

Selection Probit Pre-trends Designs

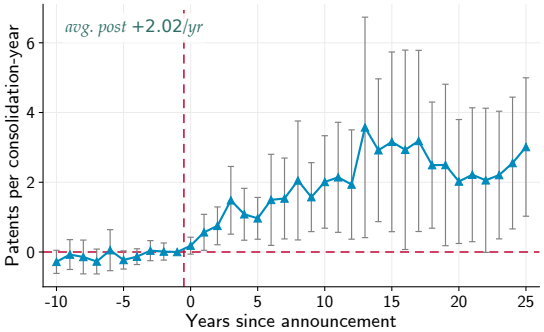
Patenting Increased After the Wave: Descriptive

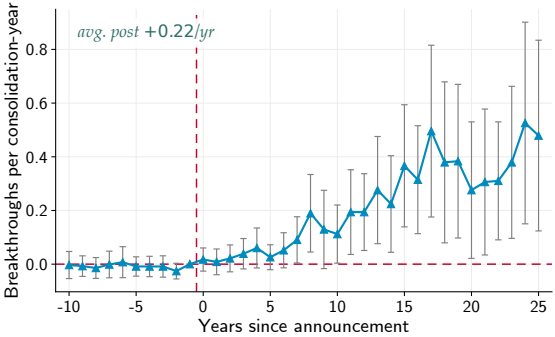
Pool consolidations across the intensive and extensive margins of patenting



Patenting Increased After the Wave: Event Study

Treat = 232 consolidations; Control = none; Design = within-firm event study





Descriptive Setup

Paper Mergers (Abandoned Consolidations as Control)

- Address selection by comparing to consolidations **announced/organized, but never durably formed**
- Two challenges: **reconstruct** each deal from historical record, and **assess why** it unraveled
  - Additional data collection effort from primary sources
  - Caveat: **limited power** (30 deals)
- Depending on **bias direction**, interpret results as lower or upper bounds
  - Hold-out firms positively selected $\rightarrow$ lower bound (and v.v.)

Collection Selection Pool By failure mode

Federal Printing Ink Co.

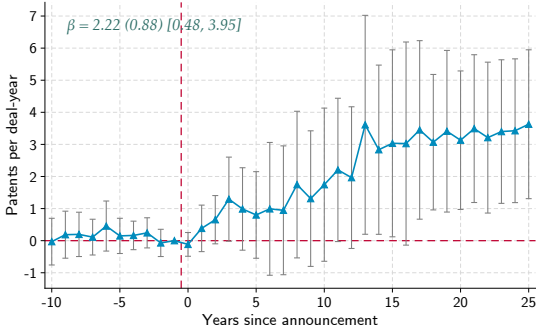
- **1899**: ∼25 ink makers organized into the **Federal Printing Ink Co.** (New Jersey, $20M)
- Terms to the **Geo. H. Morrill Co.**, a major constituent: $625k cash + $1.875M stock
- Morrill **held out**, demanding $1M cash; refused over the price
- Without Morrill's consent the combine **never commenced operations**

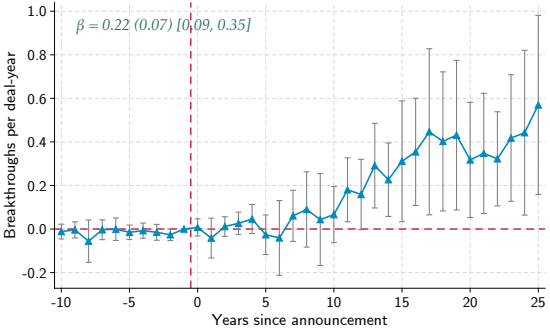
> *"The Morrill printing ink concern . . . refused to enter the consolidation on account of the difference in the matter of the* ***purchase price****."*
>
> *The Paper Mill and Wood Pulp News*, 1899

Full record | Another deal

Paper Mergers Stay Flat; Actual Mergers Rise

Treat = 265 consolidations; Control = 24 abandoned deals; Design = dynamic DiD





Setup Descriptive Robustness

Ruling Out a Common Trend: Non-Merging Firms

- Concern: a common trend in firm patenting in the **same technology or industry**
- Tailor control groups by *margin* of patenting:
  - **Intensive** (patented pre-1895): **medium-sized non-merging firms from the patent record**
  - **Extensive** (no pre-1895 patents): medium-sized firms from **Moody's** (1900)

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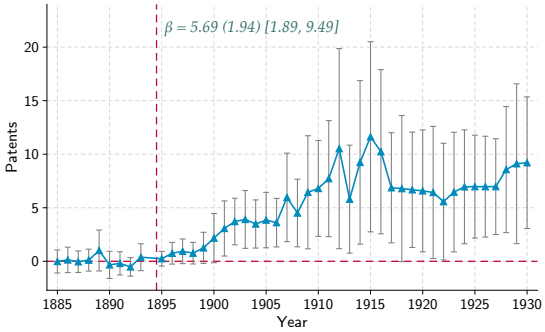
- **Intensive-margin setup**: 79 consolidations vs. 5,369 matched controls; **IPW** matches the treated pre-1895 patent distribution; **same-niche** firms excluded

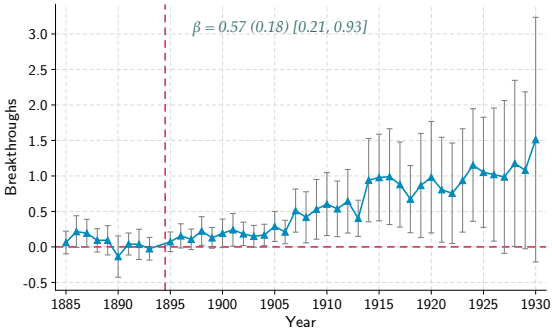
$$y_{it} = \alpha_i + \delta^{\text{tech}}_{c(i),t} + \delta^{\text{ind}}_{j(i),t} + \beta \cdot \mathbb{1}[t \geq 1895] \cdot \text{GMW Firm}_i + \varepsilon_{it}$$

Alternative approaches: BMA More; placebo More; synth. control More; SDID More

Intensive Margin: Patents and Breakthroughs Rise

Treat = 79 consolidations; Control = 5,369 matched firms; Design = dynamic DiD





Design | Niche & industry | Levels | Rel. time | Poisson

Entry, Heterogeneity, and Robustness

- **Extensive margin**: consolidations +23 p.p. more likely to begin patenting (tripling entry) Chart
- **Heterogeneity**: breakthrough gains rise with initial **market share**, concentrating in **science-based** fields — chemistry, electronics Charts
- **Robustness**: placebo mergers, synthetic control, synthetic DiD, model averaging, sample trims, filing-year timing All checks

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But are these genuine innovation gains? Or 'just patents'?

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4 **R&D Lab Mechanism**

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Why Did Firm Innovation Rise? The Lab Hypothesis

- Narrative: Industrial labs moved invention from individuals to **systematic, team-based R&D**, in an era of **weak public science** (DeLong 2022; Mowery and Rosenberg 1998; Gertner 2013)

Why labs | Lab shares

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Q1. Does consolidation create labs?

Q2. Do labs raise inventor productivity?

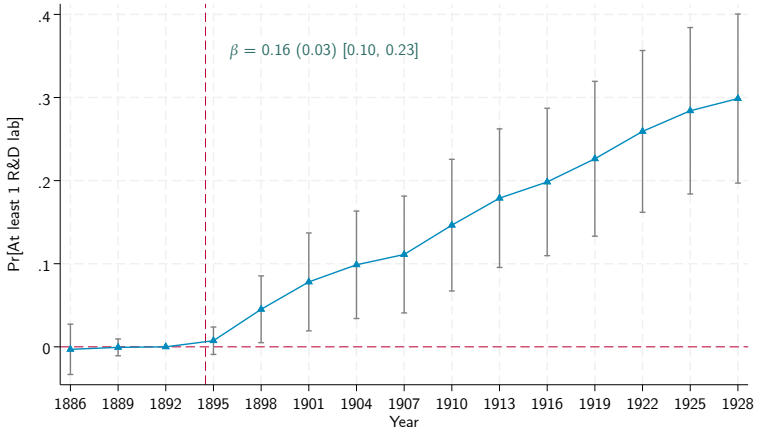
Why labs | Lab shares

New Data: the First Inventor–Firm–Lab Panel Before 1940

- **R&D labs**: digitized National Research Council surveys (1920–1946)
  - 4,500 lab locations, two-thirds with establishment dates
- **Inventors**: probabilistic disambiguation (**1 million inventors, 2.3 million patents**)
  - Matched on names, locations, technology, co-authors
- **First** inventor-level panel **before 1940**
  - Tracks inventors across harmonized firms, matched with labs
  - Essential for separating **sorting** from **productivity**

Scan Validation

Merging Firms Became Far More Likely to Open an R&D Lab

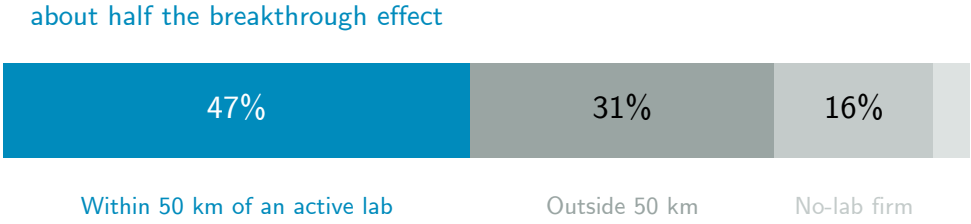


+16 p.p. average, vs. a ∼2 p.p. control-group baseline

Levels Extensive

Half the GMW Breakthroughs Arise Near Their Labs

Decompose the breakthrough gains of **Great Merger Wave firms** by the inventor's distance to the firm's R&D lab, a proxy for **in-house research**.



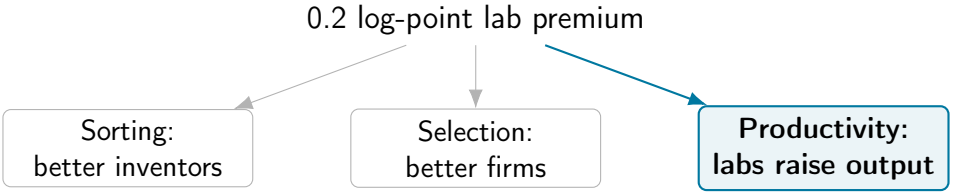
Method Full results DuPont

Is It the Lab? Sorting, Selection, or Productivity

- Descriptively, inventors at lab-owning firms produce **+0.2 log points** more per year (quality-weighted patent output)

Is It the Lab? Sorting, Selection, or Productivity

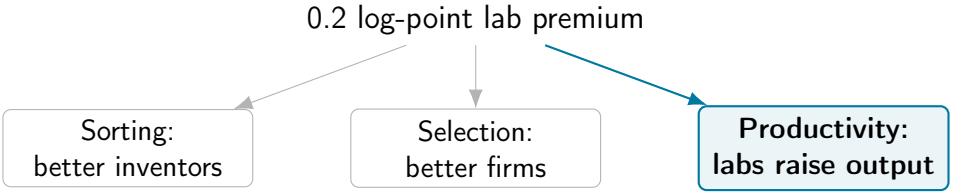
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Means Data Spells Validation

Is It the Lab? Sorting, Selection, or Productivity

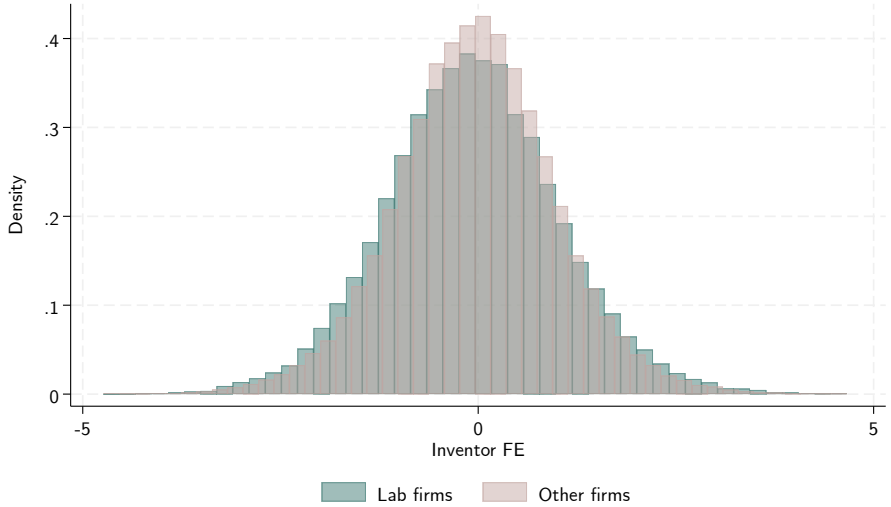
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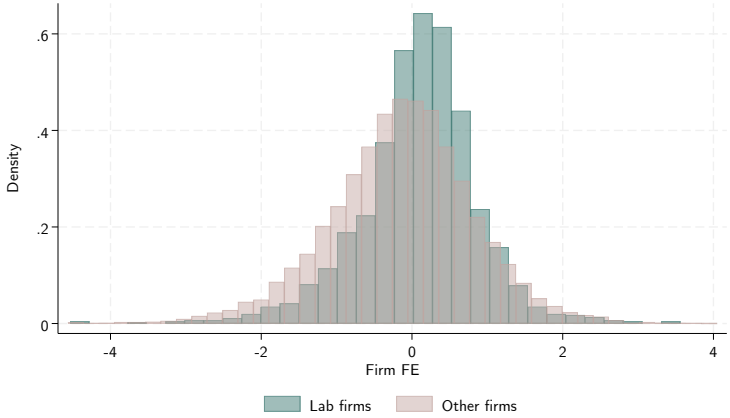
- **AKM two-way fixed effects**: $\ln y_{it} = \alpha_i + \psi_{j(it)} + X'_{it}\gamma + \varepsilon_{it}$
  - Inventor **movers** separate ability α_i from firm effect ψ_j (94k inventors, 18k firms)

Means Data Spells Validation

Higher-Quality Inventors Do Not Sort into Lab-Owning Firms



Lab-Owning Firm Effects 0.22 Log Points Higher



Persists **within** bigness and tech; ψ_j rises ∼**0.5 SD** at establishment

Within Big/Sci | $\Delta\psi$ evidence | Movers

Outline

1 Introduction

2 Background and Data

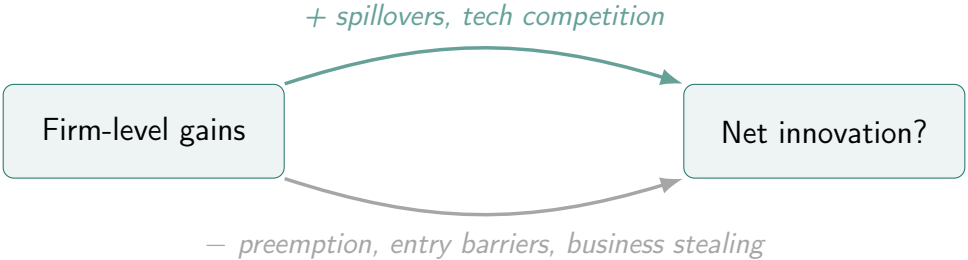
3 Firm-level Analysis

4 R&D Lab Mechanism

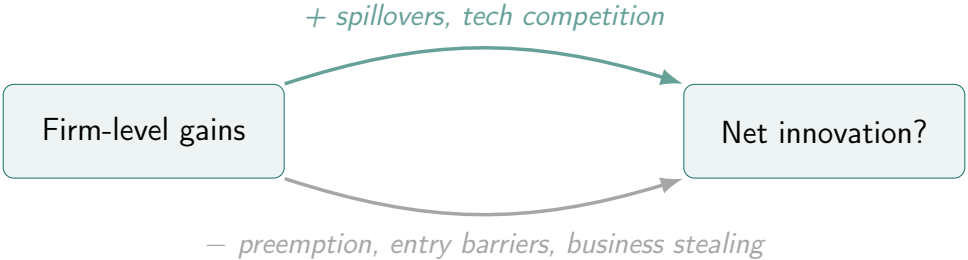
5 **Technology-level Analysis**

6 Conclusion

Do Firm Gains Spill Over?



Do Firm Gains Spill Over?



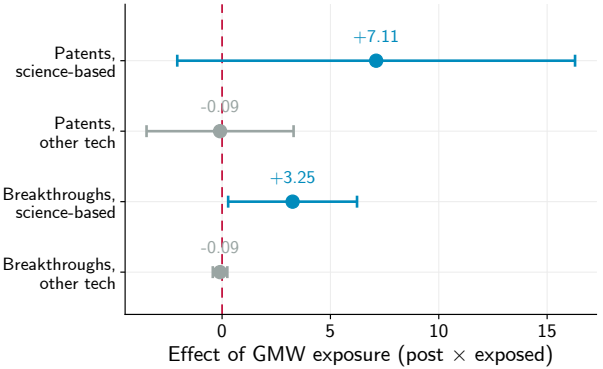
Test at the **technology-domain** level: total innovation

in **Established** vs. **Emerging** domains × **Science-based** vs. **Non-science**

Science-based = close to the scientific frontier: chemistry, electronics, instruments (Arora et al. 2024)

Established Technologies: Frontier Domains Accelerate

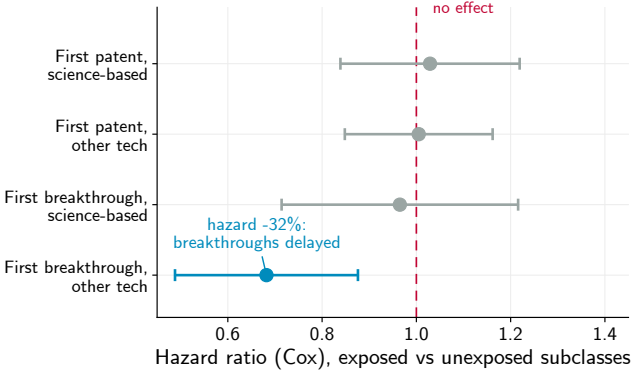
- DiD at the technology-level, **excluding GMW firms' own patents** (spillovers)
- Comparison: **exposed vs unexposed domains**, split by frontier



Setup Raw counts ES Full table Why

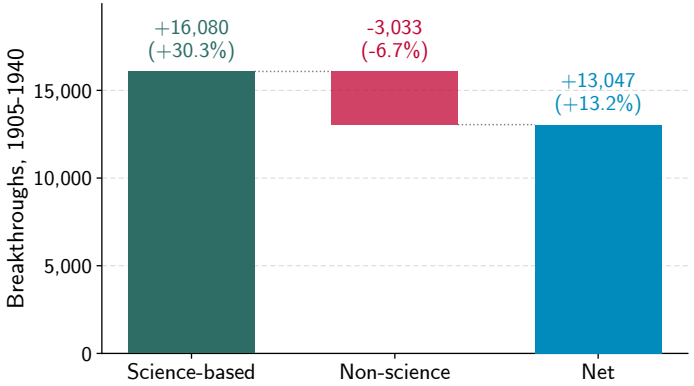
Emerging Technologies: Delays Outside the Frontier

- **Hazard** model; outcome = timing of the first patent/breakthrough (Cox hazard)
- Comparison: within-class, exposed vs. unexposed subclasses, split by frontier



Setup Robustness Why

Net Effect: +13,000 Breakthroughs (+13%), 1905–1940



Back-of-the-envelope: DiD coefficients × exposed observations; partial-equilibrium, directional

Full table

Spillover Effects Depend on the Scientific Frontier

- **Conjecture**: the shifting knowledge base drives the heterogeneity
  - Fast-moving frontier $\rightarrow$ leads stay **contestable** $\rightarrow$ "neck-and-neck" (Aghion et al. 2005) $\rightarrow$ positive spillovers
  - Technologically stable domains $\rightarrow$ consolidation entrenches $\rightarrow$ negative spillovers

Why (frontier) Why (stable)

Spillover Effects Depend on the Scientific Frontier

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  - Fast-moving frontier → leads stay **contestable** → "neck-and-neck" (Aghion et al. 2005) → positive spillovers
  - Technologically stable domains → consolidation entrenches → negative spillovers

- Two high-patenting consolidations, different stories:
  - **DuPont**: breakthrough rate 62%, stays at the frontier; Monsanto & Dow grow on their own R&D
  - **United Shoe Machinery**: breakthrough rates 3%, kept its shoe-machinery monopoly into 1947

Why (frontier) Why (stable)

Outline

1 Introduction

2 Background and Data

3 Firm-level Analysis

4 R&D Lab Mechanism

5 Technology-level Analysis

6 **Conclusion**

Big Business Drove American Innovation

1. **Firm level**: consolidation raised patenting $\sim$**4**$\times$, breakthroughs $\sim$**6**$\times$

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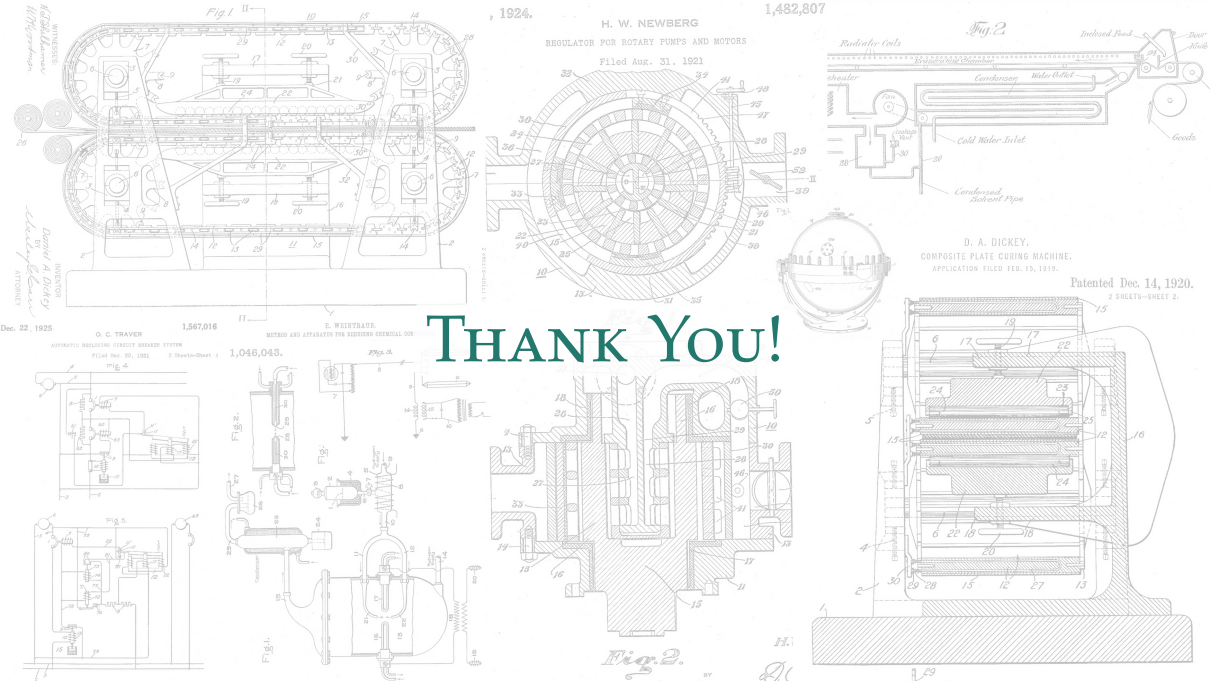
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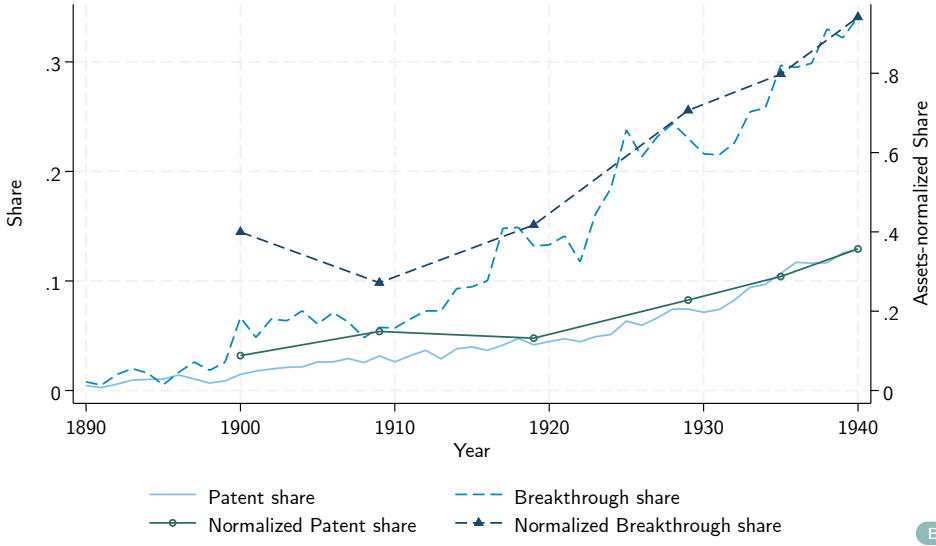
In an era of weak public science, big business became a central engine of technological progress, where systematic R&D mattered most.



Thank You!

Appendix

Big Business' Role in U.S. Innovation Grew Steadily



Back

Legal and Economic Context

- **Antitrust law** takes sharp turns
  - *Sherman Antitrust Act* (1890)
  - *E.C. Knight* (1895): cannot restrict 'disposition of private property'
  - *Northern Securities* (1904): reversal → focus on competitive effects, not form
- Competitive **price pressure** builds
  - Competitive markets + 1893-7 deflation → intense price competition
  - Lamoreaux (1985): Low-margin, high fixed-cost sectors merge most
- **Not targeting innovation** record nor potential
  - Diffusion of internal R&D mostly *after* turn of the century

Timeline Iron Age
More
Deflation
Logit Evidence
Pretrend Probit
Inventors
Back to GMW Dates

What does 'restraint of trade' mean?

- 1890. **Sherman Act** passed, but its vagueness requires court interpretation
- 1895. **E. C. Knight** decision upholds the consolidation of the Sugar Trust
- 1897. **Trans-Missouri** confirms that price fixing and pooling was illegal (railroad)
- 1898. **Addyston** decision finds price fixing by *industrial* firms also illegal
- 1904. **Northern Securities** decision first to mandate the dissolution of a merger
- 1911. Historic **break-up** decisions for Standard Oil and American Tobacco
- 1914. **Clayton act** passed, M&A which 'substantially lessens competition' is definitively illegal

Context Back

The Iron Age Editorial (1898)

In February 1898, an editorial in the trade publication *Iron Age* commenting on *Addyston* made explicit that the legal environment was incentivizing mergers:

> *The new decision is one which may gravely affect some of the arrangements now in force among manufacturers in different lines, in which some control over prices is sought by concerns otherwise acting independently in the conduct of their business. At first sight it looks as though* ***this decision must drive them to actual consolidation****, which is really more apt to be prejudicial to public interests than the losses and temporary agreements which it condemns.*
>
> — As reported in Bittlingmayer (1985).

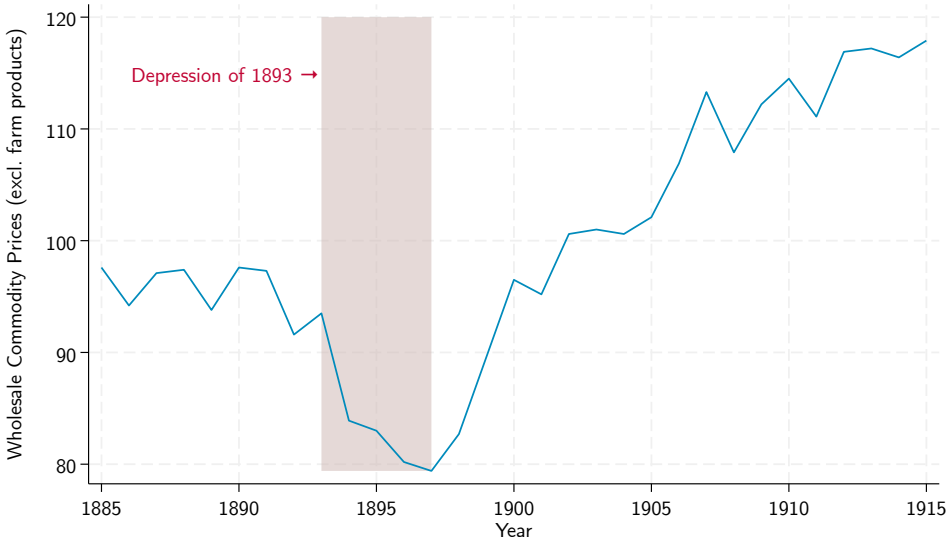
Back

References for GMW Background

- **Legal & economic drivers**: Bittlingmayer (1985), Lamoreaux (1985), Ahumada (2025), Stigler (1950), and Nelson (1959)
- **Wall Street promotion & market control**: Livingston (1986), Du Boff and Herman (1989), Stigler (1950), and Markham (1955)
- **Scale & consequences**: Golbe and White (1988), Huang, Yang, and Zhao (2025), Chandler (1977), Lamoreaux (2000), and Porter (2006)
- **Preconditions**: Donaldson and Hornbeck (2016), Grandy (1989), and Baskin and Miranti (1997)

Back

Wholesale prices fell 15% during 1893-97 Depression



Back

Lamoreaux (1985): Which Industries Consolidated?

Industry-level logit predicting consolidation (1895-1904):

- **Lower profit margins**
  $\beta = -8.64^{***}$ (SE 2.85)
- **Higher fixed costs**
  $\beta = 1.24^{**}$ (SE 0.55)
- **Larger plants**
  $\beta = 0.005^{***}$ (SE 0.002)
- Growth rate: weak/null

Sample: 232 industries, 52 with consolidation
Data: Census of Manufactures

Interpretation

Industries most likely to consolidate were those:

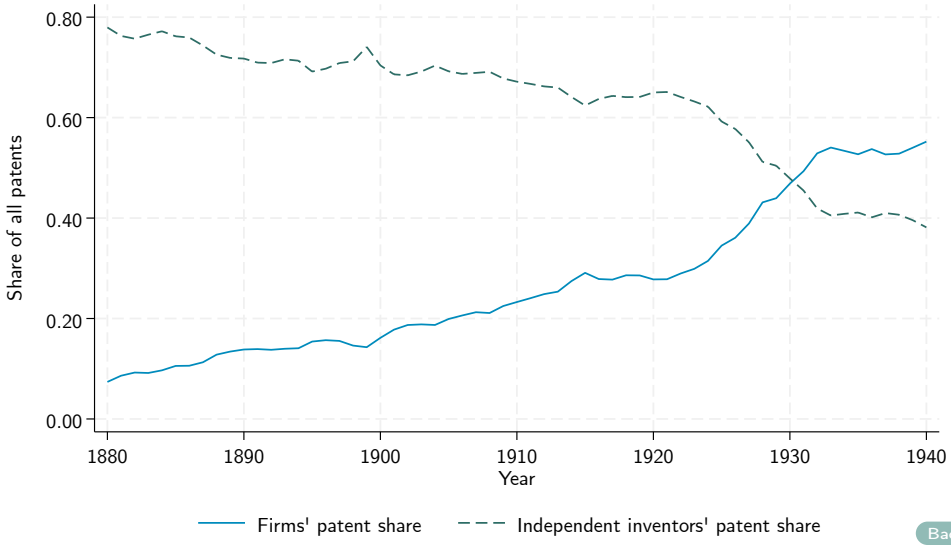
- **Most exposed to price competition** (low earnings per dollar of sales)

- **With greater economies of scale** (large fixed-cost burden)

Consistent with mergers as response to price wars triggered by the 1893 Depression

Back

Shares of Patenting Activity



Back

Data Sources: Core and Supplementary

Back

1. **Patents**: CUSP (Berkes 2018)
   - Assignees, inventor names, locations, tech classes
2. **Mergers**: Nelson (1959) worksheets
   - Acquiring & acquired firm names
3. **R&D Labs**: NRC surveys (1920-1946)
   - Lab locations, establishment dates, personnel details
4. **Subsidiaries**: Kandel et al. (2019)
   - Subsidiaries and ownership changes 1926-1950
5. Additional **ownership** changes: hand-collected
6. **1900 firms** with assets and sectors: Moody's Manual (1900)

Supporting Sources

- **Breakthroughs**: Kelly et al. (2021); **Top 100 firms**: Collins & Preston (1961)

Firm Linking Algorithm: Three-Stage Process

Back

Stage 1: Patent Assignee Disambiguation

- Classify 370K strings as firms (78% of assigned patents) vs. individuals
- Locality-sensitive hashing + deterministic matching rules
- Result: ∼137K unique firm assignees

Stage 2: Cross-Source Harmonization

- Manual dictionary: 1,500+ aliases (e.g., "American Car & Foundry" ↔ "ACF")
- Fuzzy matching + transitivity enforcement across all source pairs
- Iterative conflict resolution through additional data collection
- Result: ∼12,800 disambiguated firms with harmonized identifiers

Stage 3: Dynamic Ownership Mapping

- Year-by-year ownership resolution (1869-1960)
- Propagate ownership chains (if A owns B owns C, then A owns C)
- Result: 23,000 ownership changes tracked; enterprise-level consolidation

Firm-Level Selection: Limited Evidence

Probit models of GMW selection:

Moody's 1900 (Size):

- ln(Capitalization)
  $\beta = 0.102^{*}$ (SE 0.053)
- Sector FE: ✓
- **Pseudo $R^2 = 0.061$**

Patent Record (Innovation):

- Patents 1880–1894
  $\beta = 0.017^{***}$ (SE 0.006)
- Technology FE: ✓
- **Pseudo $R^2 = 0.041$**

Interpretation

- **Very little explanatory power**
- Among **patenting firms**, more pre-1895 patents raise Pr[GMW], but only slightly: from the 10th to the 90th percentile, Pr[GMW] moves from 1.4% to 1.6%
  - +0.19 p.p. (SE 0.06)

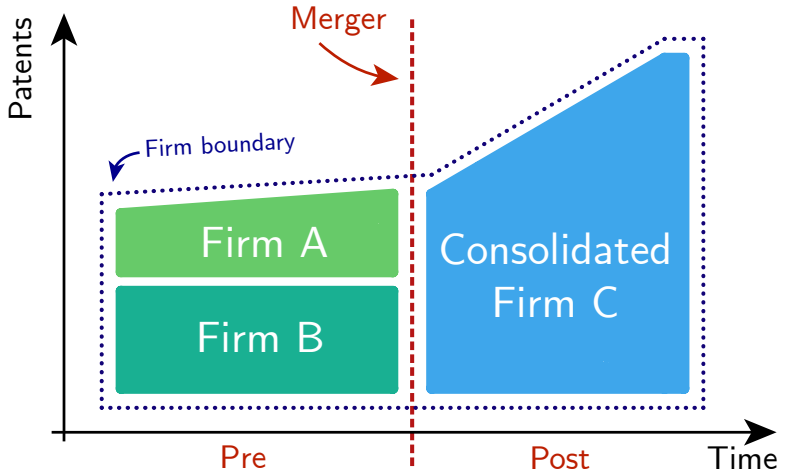
Context Back

Selection into the GMW: Price Competition, Not Innovation

- **Why firms merged**: price wars after the 1893–97 deflation (prices −15%)
  - Low-margin, high-fixed-cost, large-plant industries consolidate (Lamoreaux 1985); timing set by the antitrust window (Bittlingmayer 1985)
- **Who organized**: promoters—2/3 financiers, 1/4 banks, 1/12 insiders (Nelson 1959)
- **How deals formed**: industry-wide rollups—∼10 rivals per deal, 4 in 5 purely horizontal, 85% same tech area
  - Product-market matching, not cherry-picking of research assets
- **Merging firms not unusually innovative *ex ante***
  - 7 in 10 record no patents in 1885–94; constituent-level pre-trends flat
  - Pre-1895 patents move Pr[GMW] 1.4% → 1.6% (p10 → p90); pseudo-$R^2 \leq 0.06$
- **Corporate R&D only nascent**: ∼2% of controls have labs—an *outcome*, not a target

Lamoreaux logit | Probit | Pre-trends | Back

Constructing a Pre-period for Consolidations



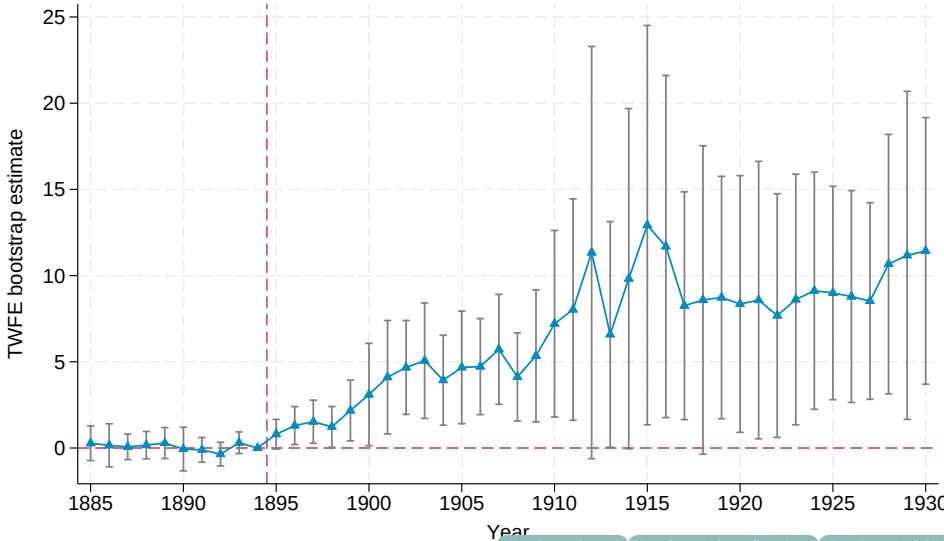
Back

Bayesian Model Averaging Results

Model:	IPW DiD	Placebo DiD	Synth. Control	Synth. DiD	BMA
Panel A: Patents					
GMW Firm	5.99 (1.91) [2.24, 9.73]	6.80 (2.49) [1.92, 11.69]	7.13 (2.00) [3.20, 11.06]	5.37 (1.91) [1.63, 9.11]	6.35 (2.23) [1.97, 10.72]
BMA weight	0.380	0.380	0.112	0.128	—
Panel B: Breakthroughs					
GMW Firm	0.56 (0.18) [0.21, 0.92]	0.60 (0.23) [0.16, 1.05]	0.63 (0.21) [0.21, 1.04]	0.50 (0.18) [0.14, 0.85]	0.58 (0.21) [0.17, 0.98]
BMA weight	0.348	0.376	0.128	0.147	—

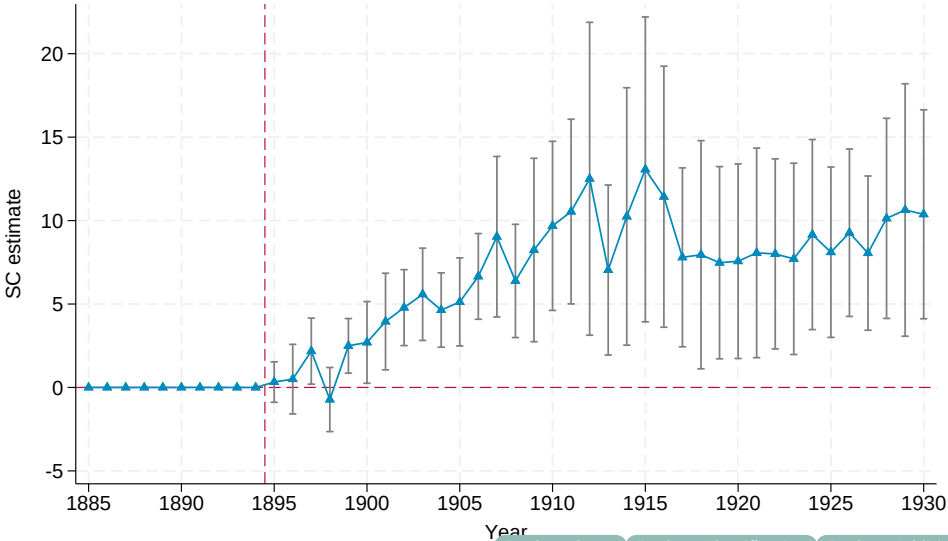
Back to Spec. Back to Identification Back to Additional Results

Placebo Merger Analysis



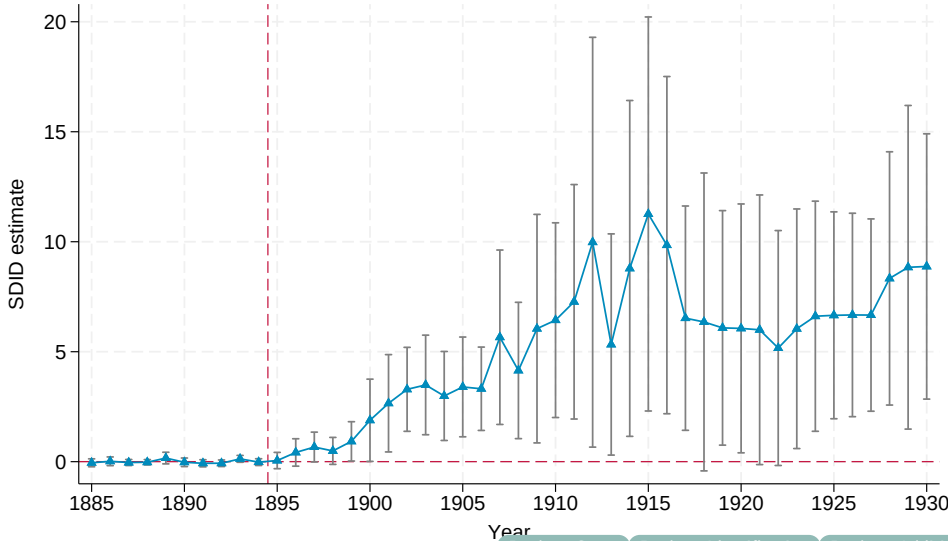
Back to Spec. Back to Identification Back to Additional Results

Synthetic Control Results



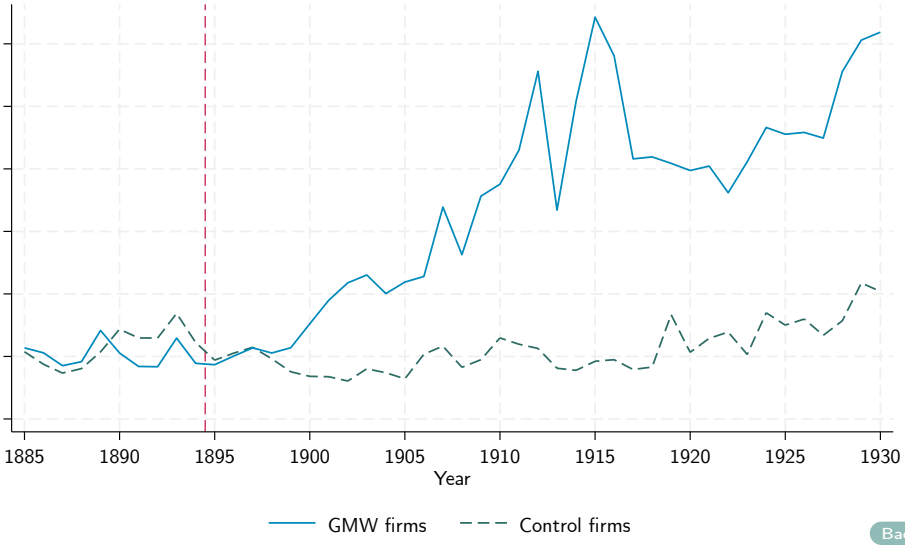
Back to Spec. Back to Identification Back to Additional Results

Synthetic Difference-in-Differences



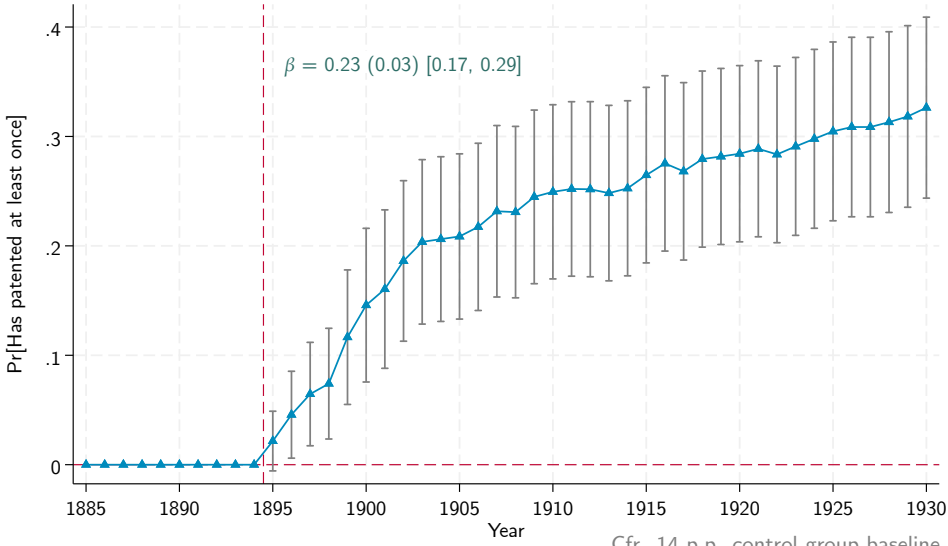
Back to Spec. Back to Identification Back to Additional Results

Raw Patenting Levels (IPW) — Unbalanced



Back

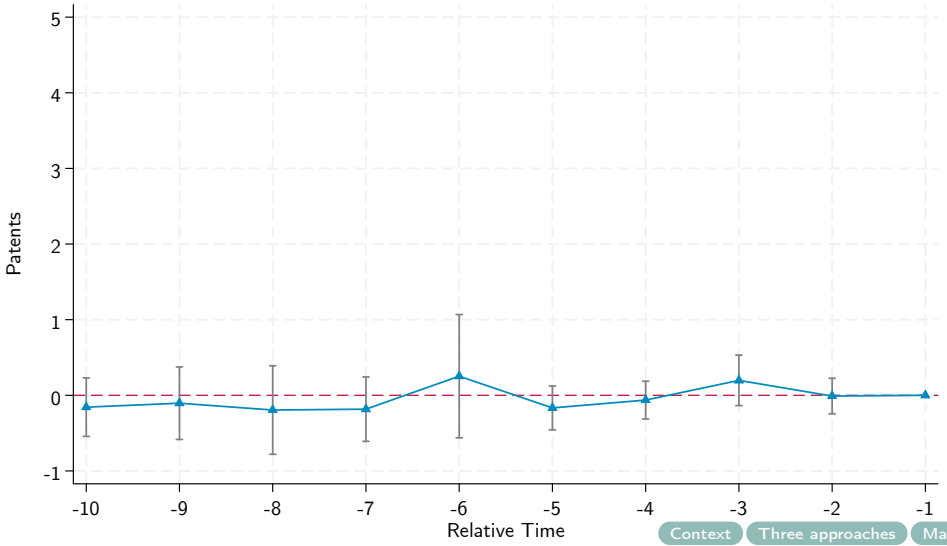
GMW firms more likely to take up patenting (*vs.* Moody firms)



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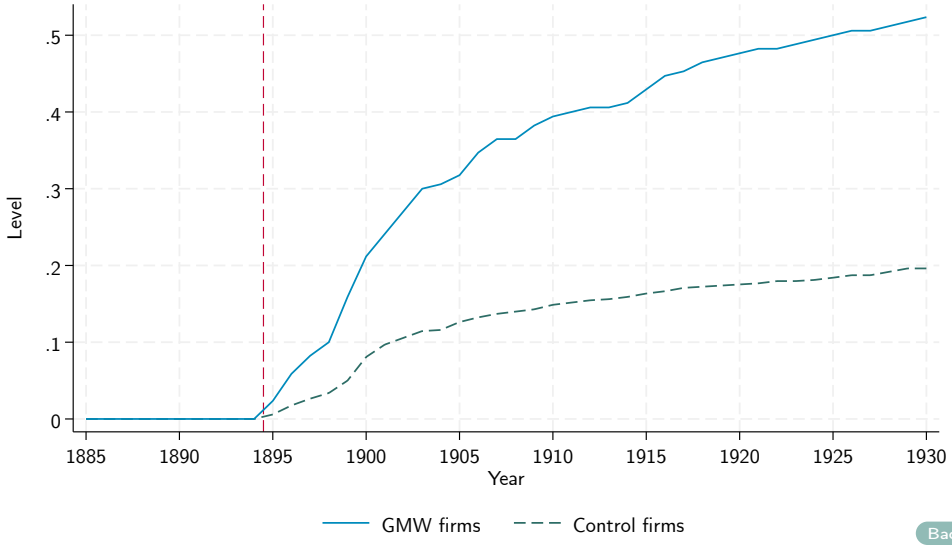
Cfr. 14 p.p. control group baseline Levels

Constituent-firm-level pre-trends in patenting



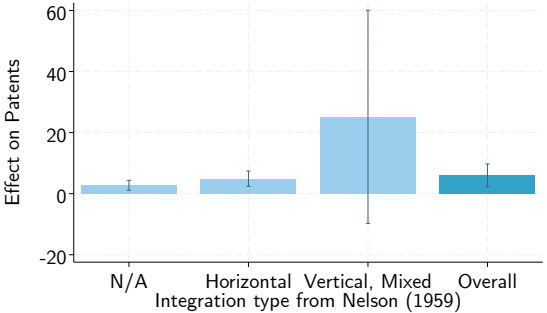
Context | Three approaches | Matched setup

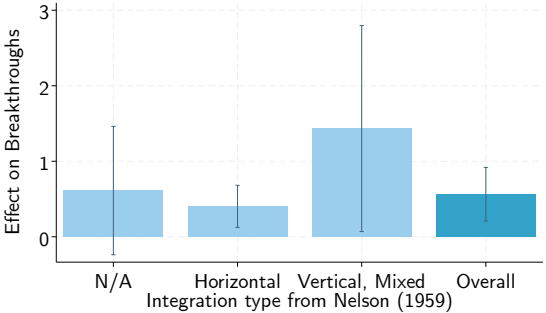
GMW firms more likely to take up patenting (Levels)



Back

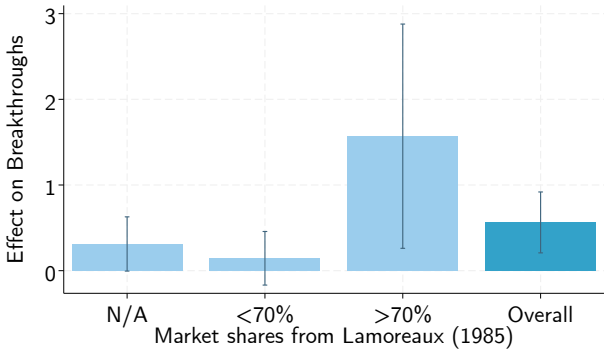
Heterogeneity by Integration Type





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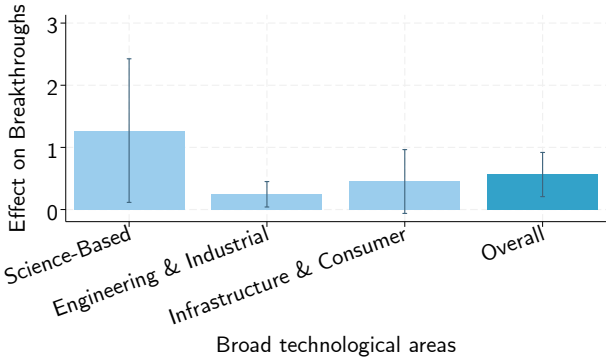
Where Breakthrough Gains Concentrate



Rise with achieved **market share** (Lamoreaux 1985): >70% → +1.57/yr vs. +0.56 avg

Patents Back

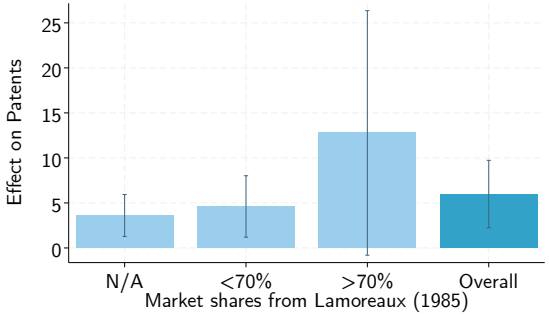
Where Breakthrough Gains Concentrate

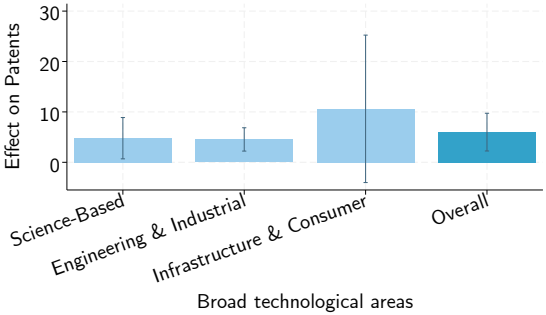


Concentrate in **science-based** areas: breakthroughs $+1.27$ vs. ≈ 0 elsewhere

Patents Back

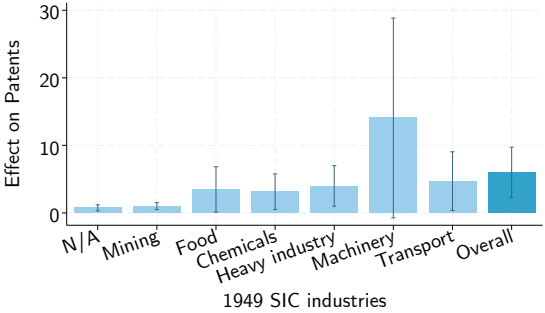
GMW Effect Heterogeneity for Patents

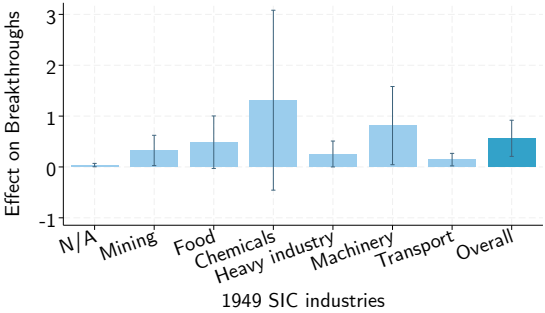




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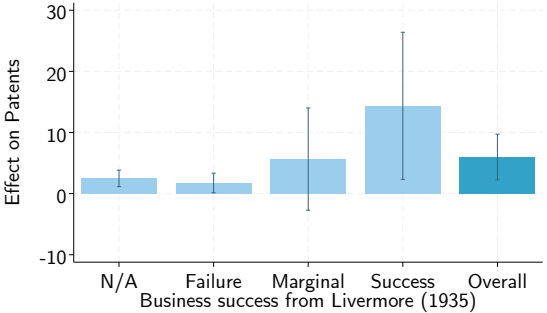
Heterogeneity by Sector

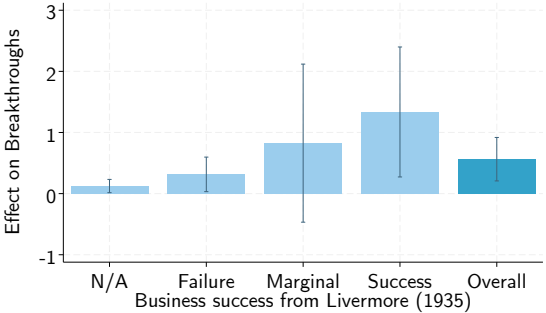




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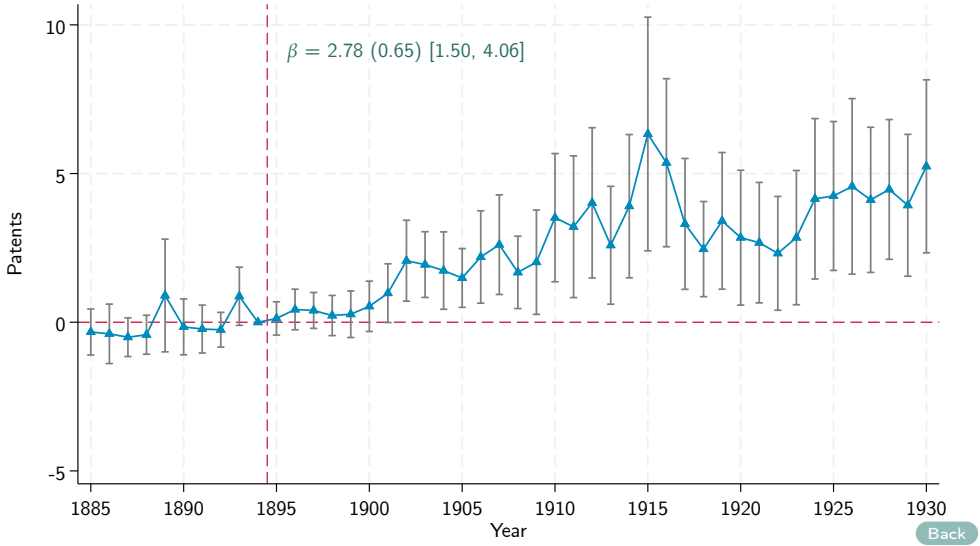
Heterogeneity by Business Success





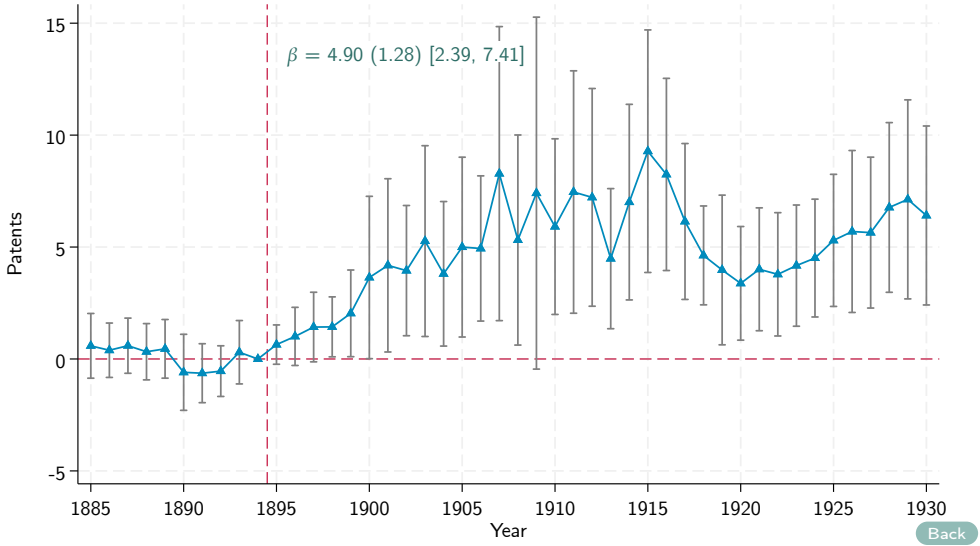
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Sample Restrictions: Trimming



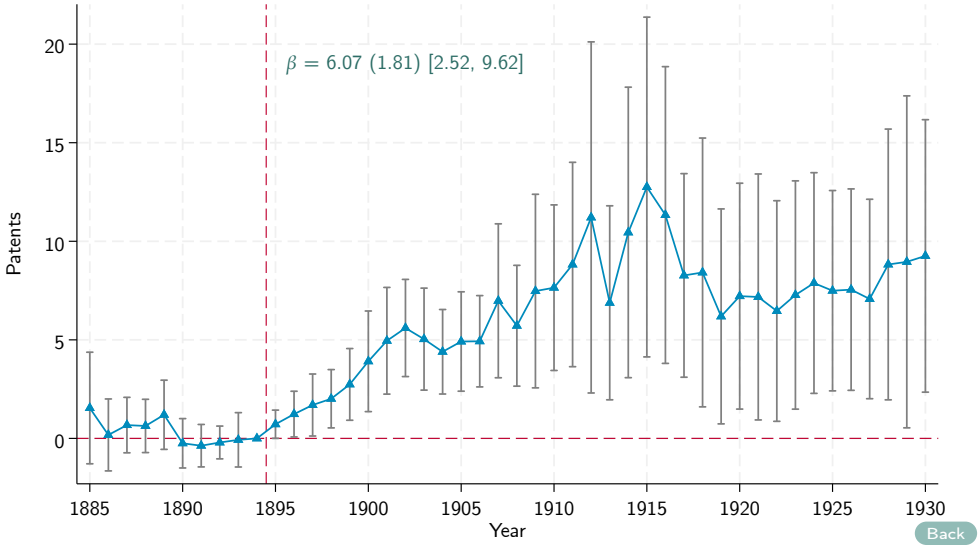
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Sample Restrictions: Horizontal Only



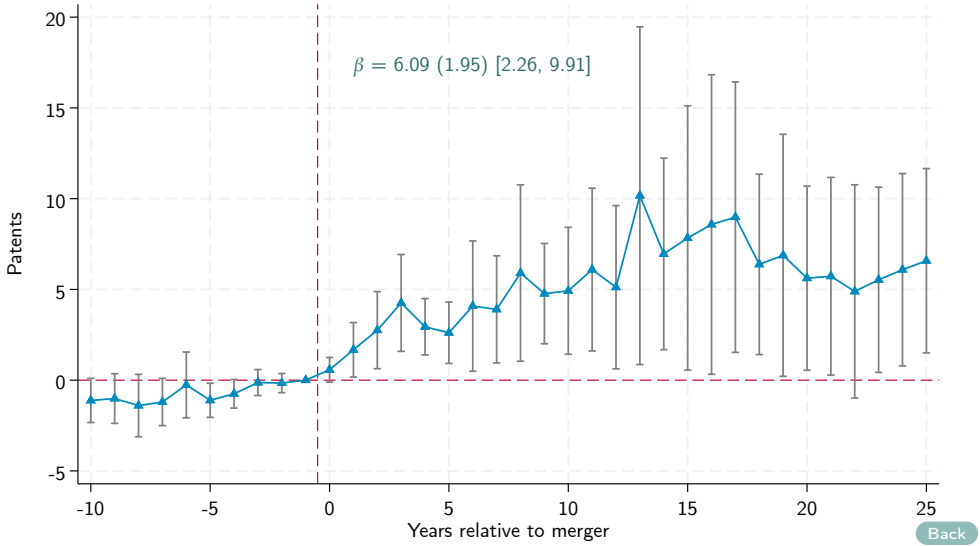
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Sample Restrictions: Unbalanced Panel



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Event Study in Relative time



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Measurement: Filing vs Issue Year

Margin:	Intensive			Extensive	
Outcome:	Patents	Breakthroughs	Has lab	Started patenting	Has lab
	(1)	(2)	(3)	(4)	(5)
GMW Firm	6.363	0.703	0.158	0.235	0.045
	(1.939)	(0.298)	(0.032)	(0.034)	(0.014)
	[2.562, 10.164]	[0.119, 1.286]	[0.096, 0.220]	[0.168, 0.303]	[0.016, 0.073]
Controls	Y	Y	Y	Y	Y
Treated pre-mean	1.884	0.093	0.017	0.000	0.001
Control post-mean	0.665	0.060	0.017	0.134	0.011
# Firms	12,156	12,156	12,156	834	834
N	559,176	559,176	559,176	38,310	38,310

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Why Labs Mattered: Organizational Innovation

- **Collaborative research structures** (Hartog et al. 2024):
  - Lab-based inventors **20% more likely** to work in teams
  - Repeat collaborations significantly more frequent within labs
  - Lab teams **3.3pp more likely** to patent novel technology combinations (+60%)

Back

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  - Lab-owning firms significantly more likely to employ prominent scientists
  - Engaged in scientific publication, bridging academia and commerce
  - Systematic monitoring of technological frontiers

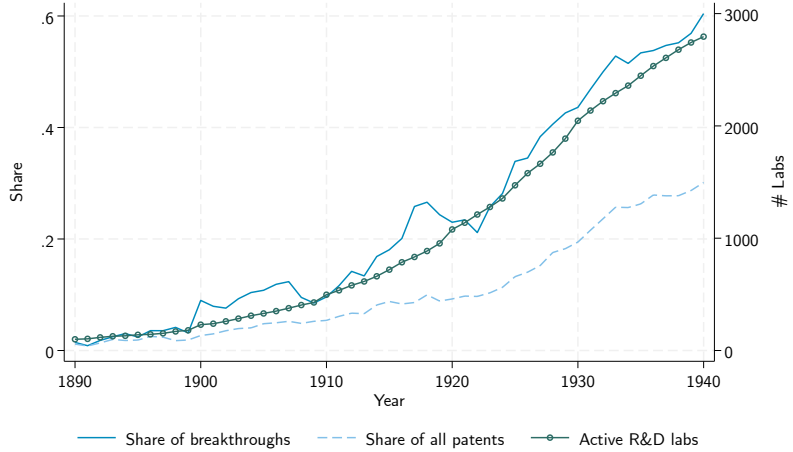
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  - Engaged in scientific publication, bridging academia and commerce
  - Systematic monitoring of technological frontiers
- **Additional descriptive evidence**:
  - Nicholas (2009): Lower quality patents near labs (citation-based)
  - **But**: Lab patents have **20% breakthrough rate** vs 11% (non-lab firms), 6% (unassigned)

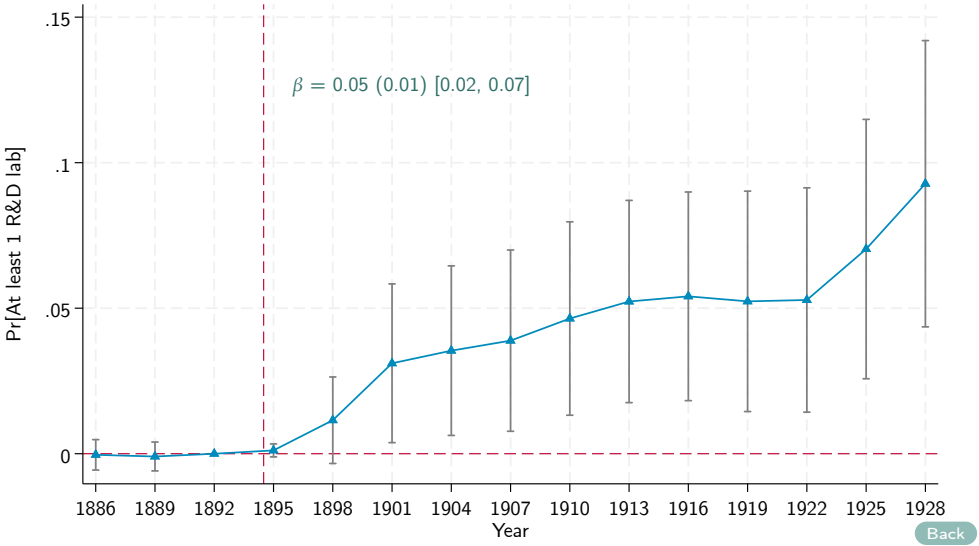
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By 1940, Lab-Owning Firms Produce Most U.S. Breakthroughs

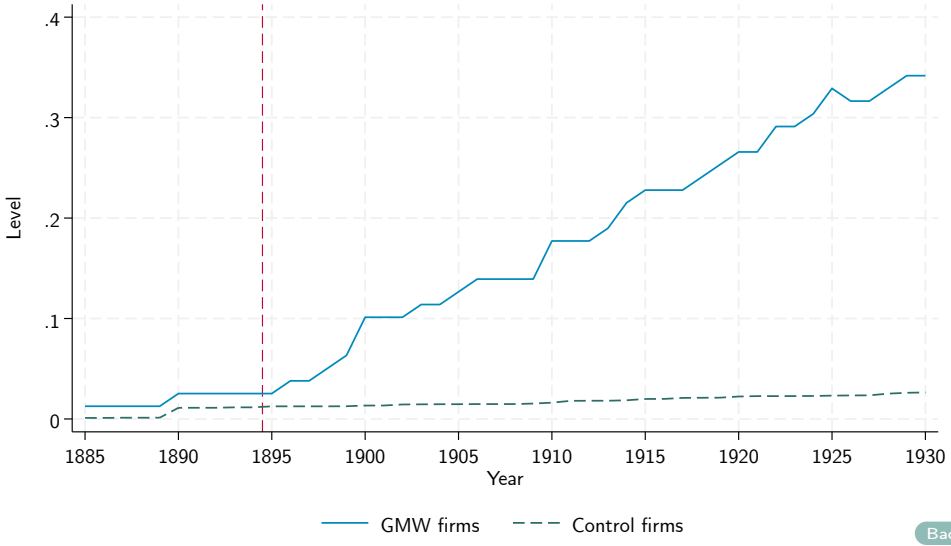


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GMW → Labs: Levels



GMW → Labs: Extensive Margin



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Spatial decomposition: method

- Partition patent counts into **mutually exclusive & jointly exhaustive** categories
- Based on **each patent**'s firm (R&D lab locations) and inventor **locations**
- By **linearity** of the difference-in-differences estimator, running separate regressions:

$$y^j_{itc} = \alpha^j_i + \delta^j_{tc} + \beta^j \cdot \mathbb{1}[t \geq 1895] \cdot \mathbb{1}[GMW\ Firm_i] + \varepsilon^j_{itc}, \tag{1}$$

with partitions j such that $y_{itc} = \sum_j y^j_{itc}$, yields a set of coefficients β^j that sum to the total effect β.

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Goals of DuPont's 1902 Eastern Laboratory

Hounshell and Smith (1988, p. 19) quote the new laboratory's, director, Charles L. Reese, as he outlined six objectives for the new lab:

(1) To improve as far as possible the chemical operations now employed.
(2) To investigate the explosives now being manufactured, to revise their Formulas and to put them on a scientific basis.
(3) To devise or discover new explosives for general and specific purposes.
(4) To keep in touch with all new and improved processes which have any bearing on operations connected with the explosives industry.
(5) To investigate new explosives brought forward by outsiders or suggested by members of the Company.
(6) To train young chemists and keep the plants supplied with technical, assistants.

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4 in 5 breakthrough gains from lab-owning firms

Outcome:	Total effect (1)	Within 50km active lab (2)	Within 50km undated lab (3)	Outside 50km any lab (4)	No lab firm (5)
Panel A: Patents					
GMW Firm	5.989	2.088	0.391	1.922	1.375
	(1.910)	(1.311)	(0.179)	(0.612)	(0.444)
	[2.245, 9.732]	[-0.482, 4.658]	[0.040, 0.741]	[0.723, 3.122]	[0.504, 2.245]
Share of total (%)	—	34.9	6.5	32.1	23.0
Panel B: Breakthroughs					
GMW Firm	0.563	0.265	0.021	0.173	0.090
	(0.181)	(0.135)	(0.010)	(0.058)	(0.049)
	[0.208, 0.919]	[0.000, 0.530]	[0.000, 0.041]	[0.059, 0.288]	[-0.005, 0.185]
Share of total (%)	—	47.1	3.7	30.7	16.0
Controls	Y	Y	Y	Y	Y
# Firms	11,801	11,801	11,801	11,801	11,801
N	542,846	542,846	542,846	542,846	542,846

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Entry for Int. Harvester in 1940

1042. International Harvester Company, 180 North Michigan Ave., Chicago, Ill.

President: S. G. McAllister.

Executive officer in charge of research: A. W. Scarratt, Vice President, Engineering and Patents.

Laboratories: Laboratories are located at: Tractor Works, 2600 West 31st Blvd., Chicago, Ill.; Canton Works, Canton, Ill.; Wisconsin Steel Company, Chicago, Ill.; Auburn Works, Richmond, Ind.; McCormick Works, Blue Island Ave. and Leavitt St., Chicago, Ill.; Farmall Works, Rock Island, Ill.; Ft. Wayne Works, Ft. Wayne, Ind.; East Moline Works, East Moline, Ill.; Hamilton Works, Hamilton, Ont.

Research staff: A. W. Scarratt, Vice President, Engineering and Patents; B. F. Courtright, Director at the Wisconsin Steel Mill; Fowler McCormick, Vice President of Manufacturing; J. E. Robinson, Supervisor, Metallurgy and Manufacturing Research; A. P. Cottle, Supervisor of Materials and Standards; L. B. Sperry, Assistant to A. W. Scarratt, Automotive Engineering; A. C. Lindgren, Assistant to A. W. Scarratt, Implement Engineering; A. W. Seacord, Manager of Manufacturing; 93 chemists, 33 metallurgists, 70 physicists, 102 engineers, 302 layout men and draftsmen, 805 shop mechanics, 108 other technical and scientific personnel, 66 road engineers and field mechanics and testers; additional personnel 223.

Research activities: Chemical, physical, electrical, optical, and metallurgical research as related to the industries served and the products manufactured (agricultural implements, power units, industrial and farm tractors, automobile trucks, Diesel and gasoline engines, etc.).

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AKM Sample Construction

- **Panel construction**
  - Balanced careers: first to last patent (includes non-patenting years)
  - Quality-weighted output: $q = 10 \cdot e^{4y - 0.8y^2}$ (Kelly et al. 2021)
- **Sample restrictions**
  - Remove implausible patterns (careers $>$ 67 years, $>$ 20 states, $>$ 100 firms)
  - Leave-one-out connectedness: network stays connected if any observation removed
- **Final sample sizes**
  - Excluding single-patent inventors: 3.2M obs, 267k inventors, 60k firms
  - LOO-connected: 1.3M obs, 94k inventors, 18k firms

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AKM Estimation: Spell-Level Approach

- **Spell** = contiguous years at same firm
- **Why spell-level?**
  - Addresses serial correlation within spells (Bonhomme et al. 2023)
  - Average output over spell: $\ln \bar{y}_{is} - X'_{is}\beta = \alpha_i + \psi_{j(is)} + u_{is}$
- **Maximizing variation**
  - Retain unassigned patents as pseudo-firms ($j = -1, 0$)
  - 227k spells, 61% movers across firms

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Inventor Data Validation: Prolific Inventors

Inventor	My Data	Wikipedia	Coverage
Thomas Edison	989	1,084	91%
Francis H. Richards	845	894	95%
Elihu Thomson	623	696	90%
John F. O'Connor	999	949	105%
Carleton Ellis	731	753	97%
Melvin de Groote	907	925	98%
George Albert Lyon	866	993	87%

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Mean differences by firm lab status

	Lab = 0 (1)	Lab = 1 (2)	Difference (3)
Innovative productivity $\ln y_{ijt}$	0.028 (1.310)	0.225 (1.401)	0.197 [0.000]
Inventor ability α_i	0.091 (1.013)	0.041 (1.112)	-0.050 [0.000]
Firm effect ψ_j	-0.141 (0.965)	0.081 (0.796)	0.222 [0.000]

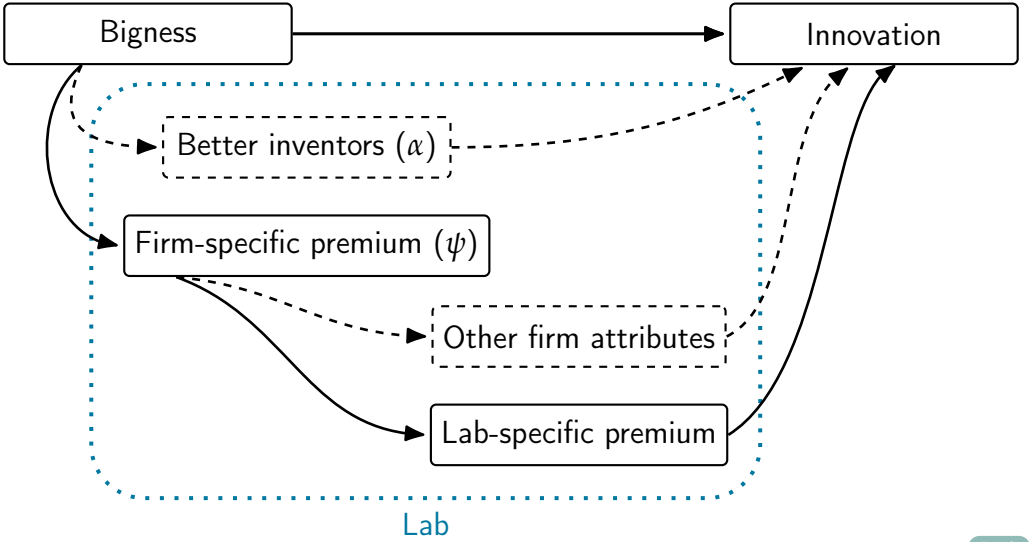
Back to intro
Back to ψ

Lab Establishment Effects on Firm Productivity

	Outcome: Change in Firm FE $\Delta\psi$		
	(1)	(2)	(3)
Opened Lab	0.576	0.580	0.461
	(0.114)	(0.117)	(0.117)
	[0.352, 0.800]	[0.351, 0.809]	[0.231, 0.690]
Became Big		-0.067	
		(0.395)	
		[-0.842, 0.708]	
GMW Firm			0.818
			(0.254)
			[0.319, 1.317]
CPC Section FE	Y	Y	Y
N	1,091	1,091	1,091

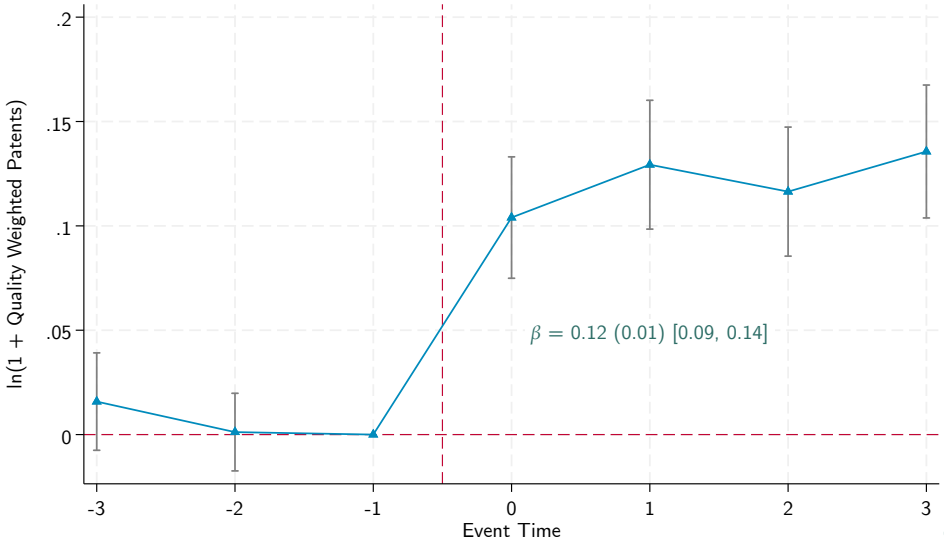
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Breaking down the productivity premium of lab firms



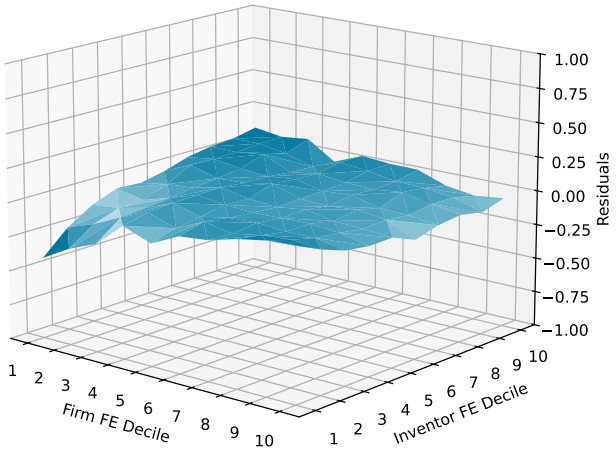
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Inventors Productivity Increases in Lab-Owning Firms



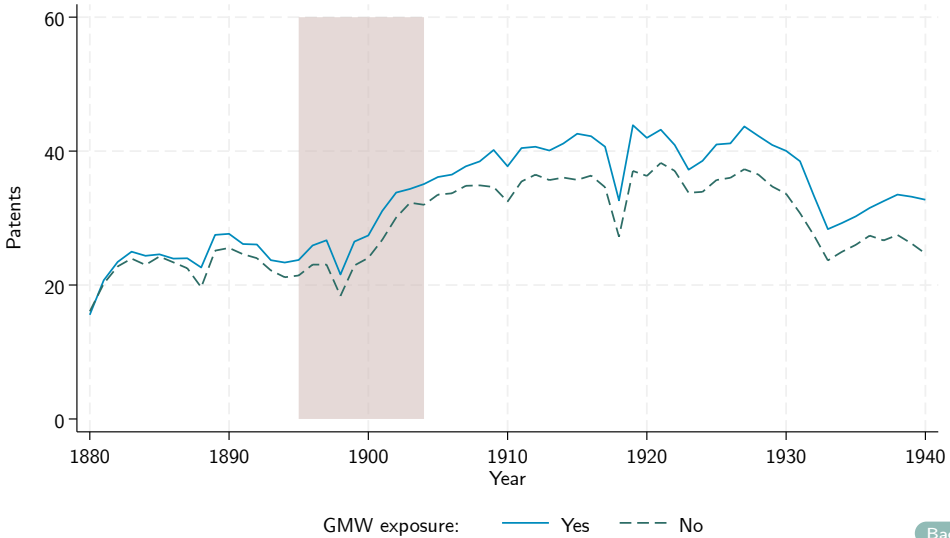
Setup Back

Residuals are mostly flat



Back

Established techs: Smaller difference on patents



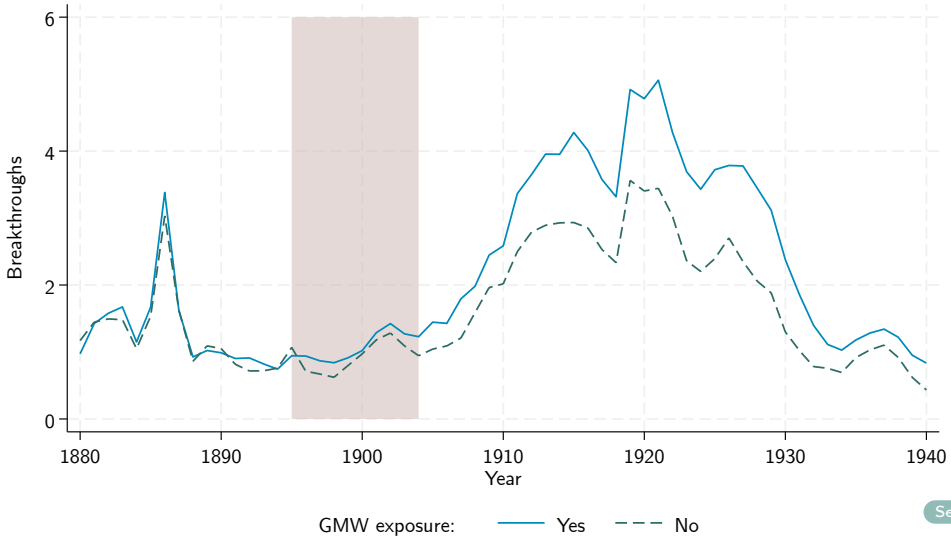
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Technology Construction: CPC Clustering Algorithm

- **Challenge**: CPC subgroups vary dramatically in pre-1895 patent counts
  - Large groups mechanically more likely to have GMW exposure
  - Need comparable technology sizes for meaningful effects
- **Solution**: Bottom-up clustering into 1,000 size-balanced domains
  - Target size = total pre-1895 patents / 1,000 clusters
  - Respect CPC hierarchy: subgroup $\rightarrow$ group $\rightarrow$ subclass $\rightarrow$ class $\rightarrow$ section
  - Preserve technological coherence within clusters
- **Algorithm**:
  1. Large units ($\geq$75% target) $\rightarrow$ own clusters
  2. Medium sibling units (50-150% collectively) $\rightarrow$ grouped
  3. Large sibling groups $\rightarrow$ split using cumulative distribution boundaries
  4. Post-processing ensures no cluster <30% target size

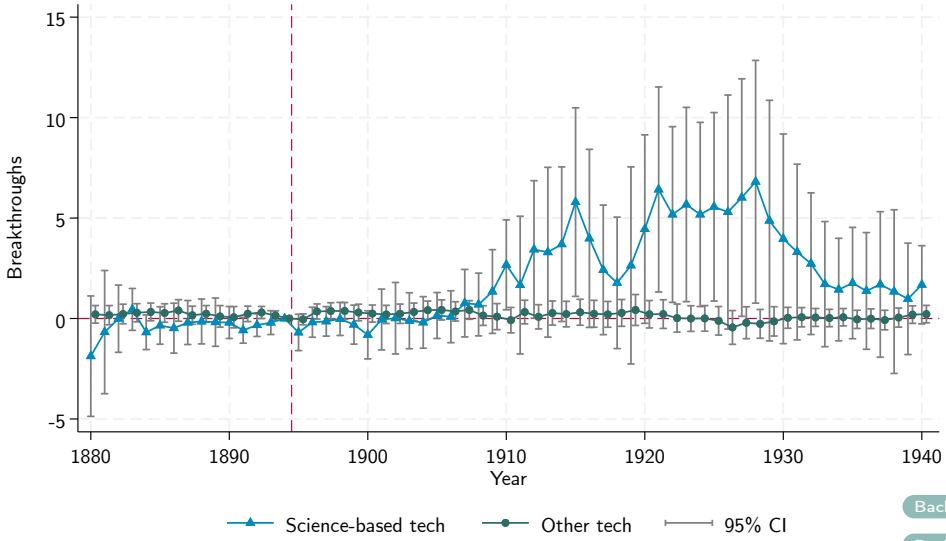
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Technologies active before 1895 benefit from GMW



Setup Patents
Back to Results

Technology-Level Event Study: Flat Pre-Trends



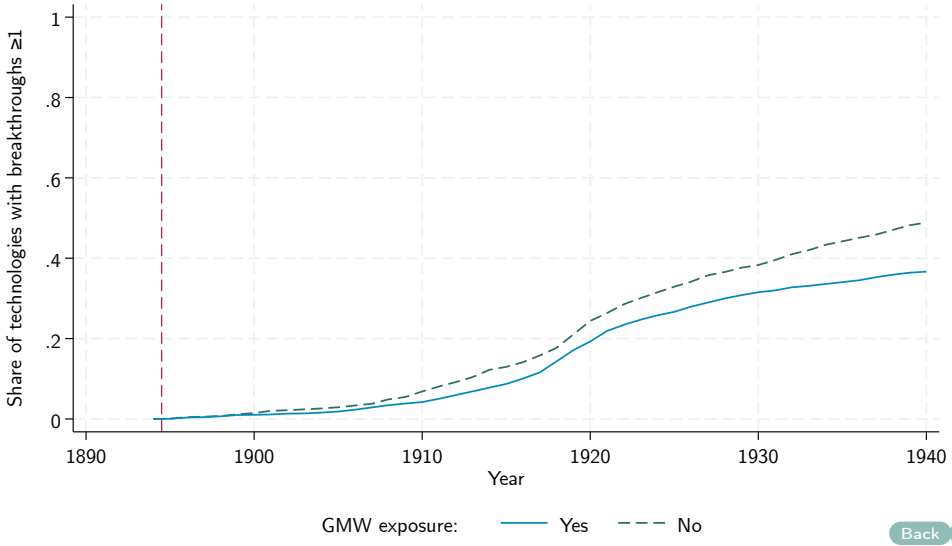
Back to Setup
Back to Results

Established Technologies: Full Results

Outcome:	Patents	Breakthroughs	Patents	Breakthroughs
Panel A: Overall Effect				
Post × GMW	1.139	0.374	0.881	0.360
	(1.664)	(0.267)	(1.649)	(0.260)
	[-2.126, 4.403]	[-0.151, 0.899]	[-2.354, 4.116]	[-0.149, 0.869]
Panel B: Heterogeneity				
Post × GMW × Science-Based	7.388	3.472	7.110	3.254
	(4.740)	(1.563)	(4.683)	(1.517)
	[-1.914, 16.690]	[0.405, 6.539]	[-2.079, 16.300]	[0.277, 6.231]
Post × GMW × Other Tech	0.162	-0.111	-0.093	-0.093
	(1.746)	(0.175)	(1.731)	(0.171)
	[-3.264, 3.587]	[-0.455, 0.234]	[-3.490, 3.304]	[-0.428, 0.242]
Excluding GMW firms	N	N	Y	Y
Year x CPC Section FE	Y	Y	Y	Y
Year x Vintage Tercile FE	Y	Y	Y	Y
Technologies	977	977	977	977
N	59,597	59,597	59,597	59,597

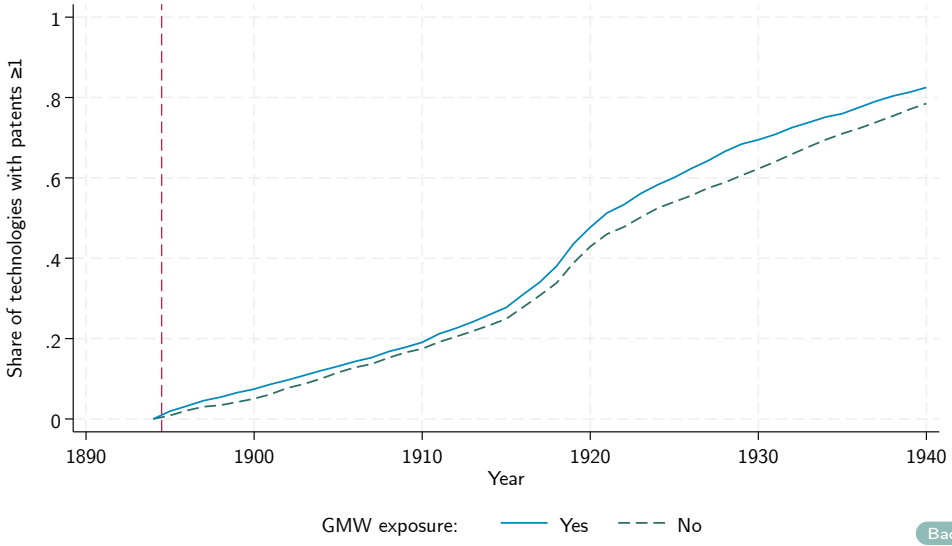
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(First) Breakthroughs delayed in emerging techs



Back Patents

(First) Patents not delayed in emerging techs



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Emerging Technologies: Robustness Checks

Outcome:	First Patent	First Breakthrough
Panel A: Overall Effect		
GMW	1.086	0.888
	(0.073)	(0.104)
	[0.952, 1.240]	[0.706, 1.116]
Panel B: Heterogeneity		
GMW × Science-Based	1.117	0.982
	(0.124)	(0.142)
	[0.898, 1.390]	[0.739, 1.303]
GMW × Other Tech	1.057	0.700
	(0.079)	(0.093)
	[0.914, 1.223]	[0.539, 0.909]
CPC Class FE	Y	Y
Groups	2,898	2,898
Subclasses	474	474
Vintage	N	N
N	84,109	109,995

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Net Effect: Full results

	Science-Based (1)	Other (2)	Total (3)
Established	10,874 (29.4%)	-2,321 (-5.4%)	8,553 (10.7%)
Emerging	5,206 (32.3%)	-713 (-28.5%)	4,493 (24.1%)
Total	16,080 (30.3%)	-3,033 (-6.7%)	13,047 (13.2%)

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Why Positive Effects in Established Frontier Tech?

- **Fast-moving scientific frontiers** create sustained competition
  - Chemistry, electronics: rapid scientific progress
  - "Neck-and-neck" competition despite consolidation
  - Difficult to establish lasting technological advantages

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- **Systematic R&D infrastructure** particularly valuable
  - Scale economies in laboratory equipment, specialized personnel
  - University-trained scientists, sustained research programs
  - Big Business uniquely positioned for these investments

Interpretation Back

Why Positive Effects in Established Frontier Tech?

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  - Scale economies in laboratory equipment, specialized personnel
  - University-trained scientists, sustained research programs
  - Big Business uniquely positioned for these investments
- **Knowledge spillovers dominate** business-stealing effects
  - Rising willingness to pay for external innovations
  - Technological races stimulate broader inventive effort
  - Strong knowledge interconnections across science-based domains

Interpretation Back

Why Delays in Emerging Tech Outside the Frontier?

- **More stable technological foundations**
  - Engineering, consumer products: incremental improvement
  - Less reliance on cutting-edge scientific discoveries
  - Slower pace of technological change

Interpretation Back

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- **Preemptive/defensive strategies** more effective
  - Easier to establish barriers to entry in stable domains
  - Patent thickets can block related technological development
  - Dominant firms may discourage disruptive innovations

Interpretation Back

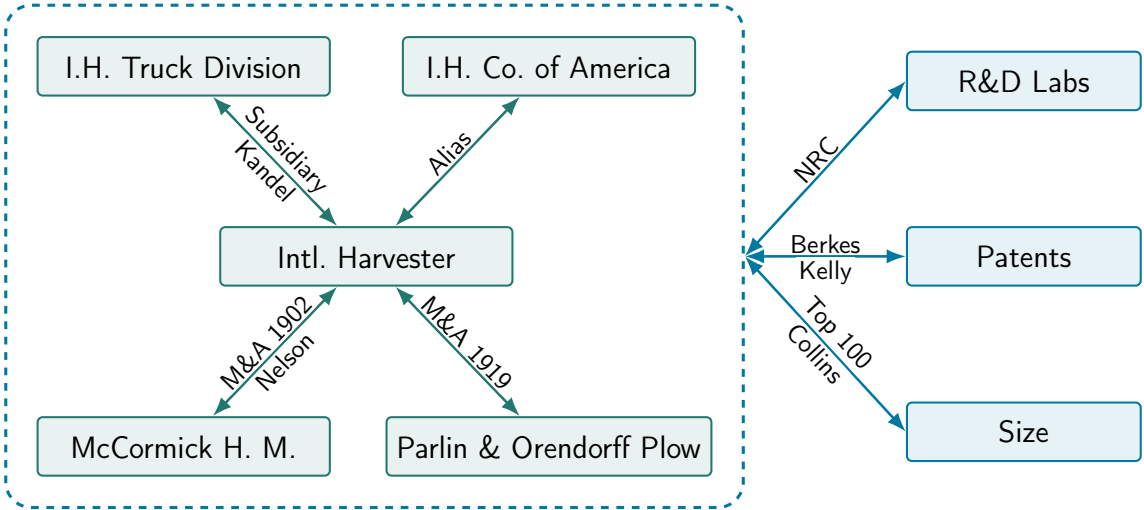
Why Delays in Emerging Tech Outside the Frontier?

- **More stable technological foundations**
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- **Preemptive/defensive strategies** more effective
  - Easier to establish barriers to entry in stable domains
  - Patent thickets can block related technological development
  - Dominant firms may discourage disruptive innovations
- **Limited spillovers**, business-stealing dominates
  - "Technological niches" with fewer knowledge interconnections
  - Reduced incentives for external innovation
  - Reallocation rather than net creation of inventive activity

Interpretation Back

Sources & Linking Overview

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Identification Approaches

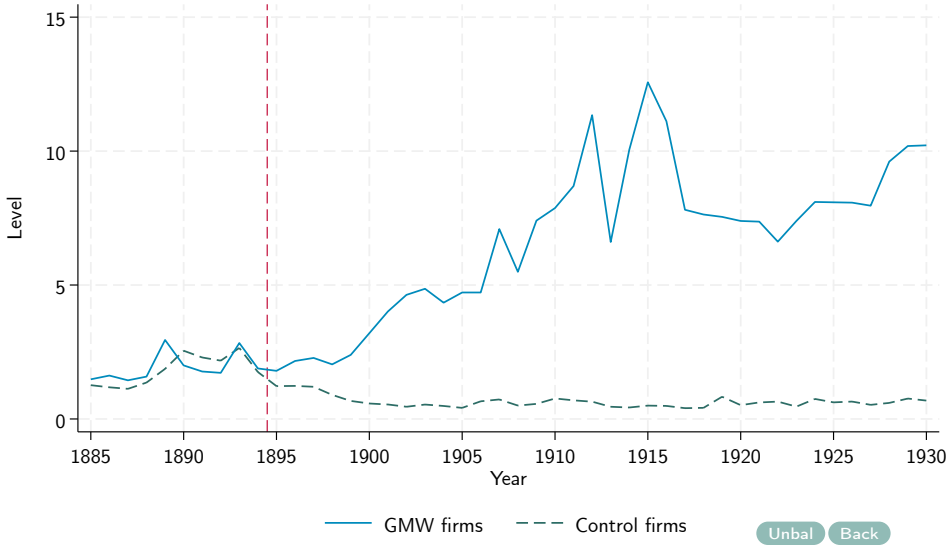
- Standard specification:

$$y_{itc} = \alpha_i + \delta_{tc} + \beta \cdot \mathbb{1}[t \geq 1895] \cdot \mathbb{1}[GMW\ \text{Firm}_i] + \varepsilon_{itc} \tag{2}$$

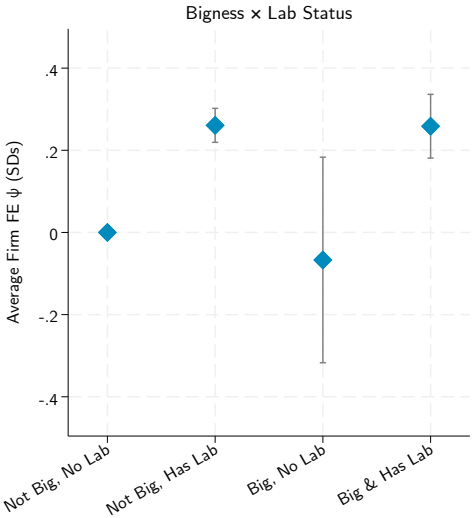
- Preferred approach: **Inverse probability weighting** (IPW)
  - Re-weight controls to match pre-1895 patent count distribution in treatment group
- **Alternative approaches** for robustness BMA
  - Placebo mergers More; Synthetic control More; SDID More

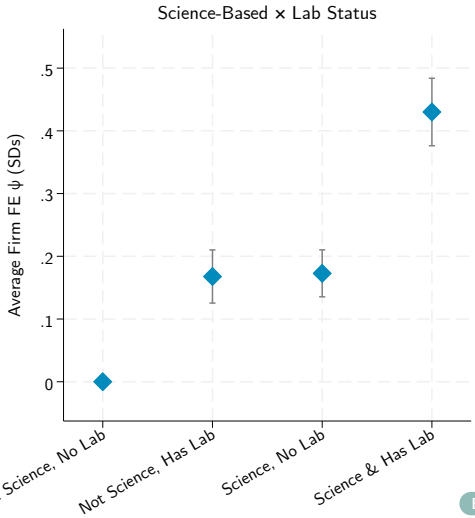
Three approaches | Matched setup | Intensive margin

Raw Patenting Levels (IPW)



Lab Premium Exists Within Bigness and Technology Classes





Back

Inventors Productivity Increases in Lab-Owning Firms

- Do inventors become more productive **after joining lab-owning firms**?
  - Sample: 14,000 inventors, 3+ years at non-lab firm $\rightarrow$ move $\rightarrow$ 4+ years at new firm
  - $\ln(1 + y_{itmc}) = \alpha_i + \gamma_t + \delta_m + \kappa_c + \sum_m \beta_m \cdot \text{RelTime}_{im} \cdot \text{ToLab}_i + \varepsilon_{itmc}$
- Inventors joining lab firms: **+0.12 log points** in quality-weighted output

ES Summary Back

Established Technologies: Difference-in-Differences

- **Sample**: 1,000 technology domains with patents before 1895
  - Exposure = any pre-1895 patents from firms that merged 1895-1904
  - Technology = size-balanced clusters of patent classes More
- **Empirical strategy**: compare exposed vs unexposed technologies Plot
  - Technology and year-by-tech area (9 CPC sections) FE; controls for technological vintage
- Identification relies on **parallel trends** within broad tech areas Event Study

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Emerging Technologies: Survival Analysis

- **Sample**: Classes (groups) with no patents before 1895 Plot
  - Exposure inherited from broader subclass
- Model **annual probability of activation** (hazard for first patent)
  - **Cox proportional hazards**:

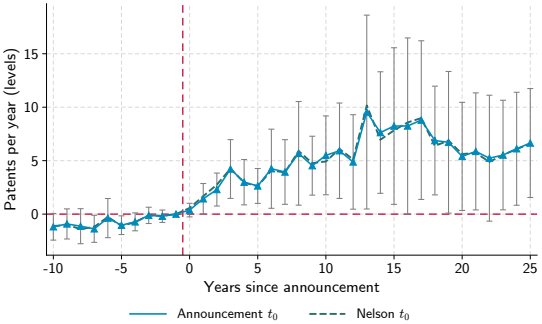
$$h_{gcs}(t|X_{gcs}) = h_s(t)\exp(\beta \cdot \text{GMW Exposed}_g + \delta \cdot \text{EarliestYear}_g + \theta_c)$$

  - Section-specific baseline hazards, class fixed effects
- Identification: **Within-class comparison** of exposed vs. unexposed subclasses

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Announcement Dates: Method

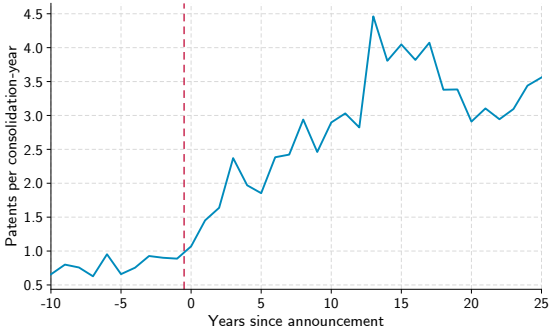
- Earliest public **announcement** of each deal, hand-collected from the *Commercial & Financial Chronicle*
  - 265 consolidations; **220 resolved** to day/month precision
- Lead over Nelson's incorporation date: **183 same calendar year**, 37 earlier; only 37/265 units shift a year in annual event time
- Censored / no-public deals **fall back to Nelson** (never dropped); results **indistinguishable** under either t_0



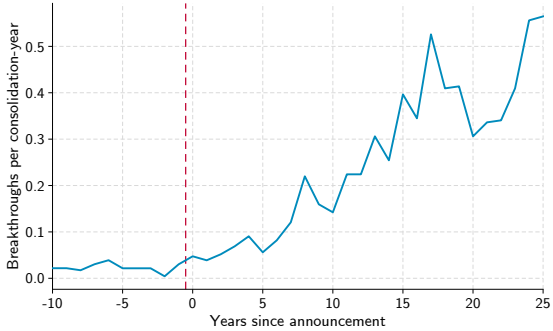
Intensive-margin S&A event study: announcement vs. Nelson t_0

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No-Control: Raw Announcement-Relative Means



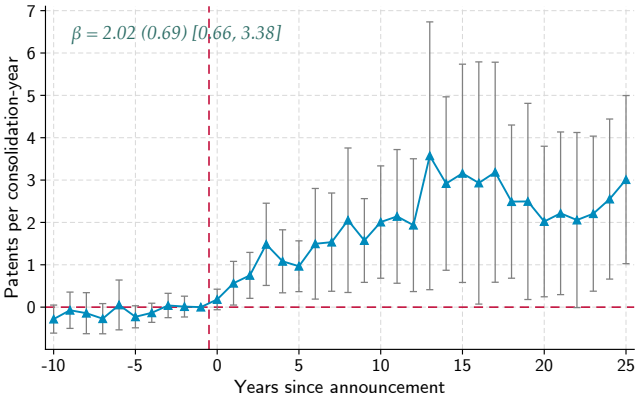
Patents per consolidation-year



Breakthroughs per consolidation-year

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No-Control Design: Why Not Sun–Abraham Here



With no never-treated units, Sun–Abraham has no clean comparison group and is not identified for this sample. The no-control relative-time object is therefore the within-firm (firm-FE) two-way fixed-effects event study shown here, read descriptively: patenting is flat before announcement and rises af

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Setup: Consolidated Firms' Own Trajectories

- **Sample**: the 232 consolidations that ever patent, tracked from their earliest public announcement; no control group (10,672 consolidation-year observations)
- **Specification**: within-firm event study

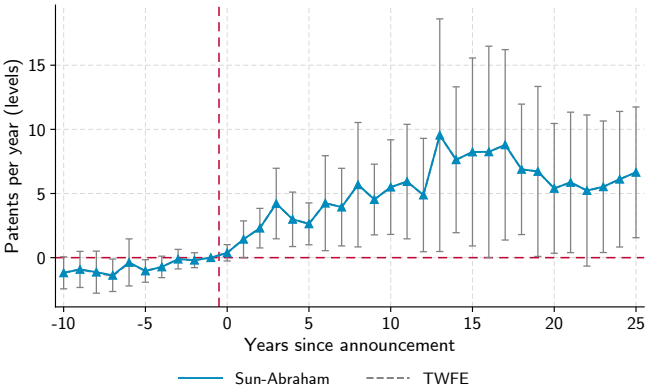
$$y_{it} = \alpha_i + \sum_{k \neq -1} \beta_k \cdot \mathbb{1}[t - t_0^i = k] + \varepsilon_{it}$$

  where α_i is a consolidation fixed effect and t_0^i is deal i's announcement year; standard errors clustered on the consolidation

- No control group and no weights; the object is descriptive, read as the firms' own pre-to-post path

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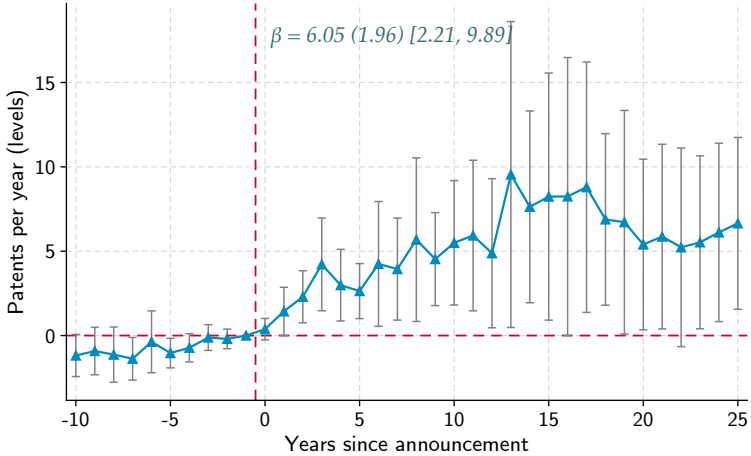
Sun–Abraham vs TWFE (Intensive Margin)



Near-coincident over the common support.

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Intensive Margin in Announcement-Relative Time (S&A)



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Data Collection: Abandoned Mergers and Announcement Dates

- **Candidate deals**: contemporary compilations (Watkins; Conant 1901; Moody 1904), net of Nelson's consummated deals, plus an abandonment-language search of the full *Commercial & Financial Chronicle*, 1890–1908
  - **263 candidates** screened down to a **pool of 30**
- **Fate verified** for every deal in digitized primary sources: CFC, *Iron Age*, Moody's Manuals, Dun reference books, NJ incorporation records, newspapers
- **Executed by large language model agents** under fixed search protocols, with three safeguards:
  - every dated claim backed by a machine-verified verbatim quotation
  - adversarial agents attempt to refute each coding
  - every inclusion, fate, and sample-selection call reviewed and decided by the author
- **Announcement dates**: earliest public announcement for all 265 consolidations and 30 abandoned deals, on one blind protocol symmetric across the two groups; an independent falsification pass is ≈**97 percent** accurate to within a quarter on the highest-risk units Back

Paper-Merger Selection Funnel

Selection step	Change	Deals
Consolidation candidates compiled, 1890–1908		263
less: consummated or durable combinations	−169	94
less: operated, then failed only later	−45	49
less: out of scope or not a merger	−4	45
Paper mergers (abandoned consolidations)		45
less: single-firm promotions (greenfield / single-patent / shell)	−7	38
less: retail / distribution rollups (out of scope)	−2	36
less: constituents recombined into a treated consolidation	−2	34
less: consummated or operating combine; duplicate attempt	−3	31
less: insufficient evidence on fate	−1	30
Control pool		**30**
of which: linkage sample (verified roster)		24
of which: descriptive-only (no verified roster)		6

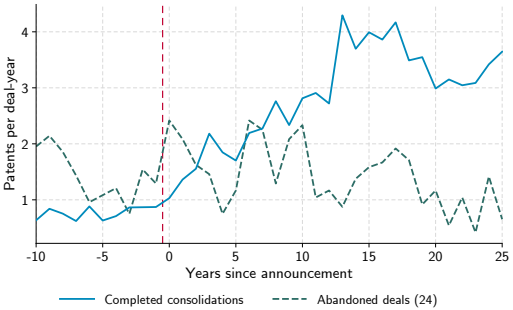
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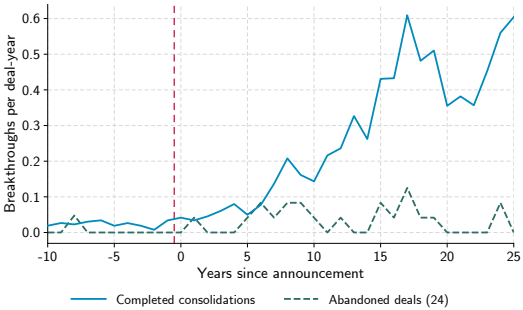
Paper-Merger Pool: Descriptives

Sample:	All Controls (1)	Linkage sample (2)	Descriptive only (3)
N	30 (100%)	25 (83%)	5 (17%)
Deal characteristics			
Year (median)	1900	1899	1902
Capitalization, $M (median)	10.5	10.0	18.0
Named constituent firms (median)	7	8	2
Cause of failure (identification role)			
Target holdout / refusal (lower bound)	10 (33%)	10 (40%)	0 (0%)
Exogenous shock (clean)	3 (10%)	3 (12%)	0 (0%)
Financing / promotion failure (upper bound)	12 (40%)	9 (36%)	3 (60%)
Unknown / silent (residual)	5 (17%)	3 (12%)	2 (40%)
Type of failure			
Aborted (explicit)	15 (50%)	14 (56%)	1 (20%)
Aborted (silent)	6 (20%)	5 (20%)	1 (20%)
Quickly undone	9 (30%)	6 (24%)	3 (60%)
Sector			
Mining & Natural Resources	2 (7%)	2 (8%)	0 (0%)
Food & Consumer Goods	9 (30%)	6 (24%)	3 (60%)
Chemicals & Materials	9 (30%)	7 (28%)	2 (40%)
Primary & Fabricated Metals	8 (27%)	8 (32%)	0 (0%)
Machinery & Electrical Equipment	1 (3%)	1 (4%)	0 (0%)
Transportation & Instruments	1 (3%)	1 (4%)	0 (0%)

By failure mode Disclosure Exit rule Back

Abandoned vs Actual Mergers: Announcement-Relative Descriptives





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Abandoned vs Actual Mergers: DiD Robustness

Specification	Post × Consolidated		Deals
Baseline (deal + event-time fixed effects)	+1.94	(0.88)	24
Sector × event-time fixed effects	+1.48	(0.71)	24
Excluding deals with weaker inclusion evidence	+1.91	(0.97)	20
Excluding the National Screw attempt	+1.49	(0.77)	23
Excluding the American Plow attempt	+2.06	(0.89)	23
Excluding the street-railway car attempt	+2.34	(0.80)	23
Excluding the three largest abandoned deals	+2.02	(0.65)	21
Excluding deals announced before 1895	+1.94	(0.93)	21
Excluding the National Saw consolidation	+1.95	(0.88)	24
Retaining post-acquisition consolidation years	+1.82	(0.85)	24
Nelson dating for completed consolidations	+1.94	(0.88)	24
Excluding constituents that publicly refused	+1.60	(0.77)	24

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Abandoned Deals: Disclosures

- **Concentration**: top-3 deals = 90.5% of the abandoned pool's patents; leave-top-3-out DiD = +2.02
- **d948 (National Screw)**: a denied 1899 rumor; disclosed, leave-out = +1.49
- **Brill** appears in both groups: the firm-level exit at its 1926 absorption partitions its firm-years exactly—no double-count
- **National Saw (hg4518)**: Nelson's 1896 is a re-charter; true consolidation 1890, caught by our announcement collection—flagged and left out

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Abandoned vs Actual Mergers: Exit Rule

- Standing rule, **symmetric across both arms**: a unit—completed or abandoned—exits the panel only on **loss of independence via absorption**, not on growth while independent
- Judged on our own evidence (CFC / Moody's / trade press), not on Nelson
- Keeps each unit's earlier years and the rest of its deal
  - Retaining the post-absorption years instead: DiD $= +0.99$ (0.94)—still positive

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Abandoned Deals: Deal-Level DiD by Failure Mode

Cause of abandonment	Deals	Patents	DiD: patents		DiD: breakthroughs	
Target holdout or refusal	9	1197	+1.76	(1.70)	+0.17	(0.08)
Exogenous shock	3	6	+2.18	(0.66)	+0.25	(0.06)
Financing or promotion breakdown	9	5	+2.02	(0.65)	+0.25	(0.07)
Unknown / silent	3	10	+2.02	(0.66)	+0.25	(0.07)
All abandoned deals	24	1218	+1.94	(0.88)	+0.22	(0.07)

Each row benchmarks the 265 consolidations against abandoned deals of one failure type (post $\times$ treated, deal and event-time FE; CRV1 SE). Patenting concentrates in the holdout / refusal deals (the conservative, lower-bound case). Very noisy and underpowered by design; the point is that the sign and $\sim$+2 scale are consistent across modes.

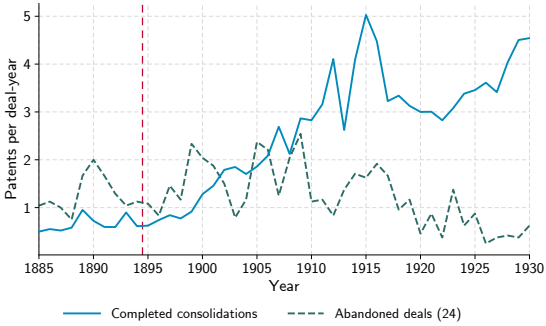
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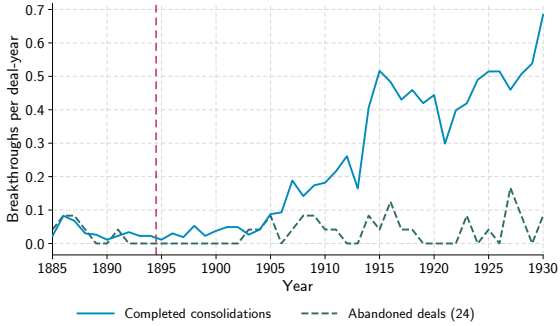
Federal Printing Ink: Full Record

- **Combine** (1899): ∼25 printing-ink makers into the Federal Printing Ink Co. (New Jersey charter, $20M authorized) — Geo. H. Morrill, Ault & Wiborg, Chas. Eneu Johnson, Sinclair & Valentine, Levey, Ullman, . . .
- **Cause of collapse**: the Geo. H. Morrill Co. (Boston) held out over the purchase price
  - Offered $625k cash + $1.875M stock; wanted $1M cash *(New England Stationer & Printer, 1899)*
  - *"refused to pay the price required by the Morrill company" (Fourth Estate, 1899)*
- **Never completed**: *"the Federal company has not as yet commenced operations"* without Morrill's consent *(Fourth Estate, 1899)*
- **Constituents stayed independent** and kept patenting — a documented target-side holdout (conservative, lower-bound case)

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Abandoned vs Actual Mergers: Calendar-Time Descriptives





Rel. time Back

Setup: Paper Mergers

- **Sample**: 265 completed consolidations and 24 abandoned "paper mergers" drawn from Nelson's worksheets, each deal's fate verified in contemporary sources (10,016 deal-year observations)
  - **Symmetric exit-at-acquisition**: a unit in either arm exits the panel once it loses independence through a later absorption
- **Specification**: dynamic difference-in-differences in announcement-relative time

$$y_{it} = \alpha_i + \gamma_k + \sum_{k \neq -1} \beta_k \cdot \mathbb{1}[t - t_0^i = k] \cdot \text{Completed}_i + \varepsilon_{it}$$

  where α_i is a deal fixed effect and γ_k an event-time fixed effect; standard errors clustered on the deal
- Patents use the Sun–Abraham estimator; breakthroughs use two-way fixed effects

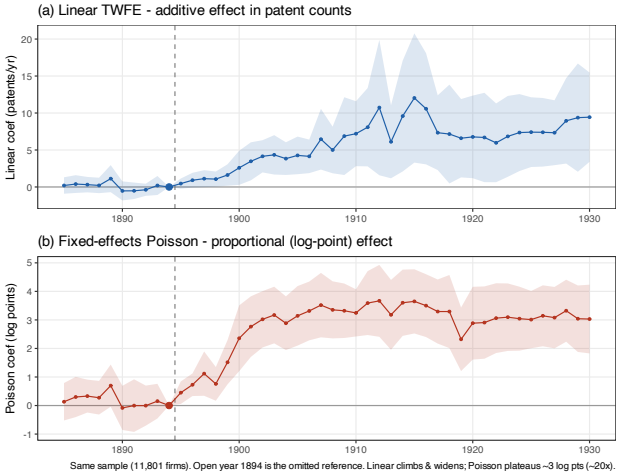
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The Consolidations: Descriptive Statistics

Sample:	All Firms (1)	Intensive Margin (2)	Extensive Margin (3)
N	265 (100%)	94 (35%)	171 (65%)
Consolidation Characteristics			
Year (median)	1900	1899	1900
Firms per consolidation	9.8	14.1	7.3
Total patents in 1885-1894	6.5	18.4	0.0
Same-technology firms (share)	–	85%	–
Initial market share			
>70%	36 (14%)	22 (23%)	14 (8%)
Between 40% and 70%	29 (11%)	22 (23%)	7 (4%)
<40%	17 (6%)	2 (2%)	15 (9%)
Not available	183 (69%)	48 (51%)	135 (79%)
Integration type			
Horizontal	132 (50%)	56 (60%)	76 (44%)
Vertical	24 (9%)	3 (3%)	21 (12%)
Mixed	10 (4%)	5 (5%)	5 (3%)
Not available	99 (37%)	30 (32%)	69 (40%)
Sector			
Mining & Natural Resources	34 (13%)	3 (3%)	31 (18%)
Food & Consumer goods	71 (27%)	18 (19%)	53 (31%)
Chemicals & Materials	37 (14%)	14 (15%)	23 (13%)
Primary & Fabricated Metals	57 (22%)	25 (27%)	32 (19%)
Machinery & Electrical Equipment	31 (12%)	20 (21%)	11 (6%)
Transportation & Instruments	23 (9%)	12 (13%)	11 (6%)
Not available	12 (5%)	2 (2%)	10 (6%)
Technological area (if ever patent)			
Science-based	47 (18%)	25 (27%)	22 (13%)
Engineering & Industrial	99 (37%)	47 (50%)	52 (30%)
Infrastructure & Consumer	40 (15%)	22 (23%)	18 (11%)
Not available	79 (30%)	0 (0%)	79 (46%)

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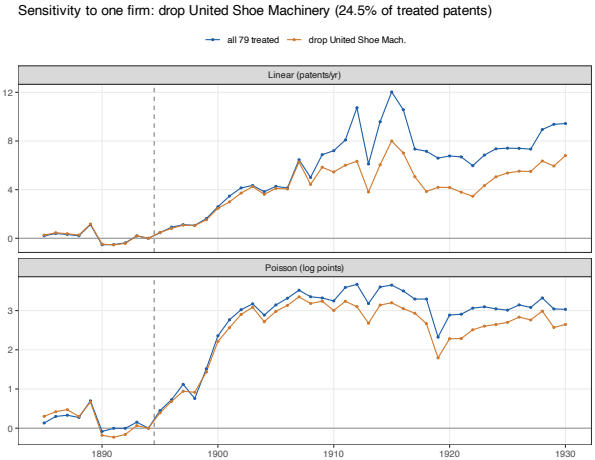
Poisson Confirms the Linear Result



Same sample (11,801 firms). Open year 1894 is the omitted reference. Linear climbs & widens; Poisson plateaus ~3 log pts (~20x).

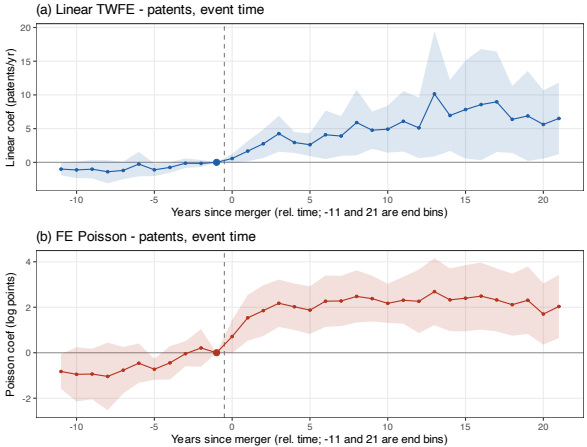
USM Pre-trend Back

Poisson: Leave United Shoe Machinery Out



Back

Poisson: Relative-Time Pre-Trend



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Product-Market Controls: Same-Niche Exclusion and Industry FE

- **Same-niche exclusion**: drop controls whose 1885–94 patenting falls (by majority) in the **largest pre-1895 CPC main group** of any consolidation $\rightarrow -7\%$ of controls
- **Industry FE**: every firm classified by **name** into 12 broad product markets (SIC-crosswalkable) $\rightarrow$ industry-by-year FE added to technology-by-year
  - Validation: 73% exact vs. Nelson SIC (29% modal benchmark); 80% blind re-classification audit; 79% vs. Moody's sections
  - Half of controls have uninformative names (person names) $\rightarrow$ excluded; same sample with baseline FE: 5.88 (vs. 5.99)
- Ladder: 5.99 $\rightarrow$ 5.98 (drop niche) $\rightarrow$ **5.69 (1.94)** (add industry FE); breakthroughs 0.56 $\rightarrow$ 0.56 $\rightarrow$ **0.57 (0.18)**

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Product-Market Controls: Estimates

	(1) Baseline	(2) Excluding same-niche controls	(3) Adding industry-by-year FE
Panel A: Patents			
GMW Firm	5.989	5.977	5.690
	(1.910)	(1.910)	(1.938)
	[2.245, 9.732]	[2.234, 9.720]	[1.891, 9.488]
% of treated pre-mean	310%	310%	295%
Treated pre-mean	1.929	1.929	1.929
Panel B: Breakthroughs			
GMW Firm	0.563	0.562	0.569
	(0.181)	(0.181)	(0.183)
	[0.208, 0.919]	[0.207, 0.917]	[0.211, 0.928]
% of treated pre-mean	536%	535%	542%
Treated pre-mean	0.105	0.105	0.105
Same-niche controls excluded	N	Y	Y
CPC section × year FE	Y	Y	Y
Industry × year FE	N	N	Y
# Treated	79	79	79
# Controls	11,722	10,858	5,369
N	542,846	503,102	250,608

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Robustness & Additional Results (Index)

- **Heterogeneity**:
  - Integration type More; Sector More; Business success More
- **Alternative identification** BMA
  - Placebo mergers More; Synthetic control More; SDID More
- **Sample & measurement**:
  - Exclude top/bottom 5% More; Horizontal only More; Unbalanced panel More
  - Same-niche exclusion & industry FE More
  - Relative time More; Filing vs issue year More
- **Benchmarks & estimators**:
  - Paper-merger robustness Table; Poisson vs. linear More; Ann. vs Nelson t_0 More
  - Sun–Abraham vs TWFE More; S&A truncation More

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The Plow Trust (American Plow Co.): Full Record

- **Roster** (22 firms, options held by U.S. Mortgage & Trust "pending the consolidation"):
  - Deere & Co., Deere & Mansur, Moline Plow, Rock Island Plow, Kingman Plow, B.F. Avery & Sons, Syracuse Chilled Plow, South Bend Chilled Plow, ...
- **Timeline**: announced 1899-05-13 (CFC: "the plow trust, $65,000,000"); NJ shell incorporated 1901-06-26 ($100k, to rise to ∼$75M — Judge Wm. A. Vincent, Chicago); Moline Plow option expires 1901; CFC 1902-09-27: *"the plan fell through"* (V. 75, p. 668)
- **Never completed**: zero operating mentions in the full CFC corpus 1890–1908; Moody's p. 478 classifies it as a paper trust
- **Constituents stayed independent**: Deere raises own stock $1.5M→$6M (1902); Moline Plow $4M→$6M (1906); Rock Island Plow $0.6M→$2.2M (1908)
- **Honesty notes**: collapse cause unrecorded (no-inference rule); largest patenter in the abandoned pool ⇒ leave-one-out battery shown Robustness

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Evidence from Lab Establishment: ψ_j up 0.5–0.6 SDs

- Compare firm-effect changes 1875–1904 vs 1905–1950:
  $\Delta\psi_{jc} = \delta_c + \beta\, OpenedLab_j + \gamma X_j + \varepsilon_{jc}$
  - Nets out **time-invariant** firm-level unobservables

	Outcome: Change in Firm FE $\Delta\psi$		
	(1)	(2)	(3)
Opened Lab	0.576	0.580	0.461
	(0.114)	(0.117)	(0.117)
	[0.352, 0.800]	[0.351, 0.809]	[0.231, 0.690]
Became Big	N	Y	N
GMW Firm	N	N	Y
CPC Section FE	Y	Y	Y
N	1,091	1,091	1,091

And inventors moving **to** lab-owning firms gain **+0.12 log points** in quality-weighted output.

Full table Mobility ES Back