Crisis Innovation

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Motivation and Research Question

- **How does a large economic crisis affect innovative activity?**

- Theoretically and empirically ambiguous
  - A large crisis can lead to substantial and persistent disruptions in innovation process: capital (Financial Crisis), labor market (COVID), and technological shock (1980s)
  - An economic crisis may create a window of opportunity to re-organize innovation process towards more efficient organizational forms (Schumpeter, 1942; Manso et al., 2019)

- We examine this question studying technology entrepreneurs and the organization of innovation in the aftermath of the **Great Depression**
  - Who wins/loses: technological entrepreneurs vs. large firms?
  - Did it accelerate or stagnate existing organizational shifts already occurring towards innovation produced in large firms?
  - Are the effects short-lived or persistent?

Empirical Design

- What role did the Great Depression have in affecting innovation?
- Use variation across counties (and within-states) in the intensity of the Depression
  - Baseline: we use county-level bank distress as proxy for local severity of the crisis
  - ”U.S. banking was highly localized, and thus vulnerable to geographically limited shocks (such as the agricultural depression)” (Bordo and James ’09)
  - Similar results using other proxy for the wealth shock (e.g. real estate values)
- Universe of US patents over 1900–2015
  - Create county-level patenting by technology entrepreneurs and firms
  - Measure impact of innovation with future patent citations
- Longitudinally matched inventor-Census matched data to examine who gets affected

Summary of Findings

1. Great Depression led to a large reduction in patenting by technology entrepreneurs
   - This reduction is highly persistent, lasting for next 70+ years!
   - Decline biggest among young and inexperienced inventors and lower cited-patents
2. Accelerated existing national shifts towards large firms
   - Relative *rise* in patenting among large incumbent firms in same regions
   - Bigger increase for same inventors with largest fall by technology entrepreneurs
   - Technology entrepreneurs move to patent within firms in these distressed areas
3. Disruption of local innovation ecosystem and equilibrium shift
   - Persistence largest in patents where firms have greater competitive advantage in terms of raising capital and managing complex technologies
   - Evidence suggests government response and/or migration played little role

Contribution

1. Large literature on economic consequences of the Great Depression, but no research on how technological entrepreneurship or the organization of innovation was affected
   - **Our contribution:** document the lasting effect of the Great Depression on independent inventors and its role in shifting of innovation into large firms
2. Small, but growing literature on how economic crises affect innovation (focuses on incumbent firms)
   - **Our contribution:** our new comprehensive patent data allow us to study the dynamic connection between innovation by technology entrepreneurs and incumbent firms in response to a crisis
3. Large literature on drivers of **innovation**
   - **Our contribution:** first to examine the role of an economic crisis in shaping organization of innovation and subsequent innovative activity in the (very) long-run
4. Literature on **entrepreneurship**: no comprehensive data exist prior to 1980s
   - **Our contribution:** offer first comprehensive and validated data on technological entrepreneurship spanning almost two centuries

Setting and Data

Innovation Inside vs. Outside Firms

- Two main organizational forms for innovation:

1. Firms
   - R&D and financing of innovation inside big firms
   - Patents assigned to firms
   - Commercialize innovation internally
   - Main organizational form today (87%–1990s; 22%–1900s)

2. Independent inventors (Lamoreaux, Sokoloff, 2005; Nicholas, 2010)
   - Financing of innovation by inventors themselves or local angel investors
   - Patents unassigned or assigned to inventor/other individual
   - Either sell patents to big firms or commercialize in own startups
   - Main organizational form 100 years ago (13%–1990s; 78%–1900s)
   - In modern data, high correlation with measures of business dynamism

- Unassigned patents are good proxy for “entrepreneurial” innovation Evidence

Firm Patent Example: General Electric's Light Bulb

A. SWAN.

INCANDESCENT LAMP.

APPLICATION FILED JUNE 7, 1905.

905,478. Patented Dec. 1, 1908.

Fig. 1.

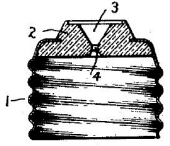
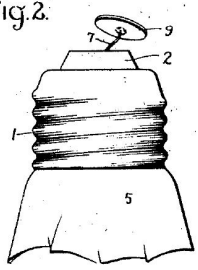


Fig. 2.



Firm Patent Example: General Electric's Light Bulb

UNITED STATES PATENT OFFICE.

ALFRED SWAN, OF NEW YORK, N. Y., ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

INCANDESCENT LAMP.

No. 905,478. Specification of Letters Patent. Patented Dec. 1, 1908.

Application filed June 7, 1905. Serial No. 264,078.

To all whom it may concern:

Be it known that I, ALFRED SWAN, a subject of the King of Great Britain, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Incandescent Lamps, of which the following is a specification.

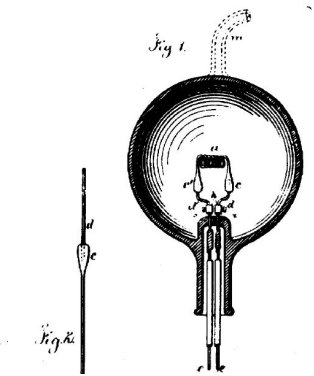
for connecting the leading-in wire to the under side of the center contact so that the solder does not show at all from the outside and connection is made with the contact direct and not through the solder used in connecting the leading-in wire thereto.

In accordance with my invention, I form

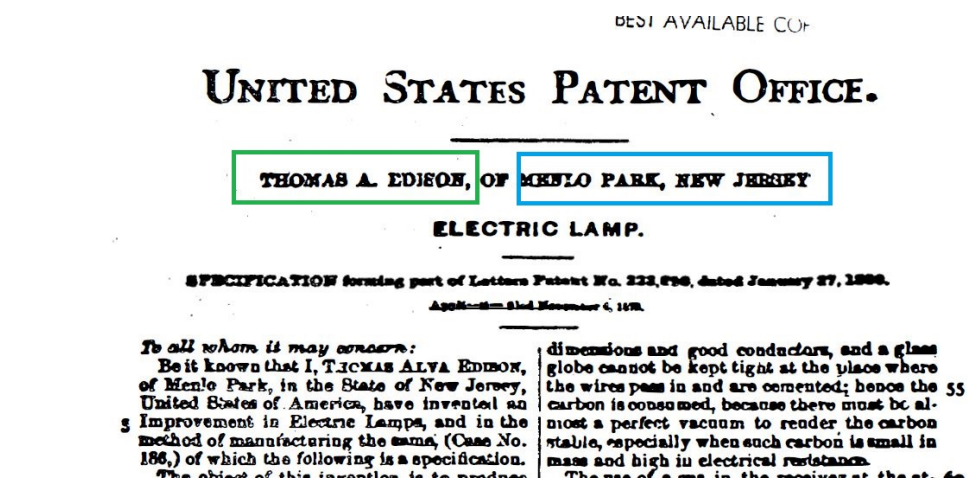
Independent Patent Example: Thomas Edison's Light Bulb

T. A. EDISON.
Electric-Lamp.

No. 223,898. Patented Jan. 27, 1880.



Independent Patent Example: Thomas Edison's Light Bulb



BEST AVAILABLE COPY

UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY

ELECTRIC LAMP.

SPECIFICATION forming part of Letters Patent No. 223,898, dated January 27, 1880.

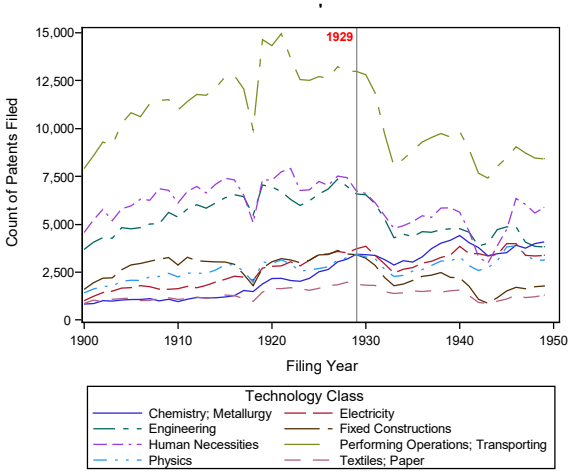
Application filed November 4, 1879.

To all whom it may concern:

Be it known that I, THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America, have invented an Improvement in Electric Lamps, and in the method of manufacturing the same, (Case No. 186,) of which the following is a specification.

dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed, because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass and high in electrical resistance.

Innovation around the Great Depression: Patents by Technology Class



Independent Inventors around the Great Depression

- Innovation by independent inventors was predominant in the early 20th century
- However, large (and persistent) decline around the Great Depression
- **Main explanations**: technological change
- **Alternative**: Crisis accelerated existing shifts for a variety of reasons
  - Financial disruptions: ”the obstacle to establishing these new firms was a shortage of risk capital” (Kenney 2011)
  - Cash hoarding: what Friedman and Schwartz (1963) coined a “contagion of fear”
  - Small biz: declines in their profits that funded entrepreneurship (Lamoreaux et al. 2009)
  - Labor: unemployment rates in excess of 20% (Margo, 1993)
  - Production goods: seizure from installment credit default (Olney 1999)
- Can’t definitively prove only one, but appears very likely access to capital (i.e. ”financial disruptions”) played an important role

Data Sources

- **Bank Distress**
  - FDIC Deposit Reports is annual *county-level* data, 1920–1936
  - Number of active & suspended banks and their deposits
  - *Bank Distress*$_c = 1$ if county has at least 1 suspension over 1930–1933
  - *Bank Distress*$_c = 1$ for 71% of counties
- **Patents**
  - Universe of USPTO-approved patents: 9 million over 1830–2015 (Berkes, 2016)
  - Filing and grant date
  - Inventors' name and their location, assignee's name (if assigned)
  - Citations by future patents: 1911–2015
  - Patent technology classification (e.g. electricity)
- **Complete count US Censuses of 1910, 1920, 1930, 1940**
  - Match 70% ($\sim$500K) of US inventors in 1905–1944 patents
  - Get demographic, geographic, and socio-economic data
  - Create longitudinal individual-level data over 1905–1944

Empirical Setting

Innovation and the Great Depression

- To examine the importance of this crisis, we exploit heterogeneity across counties in the severity of the Crisis
- **Baseline**: we use differences in bank distress. Why?
  1. Bank distress is a crucial dimension of the unfolding of the crisis (e.g. Bernanke, 1983; Gorton et al., 2019; Mitchener and Richardson, 2019);
  2. Suspension of banks should proxy areas with a larger contraction in wealth
- We find similar results with other proxy for local shock to wealth (e.g., real estate)

Difference-in-Difference around the Great Depression

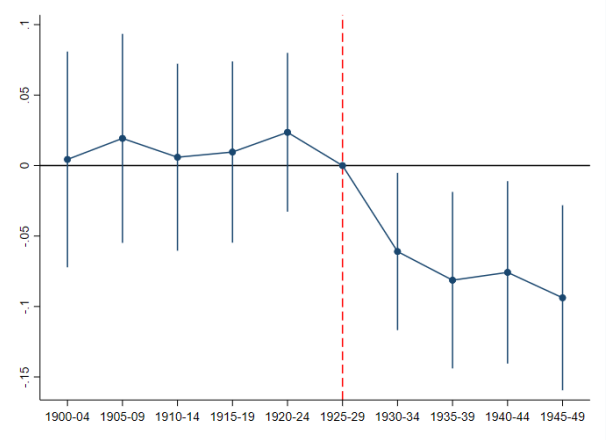
$$Ln(Innovation)_{cst} = \beta \textbf{Crisis}_{\textbf{c}} \times \textbf{Post 1929}_{\textbf{t}} + \lambda_c + \gamma_{st} + \gamma' X_{cst} + \epsilon_{cst}$$

- Indices: c – county, s – state, t – time (5-year or decade)
- *Innovation* – county-level patenting: all, firm, or independent
- *Crisis* – equals 1 if county has at least one suspended bank over 1930–33
- *Post 1929* – equals 1 for observations starting in 1930
- λ_c – county fixed effects
- γ_{st} – state-by-time
- X - controls (e.g., population)

The Great Depression Leads to Decline in Independent Innovation

Independent Patenting Drops Following the Great Depression

$Ln(\#IndependentPatents)_{cst} = \lambda_c + \gamma_{st} + \sum \beta_t \mathbb{1}_t Crisis_c + \epsilon_{cst}$, c-county; s-state; t-time



Independent Patenting Drops Following the Great Depression

Innovation most affected

- Young and inexperienced inventors
- Low impact patents (future citations)

Robustness

- Results driven by inventors who self-identify as entrepreneurs in Census data
- Robust to controlling for other confounding factors
- Consistent effect across technologies
- Robust to different shock definitions
- No decline in firm patents

GD Leads to Persistent Long-run Decline in Independent Patenting

Great Depression Accelerates the Shift of Innovation into Large Firms

Great Depression Accelerates the Shift of Innovation into Large Firms

- Noted previously: overall no effect on firms (hides heterogeneous response)
- Actual (relative) increase for large incumbent firms (column 4)
- Especially larger increase for inexperienced/young (not shown)
- Independent inventors more likely to patent within firms following the crisis (not shown)

	Ln(# Firm Patents)			
	(1)	(2)	(3)	(4)
Crisis X After1929	-0.034*	0.053*	-0.001	0.064**
	(0.020)	(0.028)	(0.016)	(0.027)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Firm Type	New	Incumbent	Small Incumbent	Large Incumbent
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.845	0.883	0.796	0.874
Obs	11,900	11,900	11,900	11,900

Why Innovation Changes Are so Persistent?

The GD Accelerates Aggregate Equilibrium Change

- Share of firm patents already rising in 1920s
- Competitive advantage in raising capital and managing complex technologies
- Consistent w/ what we find for persistence (below)
- No evidence of effects driven by government involvement or migration (not shown)

	Ln(# Independent Patents)			
	(1)	(2)	(3)	(4)
Crisis X After1929	-0.216***	-0.142***	-0.201***	-0.109***
	(0.029)	(0.026)	(0.030)	(0.023)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
LHS	High Fin. Dep.	Low Fin. Dep.	Solo Patent	Team Patent
Start Decade	1910	1910	1910	1910
End Decade	1990	1990	1990	1990
Adj R-Sq	0.849	0.831	0.860	0.772
Obs	26,775	26,775	26,775	26,775

Conclusion

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1. **Great Depression caused massive/persistent drop in technology entrepreneurship**
2. **Drove (relative) shift into (large incumbent) firms**
3. **Crisis acted as catalyst, not impediment, towards prevailing equilibrium**

Conclusion

"Depressions are not simply evils, which we might attempt to suppress, but . . . forms of something which has to be done, namely, adjustment to . . . change."

- Schumpeter (1934)

Thank you!