Crisis Innovation*

Tania Babina[†] Asaf Bernstein[‡] Filippo Mezzanotti[§]

June 2020

Abstract

The effect of financial crises on innovative activity is an unsettled and important question for economic growth, but one difficult to answer with modern data. Using a differences-in-differences design surrounding the Great Depression, we are able to obtain plausible variation in local shocks to innovative ecosystems and examine the long-run impact of their inventions. We document a sudden and persistent decline in patenting by the largest organizational form of innovation at this time—independent inventors. Parallel trends prior to the shock, evidence of a drop within every major technology class, and consistent results using distress driven by commodity shocks all suggest a causal effect of local distress. Despite this negative effect, our evidence shows that innovation during crises can be more resilient than it may appear at a first glance. First, the average quality of surviving patents rises so much that there is no observable change in the aggregate future citations of these patents, in spite of the decline in the quantity of patents. Second, the shock is in part absorbed through a reallocation of inventors into established firms, which overall were less affected by the shock. Over the long run, firms in more affected areas compensate for the decline in entrepreneurial innovation and produce patents with greater impact. Third, the results reveal no significant brain drain of inventors from the affected areas. Overall, our findings suggest that financial crises are both destructive and creative forces for innovation, and we provide the first systematic evidence of the role that distress from the Great Depression played in the long-run innovative activity and the organization of innovation in the U.S. economy.

JEL Classifications: G01, G21, O3, N12, N22, N32

Keywords: Great Depression, Business Dynamism, Innovation, Financial Crises, Startups, Angel financing

*The authors would like to thank Shai Bernstein, Charles Calomiris, Bill Collins, James Fenske, Alex Field, Christian Helmers, Taylor Jaworski, Chad Jones, Pete Klenow, Naomi Lamoreaux, Gustavo Manso, Kris Mitchener, Petra Moser, Ramana Nanda, Tom Nicholas, Bitsy Perlman, Tom Schmitz, Amit Seru, Ting Xu, Nicolas Ziebarth, and seminar participants at the Amsterdam Business School, Auburn University, University of Colorado at Boulder, Columbia Business School, Hass School of Business, 2019 HEC Workshop on Entrepreneurship, Michigan State University, 2019 Minnesota Junior Finance Conference, 2019 Labor and Finance Group, Northwestern University, Owen Graduate School of Management, Rutgers University, Stanford University, Tuck School of Business, 2019 UT Dallas Finance Conference, University of Virginia, and 2020 Virtual Economic History Seminar. All errors are our own.

[†]Columbia Business School; tania.babina@gsb.columbia.edu

[‡]University of Colorado at Boulder - Leeds School of Business and NBER; asaf.bernstein@colorado.edu

[§]Kellogg School of Management; filippo.mezzanotti@kellogg.northwestern.edu

"Many firms [of the 1930s] run by inventor-entrepreneurs were either acquired or driven out of business"

Landes et al. (2012)

"1929-1941 were, in the aggregate, the most technologically progressive of any comparable period in U.S. economic history"

Field (2003)

How do financial crises affect innovative activity? Are the effects short-lived or persistent? Theoretically, a crisis may create important setbacks in the production of innovation and a "missing generation" of highly productive entrants which could reduce business dynamism and growth (Hall 2015; Gourio et al. 2016). Alternatively, periods of economic duress may represent an opportunity to reshape innovation efforts towards more efficient organizational forms and higher-impact projects (Schumpeter, 1942; Caballero et al. 1994; Manso et al., 2019). Empirical evidence so far is mixed. Aggregate data show an increase in important innovations during the Great Depression (Field, 2003; Kelly et al., 2018). However, firm-level analysis suggests a decline in quantity (Nanda and Nicholas, 2014; Huber, 2018) and quality (Nanda and Nicholas, 2014) of innovation produced by firms that are more exposed to a crisis.[1]

The question of how a crisis affects subsequent innovation faces tough empirical challenges. First, the aggregate trends can be driven by factors unrelated to the Great Depression, and the firm-level evidence does not account for reallocation effects, which are the key driving mechanism in theoretical models. Moreover, empirical evidence is challenging to obtain in the modern period. Firm dynamics are slow moving (Luttmer 2012), making it generally difficult to evaluate a crisis without a sufficiently long time span following the event. Furthermore, current innovative activity, and especially technological entrepreneurship, is concentrated in just a handful of locations (Jaffe et al., 1993; Moretti, 2019), making it hard to find meaningful variation that could be used to cleanly identify the effect of a shock that can account for reallocation. By contrast, prior to the 1930s, innovation produced by independent inventors outside a traditional firm was the predominant form of patenting. As a result, pockets of technological entrepreneurship, supported by local capital and national markets for technology and patents, were ubiquitous across the U.S. (Lamoreaux et al. 2009). The relatively widespread distribution of entrepreneurial innovative activity within the US combined with a long period of time following the event makes the Great Depression an ideal setting to overcome modern empirical challenges in examining the long-run influence of crises on innovation.

[1]Researchers have also examined the partial equilibrium effects of economic distress on the productivity of inventor-employees (Bernstein et al. 2016) and found a decline in the innovation of employees exposed to housing shocks.

We provide two methodological contributions. First, we develop a new measure of technological entrepreneurship based on independent patenting, spanning more than a century. This enables us to study the drivers of entrepreneurship prior to the availability of modern data starting in the 1980s for the first time. Second, we use regional variation in economic distress in the aftermath of the Great Depression to examine the effect of crises on county-level technological entrepreneurship and overall innovative activity. There are two key benefits to this approach. County-level analysis allows us to capture local reallocation effects, and significant regional variation in bank distress during the Great Depression allows us to empirically measure the impact of the crisis on local innovation (Calomiris and Mason, 2003). We use a differences-in-differences design by exploiting county-level variation in bank suspensions in the early 1930s, which are a proxy for local economic distress, and by comparing changes in innovation across counties. Our specification also includes state-time fixed effects to flexibly control for contemporaneous changes in state-level policies and local business cycles.

We document that the local disruptions from the crisis predicted a sudden decline of more than 10% in patenting by technological entrepreneurs, but no aggregate local effects on firm patenting. Combining these two margins, the shock led to an overall local decline in patent production which cannot be explained by aggregate national factors since regional variation in innovation allows us to control for any aggregate or regional changes associated with patenting (e.g., technology, regulation, costs of incorporation). Parallel trends prior to the shock, no reduction in firm patenting, evidence of a drop within every major technology class, and similar results using alternative shocks based on variation in local property values induced by the commodity price boom and bust related to WWI (Rajan and Ramcharan, 2015)—all suggest that the effects are causal.

Even though the crisis itself was relatively short-lived, the effects on technological entrepreneurship appear to be permanent—lasting for every decade for the next 80 years. This long-term decline is quite different from Nanda and Nicholas (2014) who find that the quantity and quality of patenting by firms operating in more distressed counties converged to the level of firms in less stressed counties by the end of the 1930s. Therefore, even if distress from the Great Depression were only a catalyst for changes already on the horizon, this lack of "catching-up" by distressed counties suggests that the shock had important distributional effects. This evidence of persistence and the lack of "catching-up" by distressed counties is consistent with the idea that large shocks can lead to equilibria shift in the organization of innovation: the reduction in activity by technology entrepreneurs may have led to a dissolution of other important aspects of the local ecosystems, such as funding networks or patents agents, that help facilitate the innovation process (Lamoreaux et al., 2006). Such systems/networks can exist as an equilibrium, but also devolve into equilibria where patenting moves into firms when faced with disruptions to entrepreneurial activity (Aghion and Tirole 1994, Gromb and Scharfstein 2002, Hellmann 2007). For example, while many regions in the U.S. would love to develop into Silicon Valley, perhaps not surprisingly, moving to an equilibrium where the local environment supports that sort of technological entrepreneurial activity is not trivial.

The finding of a substantial and persistent decline in patenting by independent inventors is concerning for innovative activity since independent innovation was a major source of new technologies in the early 20th century. Lamoreaux et al. (2009), Nicholas (2010), and Akcigit et al. (2017) have all noted that the average quality and impact of these patents were higher than for the average firm patent. In fact, more than one-third of independent patents filed at this time were cited by patents filed more than 50 years later (Lamoreaux et al., 2009). Given these findings, one might naturally conclude that crises are purely destructive forces for innovative activity. However, despite the negative effects on independent patenting, additional analysis suggests that innovation was more resilient than it might appear at first glance.

First of all, the average quality of surviving patents rises so much in the distressed regions that there is no observable change in the aggregate future citations of these patents, in spite of the decline in the quantity of patents filed. Consistent with this finding, we also document that average quality of independent inventors' patenting actually increased over the period and high quality patent were mostly unaffected. Secondly, the shock is in part absorbed through a reallocation of inventors into established firms, which overall were less affected by the shock. We document this by building a longitudinal inventor-level panel linking inventors across four decennial full count US Censuses. We show that among serial inventors—those with patents both before and after the Great Depression—those in regions with bank distress were more likely to transition into firms. In the short-run, firms show little changes in the quality of their innovation, measured through total or average future citations, but over the long run, firms in more affected areas compensate for the decline in entrepreneurial innovation and produce patents with greater impact—perhaps driven in part by this influx of high-skilled human capital. Third, the results reveal no significant brain drain of inventors via out-migration from the affected areas. This is surprising, given some evidence of relatively high mobility among inventors in this time period (Akcigit et al. 2017 and Sarada et al. 2019). However, the null result of distress on inventor geographic mobility coupled with the increased mobility of independent inventors into firms suggests that obtaining paid employment was preferable to bearing the costs of geographic reallocation.

With regard to the mechanisms, a variety of tests show that our results are not driven by the decline in local demand. For example, the growth in local retail sales during the Great Depression—the key variable used to measure local demand shocks (Fishback et al. 2001)—does not predict significant changes in local innovation. Instead, the results are more likely explained by the link that bank distress had to local financing. On the one hand, this channel may not be surprising since sources of capital for developing innovation were local, but secondary markets for technology and patents were national in scope (Lamoreaux and Sokoloff 2001a). On the other hand, this result may appear puzzling, because banks themselves weren't the dominant direct source of capital for independent inventors (Lamoreaux et al. 2006).

One possible explanation is that the contraction in banks activity is connected to a reduction in the amount of capital that is available to local investors in new ventures. As suggested by previous research (Lamoreaux et al., 2006), and as is often the case for entrepreneurs today, independent inventors relied heavily on local wealthy individuals and local networks to raise the capital that was necessary to develop and bring to market their technology. In that period, distress in the local banking sector was intimately tied to the fortunes of local wealthy investors by reducing the ability of these individuals to invest directly in new technological ventures and perhaps permanently disrupting these networks. Consistent with this narrative, using a unique data on private filings in Illinois firms in the pre-Depression period, we show that local investors were indeed a key source of funding for early-stage tech companies. Furthermore, we provide evidence that wealthy investors were generally highly exposed to shocks to local markets, and in particular to real estate.

Building on this idea, we also show that shocks to proxies for local real estate wealth also appear to predict changes in technological entrepreneurship as well as increased bank distress. Following Rajan and Ramcharan (2015) and Jaremski and Wheelock (2018), we exploit variation in local property values induced by the commodity price boom and bust related to WWI, and we replicate our main findings on both quantity and quality of innovation. This evidence is consistent with the wealth of local capital playing a critical role in the shift in organizational form caused by the Great Depression. Furthermore, the use of shocks in commodity prices following WWI, instead of bank distress in the early 1930s, also provides additional evidence that our overall findings are not driven by reverse causality.

Overall, our findings suggest that financial crises are both destructive and creative forces for innovation, and we provide the first systematic evidence of the direct role distress from the Great Depression, rather than technological change or regulation, played as a catalyst for long-term changes in innovative activity in the U.S. history. We next discuss our results within the context of existing literature.

1 Existing Literature

Our results complement and help reconcile a growing literature examining the effects of large economic shocks on innovation. Nanda and Nicholas (2014) show that among firms owning R&D labs prior to the Great Depression, bank distress had negative effects on their innovation in terms of both quantity and quality of patenting, especially for firms operating in industries that were more dependent on external finance.[2] On the surface, these results seem in contrast to evidence in Field (2003) and Kelly et al. (2018) who emphasize the aftermath of the Great Depression as an era of incredible technological progress and innovation. Nanda and Nicholas (2014) provide some reconciliation by suggesting that it was only R&D firms operating in capital-intensive industries that were disproportionately affected, since they do not find that bank distress affected innovation of firms with lower levels of capital requirements. Our paper helps to provide additional reconciliation between these findings.[3] In particular, we find that organizations more dependent on external finance, in our case independent inventors, experienced a much larger decline in the quantity of patenting in regions with bank distress. However, while Nanda and Nicholas (2014) find a matching reduction in the quality of the firms' innovation, we find exactly the opposite among independent inventors. Furthermore, we also find evidence that even the overall decline in patenting quantity in areas with more distress was, at least partially, offset in the long-run by a transition of innovation into firms. These cross-organizational migrations help explain our findings on the relatively muted local aggregate response by firms, despite observed declines in Nanda and Nicholas (2014) at the established firm level, and the rise in the quality of surviving innovation consistent with Kelly et al. (2018). In that respect our findings are supported by Lamoreaux et al. (2009) who shows specific instances when distress from the Great Depression led to shifts of recent potential technological entrepreneurs, graduates of Case Western

[2] Huber (2018) finds similar firm-level effects on patenting rates during the Financial Crisis by exploiting variation in German firms' exposure to a large bank's lending cut. He does not look at citations.

[3] To the extent that independent inventors are entities particularly dependent on external financing, our results are consistent with Nanda and Nicholas (2014) and therefore extend their mechanism also beyond traditionally defined established firms. However, independent inventors cannot simply be considered a special type of established firm. Similar to today's start-ups, independent inventors were organizations distinct from established firms that differed from them in terms of strategy, funding methods, and scope. So perhaps not surprisingly, we find some critical differences in the response of independent patenting from those for established firms in Nanda and Nicholas (2014).

University, into firms.

While modern patenting is dominated by within-firm advancements, that organizational structure of innovation is neither historically ubiquitous (Nicholas, 2010; Kenney, 2011; Landes et al., 2012) nor clearly theoretically dominant (Aghion and Tirole 1994; Gromb and Scharfstein 2002; Hellmann 2007). In our main analysis, we focus on the overall innovative activity by independent inventors. During this period, independent inventors are in many dimensions akin to technology entrepreneurs today (Lamoreaux and Sokoloff 2001b; Nicholas 2010). In fact, similar to start-ups today, independent inventors were early-stage organizations that developed new technologies in order to raise money either from external investors or sell the technologies to larger firms. Importantly, independent inventors—both quantitatively and qualitatively—were not minor players in this space, but were at the forefront of the technological frontier of the time and, by many metrics, the largest organizational form of innovation at this time (Nicholas 2010). In this context, we think of this analysis as speaking to the extent to which local financial distress can affect long-run business dynamism. This is a concern that has grown in interest following declines in new firm entry (Bassetto et al., 2015; Siemer, 2016; Moreira, 2016), slow-downs in technological advancement, (Hall 2015), and declines in productivity (Duval et al., 2020) in the aftermath of the Great Recession. These sorts of concerns in the fallout from major financial crises are not new however. In fact Schumpeter (1942) considers just such a decline in economic growth driven by the decline in independent inventors following the Great Depression.

In this regard, this paper contributes to our understanding of how economic crises can affect the allocation of resources in the economy. Caballero et al. (1994) have formalized and extended a long argued point that recession could have positive effects by fostering "creative destruction" and therefore helping the reallocation of investment towards more productive use. In fact, even more generally than just "liquidationist-style" arguments, such crises could cause an overall shift in organizational form or in the incentives for existing inventors, which alter the impact of surviving patents (e.g. Gromb and Scharfstein 2002). Our evidence is consistent with these types of mechanisms. In fact, our results suggest that while periods of severe and prolonged financial distress may cause declines in the quantity of patents filed by start-up like enterprises, innovation as a whole appears to be quite resilient. In contrast to prior research looking at large and established firms, we show a rise in allocative efficiency towards higher quality inventions and a shift in the organizational form of innovation production.

Our work contributes to the debate on the role that the disruptions to the financial system played in instigating the Great Depression, and its consequences for economic outcomes. Economists have typically focused on the effects of monetary policy (Friedman and Schwartz (1963); Richardson and Troost (2009); Gorton and Metrick (2013)), demand declines (Temin et al., 1976; Romer, 1993), international flows (Eichengreen, 2004), shocks to productivity (Cole and Ohanian, 2007), and bank lending amplifiers (Bernanke, 1983; Gorton et al. (2019)). In many ways, the Great Depression has been extensively used as a laboratory to examine the real effects of banking shocks (e.g., Ziebarth 2013), and we add another component to that discussion—the effects on innovation. The Great Depression represents one of the most severe financial crises in the history of the United States, with a third of US banks suspended and US gross domestic product falling by 26%. Recent empirical work has shown that bank failures had large negative effects on income growth (Calomiris and Mason, 2003), business revenues (Ziebarth, 2013), business failures (Babina et al., 2017), and employment (Benmelech et al., 2017; Lee and Mezzanotti, 2017). We document that there were also clear effects from local distress on technological entrepreneurship. Unlike most of the prevailing literature though, we also document a "bright side" to the Great Depression in the form of creative destruction. Our findings complement recent work by Manso et al. (2019) suggesting some forms of creative destruction and exploitative innovation during economic downturns. Also, a broad literature shows that immigration (e.g., Kerr and Lincoln, 2010, Moser et al., 2014), taxation (e.g., Akcigit et al. 2017), intellectual property laws (e.g., Moser, 2005), and exposure to innovation (e.g., Bell et al., 2019) can alter innovation, sometimes in surprising ways, and our findings on the dark and bright side of crises adds another important factor to consider in the drivers of innovation.

2 Historical and Institutional Background

2.1 The Organization of Innovation in the Early 20th Century

In the early 20th century, US innovation was in large part created within two main organizational forms: the R&D labs of established firms and independent inventors. While the boundaries between these two types of organizations may have been blurry in some dimensions, there are several aspects in which these two organizational forms differed substantially. First of all, the way they finance themselves was quite different. In general, independent inventors funded themselves in large part using their personal resources or raising equity financing from local wealthy individuals who played a role similar to modern angel investors (Lamoreaux et al. 2009; Nicholas 2010). In the quest for new financing, inventors were relying heavily on the connection they could obtain through local bankers and businessmen (Lamoreaux et al. 2006; Kenney 2011). Importantly, in this market financing was inherently linked to a specific project or business idea (Lamoreaux et al. 2006; Lamoreaux et al. 2009).

In contrast, the financing of innovation by established firms—as is the case for most modern companies—was less dependent on the local networks of investors. While an exact quantification is difficult to achieve, it is generally accepted that a large part of established firms' R&D investments were covered by internally generated cash flows (Hall and Lerner, 2010). At the same time, firms raised funding through a variety of mechanisms, such as the sale of equity securities (Nicholas 2008; Lamoreaux et al. 2009), issuance of bonds (Jacoby and Saulnier 1947; Babina et al. 2017) or borrowing from banks (Nanda and Nicholas, 2014). These sources were generally used to fund more traditional corporate activities (e.g. working capital, tangible investment), but access to these markets—by affecting the general financial condition of a company—could have had implications for innovation decisions.

The second key distinction between the two organizational forms was their business objectives and strategies. On the one hand, firms operating R&D labs were primarily interested in commercializing the technology directly, either by creating new products or integrating the new technology into their pre-existing portfolios. On the other hand, independent inventors did not generally have a pre-existing product base. For them, the development of a new technology was meant as either a step to raise financing to start a business or to monetize the technology through the sale of a patent or its licensing.

In this context, there are two important things to point out. First, while the financing of startups was in large part local, the markets for technology were already national (or at least regional) by the beginning of the 20th century (Lamoreaux et al. 2006, 2009). This dimension is going to have important implications for our empirical analysis. Second, in comparing independent inventors and firms we need to understand the dynamic connection between the two organizations. While not every independent inventor is aiming to establish a firm, some of them will eventually turn their organization into an established firm. One implication of this process is that patenting activity by independent inventors will always capture innovation happening outside traditional firms. However, we recognize that our categorization is inherently imperfect, since we may categorize patenting made by early-stage enterprises as firms' activity, despite in practice this enterprise resembling more independent inventors than an established firm.

When discussing independent inventors, it is important to highlight how this organizational form was quantitatively very important during the early part of the century. For instance, Nicholas (2010) show that in the 1920s 70% to 80% of all U.S. patents were attributed to independent inventors. At the same time, independent inventors were also important from a qualitative standpoint. Historically, some of the most impactful inventions were initially developed by independent inventors. Lamoreaux et al. (2009) and Nicholas (2010) find that over the 1900–1929 period, independent patents were, on average, higher quality than firm patents, as measured by future citations and the number of claims in the patent text. For example, Lamoreaux et al. (2009) show that 33% of a random sample of patents filed over 1928–1929 are cited by patents filed over 1975–2000 in the NBER patent data. This number is higher for independent patents (36% receive future citations) and lower among patents filed by firms with R&D labs (25 to 30%).[4] This evidence is consistent with the results in Kelly et al. (2018), who show that between 1930 and 1950 independent inventors represented a substantial share of breakthrough patents.[5]

In light of these distinctions, there is a strong parallel between independent inventors in the early 20th century and technology entrepreneurs or start-ups in modern days. From a financial standpoint, they both heavily rely on external early-stage local investors as a key source of financing, at least after an initial phase of self-financing and bootstrapping. In this regard, as in the early 20th century, personal contacts and local investors' networks are still key for the process of raising funds (Shane 2008; Bernstein et al. 2016; Gompers et al. 2019).[6] Moreover, the core investment thesis for both independent inventors in the 1920s and modern technological entrepreneurs is fairly similar: modern start-ups—similar to independent inventors–are focused on the development of a new technology with the objective of either selling the technology to an established company or raising financing to commercialize the product internally. Lastly, in both cases these organizations are an important engine for the development of new ideas and technologies.

Therefore, while it is undeniable that several aspects of the organization of innovation have dramatically changed over the past century, it is also the case that the key economic features through which both firms and technology entrepreneurs operate have remained surprisingly stable. This parallel implies that a study of independent inventors may provide insights that can be useful to understand the process of innovation today. Furthermore, this also suggests that measuring the activity of independent inventors at

[4]Similarly, independent patents have an average of 35 claims, while patents by firms with R&D labs have 2 to 20 claims, depending on firm size.

[5]Technically, their paper only focuses on unassigned patents. As it will be clear in the data section, this definition is consistent with the one used in our paper to define independent inventors, but slightly more restrictive.

[6]In this regard, the key difference is that the financing of early stage enterprises today is relatively more institutionalized, because of the creation of organized angel groups (Kerr et al., 2011) and the growth of venture capital organizations (Ante, 2008; Kenney 2011).

the local level could also proxy for the vitality of the local innovative environment. In modern data, the dynamism at local market has been usually examined by looking at the amount of economic activity that is undertaken in technology start-ups (e.g. Guzman and Stern, 2016) or young firms more broadly (e.g. Haltiwanger et al., 2012). Similarly, a measure of technological entrepreneurship based on independent inventors captures the extent to which technology is developed outside of more mature firms. As such, the measure allows us to study drivers of entrepreneurship over a very long time horizons and, for the first time, uncover the dynamics of entrepreneurial development across the US before the modern US Census data on new firms became available in the 1980s. Moreover, fine regional variation in patent data allows us to control for any aggregate or regional changes associated with patenting rules or other changes.

We perform two sets of analysis to examine whether our new measure of entrepreneurial activity is correlated with entrepreneurship rates in current data when both are available. Figure A.1 shows that independent innovation rates are correlated with the rates of employment in young (0-3 year old) firms. Moreover, we find a sizable correlation (0.5) between the county-specific rates of patents produced by independent inventors and employment in 0-3 year old firms, providing support for the alternative measure which is available to us during the period we study.

2.2 Innovation during the Great Depression

The Great Depression was the largest financial crisis in U.S. history, with almost a third of all banks suspended and a real GDP decline of 26% (Margo 1993; Richardson 2007). The concurrent disruption of banking activities and real economic growth were more than just coincident. At this time, financing was a more localized affair because of regulatory and technological constraints (Nestor 1992; Mitchener and Wheelock 2013). When banks failed, this caused massive disruptions in the ability of local firms to obtain financing.

To motivate the discussion, Figure 1 shows that the decline in annual patenting happened within virtually all major technology classes right around the Great Depression. Moreover, while there is some evidence of decreased innovation in established firms that are more exposed to the crisis (Nanda and Nicholas, 2014), it is not clear to what extent the aggregate decline could be driven by firms vis-a-vis independent innovations. To start examining this issue, we plot in Figure 2 the number of patents by independent and firm inventors in the first half of the 20th century. This figure shows that, while independent inventors accounted for the majority of patenting in the 1920s, this changed quickly around the Great Depression. In particular, the number of patents filled by independent inventors felt by almost 50% during the years of the Depression. As a result, patents by independent inventors were surpassed by patents filed by companies. This shift was also persistent, with independent inventors never catching back up to firms. The long-term decline in innovative dynamism in our data, which are based on all US patents, corroborate the findings of Nicholas (2010), who uses decennial data on sub-sample of US patents.

Clearly, there could be several explanations for these trends. One commonly held view is that this shift reflects a change in the nature of technologies developed during this period (Teece David 1988; Hughes 2004; Lamoreaux and Sokoloff 2005). In particular, as the process of developing and using technologies became more capital intensive and complex, firms became a relatively more efficient organizational form. For this argument to hold, the standard assumption is that firms—for both institutional and economic reasons—are in a better position to finance larger investments over long periods of time. Consistent with this argument, Figure 2 shows that the decline in independent patents starts before the Great Depression.

However, the aggregate trends can be driven by factors unrelated to technology. Moreover, this simple hypothesis fails to explain the full dynamics of the contraction in independent inventors' patenting during this period. Since it is not likely that technological shocks occurred across all industries nearly simultaneously (and concurrently with the Great Depression), an explanation that is only technology-based will likely fall short to rationalize all of the contraction in independent patenting. Clearly, we are not claiming that technology considerations were not important to understand the decline. Instead, we are simply highlighting how a more complete theory requires something else to understand the sudden decline in independent inventors during this period.

In this context, another view is that the Great Depression contributed to the demise of independent inventors. In particular, several economic historians have suggested that the shocks to local financing brought about by the Depression led to disruption of local investors' networks and to a reduction in the willingness to supply early-stage financing. For example, Kenney (2011) writes that "the obstacle to establishing these new firms was a shortage of risk capital, which they believed was due to the changes caused by the Depression that discouraged wealthy individuals from risking their capital in untested firms."[7] In addition, Lamoreaux et al. (2009) concludes that "the subsequent dominance of large firms

[7]Other examples are Landes et al. (2012): "Many firms [of the 1930s] run by inventor-entrepreneurs were either acquired or driven out of business" and a Wall Street Journal editorial on January 24th, 1938: "there is no 'venture capital' to speak of [in the U.S. economy] because there is no venture spirit on the part of capital owners or those

seems to have been propelled by a differential access to capital during the Great Depression."

Importantly, these two explanations are not necessarily orthogonal to each other. While we believe that technology alone cannot explain the sudden decline in independent inventors around this period, this force could very well play an important role in explaining the persistence of the decline and the speed of transition between the two organizational forms. Therefore, our tests will simply examine how the financial disruption brought about by the Great Depression was a catalyst for the decline in the activity of technology entrepreneurs, keeping constant the overall trends in technology.

2.3 Bank Distress and Technology Entrepreneurs

While the notion that bank distress could dramatically affect the innovative process is intuitive, the exact mechanism through which this phenomenon could take place is more ambiguous. As discussed before, previous research has already established that bank lending did not have a significant direct impact on independent inventor activity activity during this period. One exception may be the innovation activity that was undertaken within established firms (Nanda and Nicholas, 2014).[8] However, distress in the banking sector may still have affected the funding of technology entrepreneurs via more indirect channels. One hypothesis is a distress-driven decline in demand: as local firms suffer because of the contraction in lending, the demand for technologies developed locally may decline. In general, we think that this demand explanation will fall short in explaining our results: the market for technologies at the time was already quite developed and demand was in large part national or regional (Lamoreaux et al. 2006, 2009). Despite this, in our empirical analysis we will explore the potential role of demand factors.

Alternatively, we hypothesize that bank distress could impair the supply of funding coming from wealthy individuals acting like "angel investors" in the local market.[9] This disruption of local "angel financing" could happen for several reasons. First, banks were known to be central nodes of information transmission between local inventors that needed financing and wealthy individuals, such as bank clients, local businessmen, land owners and banks' officers and directors themselves, who were willing to back the

who normally would be borrowers of that capital."

[8]In Nanda and Nicholas (2014), the concentration of the effect in industries that are actually more dependent on external finance may help rationalize this result with Mowery and Rosenberg (1989), who document that firm investments in R&D facilities and personnel actually rose during the Depression.

[9]In our setting, bank distress is not used because of the direct effect that banks can have, but - as we discuss here - because bank distress can proxy for several sources of distress to local wealth. As a result, we do not think that our setting is appropriate to settle the discussion "between" Bernanke (1983) and Friedman and Schwartz (1963) on the role of intermediation in explaining the depth of the recession in 1929-1933.

inventors (Lamoreaux et al., 2006). Hence, failure of local banks can sever information flows and destroy relationship capital, which are important pieces of the local innovation ecosystem. This effect in principle could affect any type of organization, but it should have a larger impact on independent inventors, since this type of organization has fewer financing alternatives, receives financing on a project-by-project basis, and is more dependent on local networks to secure financing.

Second, local bank distress would likely reduce the ability or willingness of local wealthy individuals to invest directly in new technological ventures. This second mechanism would require two assumptions. First, it would need to be the case that the wealth of local investors is exposed to potential negative effects of bank distress. Many financial-backers were business owners of established companies in the area, and therefore their fortunes were directly tied to those of local banks. At the same time, wealthy individuals were likely to have a relatively substantial part of their wealth invested in real estate, which was also sensitive to the condition of the banking sector. In order to provide evidence in the direction of our hypothesis, we have examined the Study of Consumer Purchases in the United States (1935-1936), which can provide us with a partial but unique outlook on the portfolio of individuals in this era. Using these data, we are able to provide two stylized facts that are in line with our narrative. In particular, even among business owners, the exposure to stocks and bonds—as examples of assets that are not local and therefore less affected by the local distress—is relatively small. In particular, we find that only 10% of business owners obtain any income from these securities. Furthermore, exposure to real estate is much larger in magnitude: overall, 42% of business owners report owning at least 50 acres of land during this time.

Secondly, it would also need to be the case that investors in technology entrepreneurs are local and potentially even these same business owners. While direct evidence of this hypothesis is hard to find, a large body of historical work suggests that many financial-backers of technology entrepreneurs were business owners of other companies in the area (e.g. Lamoreaux et al., 2006). To overcome data limitations, we have digitized investment prospectuses of about one hundred early-state technology firms that were planning to sell securities in Illinois between 1919 and 1924, as discussed in Akkoyun (2018).[10] In large part, these firms are early-stage technology companies, and therefore the investors reported at this point are likely to reflect those individuals that invested in the business at its infancy. We identify

[10]We kindly thank Cagri Akkoyun for sharing with us the original copies of the documents he has collected from the Illinois Securities Division.

potential investors by looking at firms' directors that are also not officers of the company.[11] Of the 114 individuals that we identify as early investors, and for which we have information of the city of residence, we find that in 66% of cases these individual live in the same city in which the company headquarter is located. While not perfect, this evidence is consistent with the historical literature and it supports the hypothesis that most of the investors in early-stage independent innovation were local.

Access to this sort of local financing might explain why during the 1910s and 1920s independent inventors were responsible for the majority of patents in Illinois' major innovation hub - Cook County and in particular Chicago. As has been shown by Mitchener and Richardson (2019), due to a pyramiding structure of bank reserves leftover from the national banking period, almost a 1/4 of all banks they examine in other cities deposited funds in Chicago's reserve city banks. With the onset of the Great Depression, banks feeling liquidity pressure withdrew their funds from Chicago's banks causing a massive strain on their financial system. In fact, Chicago had the highest bank failure rate of any urban area in the U.S. (Guglielmo 1998) with 82% of banks in mid-1929 gone by mid-1933 and more than 60% of deposits withdrawn (Calomiris and Mason 1997; Postel-Vinay 2016). The result was a severe financial crisis in Chicago and the surrounding areas, since what started with banks going under quickly spilled over more broadly into overall economic turmoil (Bernanke 1983). Despite an increase in patents filed by independent inventors in Cook County in each of the two decades preceding the Great Depression, in the 1930s independent patents filed would plummet by 47%, while those by firms would fall only 9%. Independent patenting would continue to fall by double digit percents in each of the following 3 decades, while firm patenting largely recovered to pre-crisis levels.[12] Despite the large decline (29%) in total patenting in the 1930s relative to 1920, total future citations over the next 80 years from patents filed during this period would actually rise 34%. While a single county is obviously insufficient evidence on its own, it is certainly consistent with our overall evidence on the effects of economic distress on innovative activity in the aftermath of the Great Depression and the importance of disruptions to local investor capital as a driver of that shift in patenting patterns.

[11]We exclude officers because we believe these individuals are more likely to be founders, rather than early investors. This exclusion will actually work against us, since officers tend to reside in the same location as the firm.

[12]This appears to occur both for the entry/exit of inventors, but also among those inventing across both decades. Cook County actually has the most inventors who patent independently before the Great Depression and in firms after of any county in the U.S. in our sample.

3 Data

3.1 Measure of Innovation

We use data on the universe of United States Patent Office (USPTO) patents, representing over 9 million patents from 1830–2018, which include filing and grant date, inventor's name, assignee's name (if assigned), and their locations are provided to us by Berkes (2016).[13] For patents filed in 1910–2018, we also have information on future patents that cite these patents as well as the patents' technology classification (e.g. electricity) coming from the USPTO's Cooperative Patent Classification (CPC). We perform extensive cleaning and standardization of the data.

We separate patents in four groups: independent patents, U.S. firm patents, foreign patents, and patents with missing information on the location of inventor and assignee, if assigned. Figure 3 shows an example of an independent patent—the famous light-bulb invention by Thomas Edison, who in 1880 founded "Edison Electric Light Company" to market his hew invention. The independent inventors' patents are usually either unassigned, assigned to the inventor, or assigned to other individuals (e.g., angel investors). We define independent patents as those granted to inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. Figure 2 shows an example of a patent assigned to a U.S. firm (i.g., General Electric) at the time of the patent grant. Patents assigned to firms are usually produced by inventors employed within large firms with in-house R&D labs who would have been contractually obliged to assign their inventions to their employers (Lamoreaux and Sokoloff 2001b; Lamoreaux et al. 2009; Nicholas 2010). Thus, we define U.S. firm patents as those that were assigned to a U.S. company at the time of the patent grant date.

As described above, the financial markets for funding startup-like innovations were highly localized, and hence a county-level geography roughly identifies the physical proximity of innovator and local investors. We match county-level information to inventors' city-state locations. We are able to match 99% of patents with city-state information. We then create a five- or ten-year panel and aggregate patents at each county-period for all U.S. patents, independent U.S. patents, and U.S. firm patents. For all three patent categories, we calculate county-level measures of number of patents, number of future citations citing those patents, and average number of future citations measured as total citations over number of

[13] We are incredibly grateful to Enrico Berkes for sharing this data with us. For more details on the impressive construction of this data please see Berkes (2016).

patents.

3.2 Bank Distress

Our measure of bank distress follows much of the literature (Calomiris and Mason 2003; Nanda and Nicholas 2014) in using Federal Deposit Insurance Corporation (FDIC) county-level annual reports on active and suspended banks and their deposits from 1920-1936. These data are unavailable in the states of Wyoming, Hawaii, and Alaska, and in the District of Columbia, and do not distinguish bank failures from bank suspensions. However, Calomiris and Mason (2003) argue that these shortcomings do not interfere with identifying bank distress empirically. We use 1930 as the starting year for our banking sector distress indicator since it wasn't until at least 1930 that banks began to fail in serious numbers, destroying relationship capital and access to finance (Bernanke 1983; Calomiris and Mason 2003; Nanda and Nicholas 2014). Suspensions and failures of banks from 1930 through 1933 proxy for the disruption to the local financial ecosystem. We indicate that a county is in distress during the Great Depression if there is at least one bank suspended in that county from 1930-1933, which represents 71% of all counties. This provides a relatively simple intuition for interpretation of any observed treatment effects and is our primary measure of distress throughout the paper. Given how many counties experience distress, we also consider two additional measures of bank distress. First, we use a continuous measure of the cumulative percent of all banks suspended in a given county over 1930-1933 as a fraction of 1929 banks. Second, we use a dummy equal to one for counties with the above median deposit suspensions. We match bank distress data to the county-level panel data using inventor's county location. Table 1 presents summary statistics on the county-level patent measures for aggregates for the 1920s and on other county-level measures used in the analysis.

3.3 Complete Count U.S. Census

Using complete count U.S. censuses of 1910, 1920, 1930, 1940, we can match 70% of U.S. inventors (~500k people) on patents filed over 1905–1944, which allow us to get detailed demographic, geographic, and socioeconomic data at an individual level and create a longitudinal sample of inventors across four decades. We use longitudinal inventor data to examine mechanisms.

4 Results

4.1 Setting

The key objective of this section is to identify the impact of the disruption to local financing caused by the Great Depression on innovation activity. To examine this question, we use a differences-in-differences specification which compares innovation activity across counties that were differentially affected by bank distress during the Depression period. To remove the effect of regional business cycles and changes in state-level regulation, all our specifications will also contain state-by-time fixed effects. We also include county-fixed effects to control for time-invariant differences in innovation across counties.

We quantify innovation across locations using innovation produced by independent inventors, firms and overall innovative activity. We initially examine the short- and medium-run impact of the shock, in particular looking at the periods 1910–1940. Our primary specification is:

$$Ln(Innovation)_{cst} = \alpha_c + \gamma_{st} + \beta\, BankDistress_{cs} \times After1929_t + X^{'}_{cst}\zeta + \epsilon_{cst} \tag{1}$$

where c denotes a county, s – a state, and t – time (defined in decades). $Ln(Innovation)_{cst}$ is the natural logarithm of either number of patents, total future patent citations, or average citations per patent[14]; α_c are county fixed effects; γ_{st} are state-time fixed effects; $BankDistress_{cs}$ denotes the degree of bank distress in county c in state s during the Great Depression and equals one if the county had at least one bank suspended over 1930–1933, and 0 otherwise; $After1929_t$ equals 1 for observations starting in 1930, and 0 otherwise. X_{cst} will include county-specific controls discussed later. These are usually measured before the time of the Great Depression and interacted with post-dummy, $After1929_t$. Our main results will use decennial data, but we will also consider five-year windows when estimating the dynamic model. The estimate of the effect of local bank distress on innovation is given by β, which measures differences in patenting in counties with higher bank distress compared to counties with lower bank distress. We cluster standard errors by county which is the level of our treatment (Bertrand et al., 2004).

There are clearly several potential threats to identification. One issue may be reverse causality. In particular, it could be that the weakness of the innovative sector led to bank failure, and not vice-versa. To understand whether this is a valid concern, it is important to understand the causes of bank

[14] We add one to the number of patents before taking logs in order to avoid issues with counties without any patents over a given period as is standard practice.

distress during the Depression. To the extent that failures were driven by panics rather than weakness in the fundamentals (e.g. Friedman and Schwartz, 1963), then reverse causality should not be a concern. However, if distress is driven by a deterioration of the demand for credit, then reverse causality could be a more serious concern. In general, there is some consensus that the demand channel is not able to explain a large part of the contraction. For instance, Calomiris and Mason (2003) find that lagged liabilities of failed companies do not explain bank failures. This hypothesis is likely to be even less plausible for the innovative sector, which had minimal exposure to banks' loans. In this context, Nanda and Nicholas (2014) show that publicly traded R&D firms—which are likely the R&D firms with a higher share of assets funded by bank loans—only accounted for a minimal share of banks' outstanding loans. Overall, reverse causality does not appear to be a key concern in this specific context. However, some of our robustness test will also provide further evidence against this concern.

Alternatively, the presence of omitted variable bias is a serious concern in this analysis since bank distress was clearly not randomly assigned. While it will not be possible to present one single test that can rule out this hypothesis, the battery of analyses that we present in the next section will help to assuage concerns on this dimension.

4.2 Main Result and Robustness

In Table 2, we show initial evidence that county-level variation in exposure to the financial crisis, proxied by bank suspensions, is associated with a reduction in the quantity of total patenting (column 1), driven by the decline in independent patents (column 3) and no changes in firm patenting (column 2). We focus on the significant result for the independent innovation, and revisit firm innovation later in the paper. In particular, our estimates suggest that counties that experienced bank distress saw a drop in independent patenting around the Depression that was 13% higher than counties in the same state without bank distress. This effect does not crucially depend on the way we measure bank distress. Indeed, Table (A.1) shows that the results hold using alternative measures. For instance, the effects are consistent when splitting the sample at the median of distress—measured as share of deposits at suspended banks—or also defining as affected counties those that are not in the bottom quartile in terms of distress.

By the same token, we also show in Table A.2 that results are essentially identical if we conduct alternative transformations of the outcome. One concern is related to the presence of zeros in the data, which led us to add a unit to the traditional log-transformation. To start, it is important to point out that in this setting the presence of zeros is relatively second-order. In column 2, we actually construct the outcome without adding the unit, therefore dropping the zero observations and focusing on a purely intensive margin. We find that our estimates are very similar to the main one (reported in column 1), and the drop is sample size is only about 10%. However, we provide two alternative to our approach. First, our preferred alternative is to use the inverse hyperbolic sine transformation, which provides more smooth transformation around zero and still allows a similar interpretation of the results (column 3). Second, we also check our results adding a smaller base (0.5) to our outcome (column 4). In both cases, we find almost identical results to our baseline. Lastly, Table A.3 shows that the regions with bank distress have substantial reductions in independent pateneting even weighting our regression by the size of the county in 1920.[15]

However, before we can causally interpret the results in this direction, we need to provide more evidence that can help us to rule out confounding factors discussed earlier. To start, we examine the dynamic of the effects using a longer panel (1900-1950) organized over five-year windows. If our results are explained by an omitted variable that is unrelated to bank distress, we should expect to find our result also before the Depression. In other words, we should find that high distress counties were already experiencing different trends in innovation activities before the shock. This would be the case if, for instance, areas with high bank distress during the Depression are regions with declining economic activity. Figure 4 provides evidence that is inconsistent with this concern. In general, we find that until 1930s counties that experienced distressed during the Depression did not differ in their relative trends in independent inventors' activity. This changed sharply during the period 1930-1934. At this point, we document a reduction in innovation activity by technology entrepreneurs in affected areas.

Given the lack of differential trends, the main remaining concern for our analysis is that bank distress at the county level may be correlated with some other shock that was contemporaneous to the Depression but unrelated to the contraction in funding. One hypothesis is that bank distress captures heterogeneity in demand for technologies across counties, which in turn may affect the production of technologies in the area. To the extent that this shift in demand happens roughly at the same time as the Depression or as a result of it, its effect may be undetectable in the pre-trend analysis. Regarding this concern, there are a few important things to consider. First, from a theoretical standpoint, a demand-side explanation

[15] As discussed more later, we also find that our results are robust to the exclusion of patents without any citation (Table A.8). In other words, the decline is not simply because independent inventors stopped producing patents of no value. More discussion on the shift in patent quality is provided later.

would require that, in some way, the decision of an inventor to develop a technology is influenced by the demand for that technology in the local area. However, this hypothesis goes against a large body of work in economic history (e.g., Lamoreaux and Sokoloff 2001b), which has shown that the market for technology during this period was either national or—at the very least—regional. Therefore, variation in demand should not be captured in our analysis, particularly after the inclusion of state by time fixed-effects.

Second, to the extent that firms and technology entrepreneurs produce a similar type of innovation, a demand explanation would also predict a decline in firm innovation in distress areas. However, as we show in Table 2, we find that bank distress does not seem to predict any short-run changes in aggregate patenting by firms at the county level. This firm-level result helps more broadly to address other alternative explanations, which would generally predict a similar response between firm and independent inventors. For instance, one special case is the reverse causality hypothesis discussed earlier. If the decline in banks was caused by the reduction in innovation and not vice-versa, the contraction should be observed also in firms. If anything, the effect on firms should actually be larger, since banks and firms are more likely to be connected through direct lending relationships.

These arguments suggest that demand-side explanations are unlikely explanations for our results. However, we can also provide direct evidence against this hypothesis. In general, if we think that a demand shock explains our results, we should also expect to find this result for technologies in which local demand is likely to be more important. Despite the claim that the market for technology was mostly national, it may still be plausible that certain technologies are more sensitive to local demand than others. To examine this issue, in Table 4 we reshape our data at county-time-technology level, where the technology is based on the CPC technology classes.[16] Since it is hard to categorize ex-ante which technology is more likely to be affected by local demand, we take two approaches that do not require any ex-ante categorization. To start, we augment our main specification using technology by time fixed effect. To the extent that demand explains our results and this is heterogeneous across technology, we should expect our main effect to go away. Instead, we find that the result with this new set of fixed-effects is still large and significant (column 2) and not different from the estimates at this level of aggregation without any of these additional fixed effects (column 1). On top of this, we repeat the main specification separately for each of top largest technology classes, as measured by the number of independent patents

[16] In particular, these groups are human necessities, performing operations or transporting, fixed constructions, mechanical engineering, lighting, heating, weapons, blasting engines or pumps, and physics.

in 1920s. Across all five, we find sizable and significant results (columns 3 to 7).

While these results provide strong evidence against the role of demand in explaining our results, there is still a potential concern that the response to the Depression may in part reflect other differences across distressed and non-distressed areas. To visualize this fact, in the first panel of Figure 3 we plot the estimated differences in county-level characteristics between areas that experienced bank distress during the Depression to areas where there was no failure. This analysis is conducted adjusting for state differences.[17] On average, we find that counties experiencing bank distress are significantly different than areas that did not experience bank failures. For instance, our treated areas tend to produce more patenting (looking at both total and independent patenting) in the 1920s and they also had more banks. Not surprisingly, these areas that experienced bank distress also end up with higher unemployment in 1937 and they were also more exposed to the agricultural boom in 1917-1920, which is generally considered one of the sources of weakness for the banking sector before the Depression (Rajan and Ramcharan, 2015; Jaremski and Wheelock, 2018). However, most of these differences between treatment and control are really explained by the fact that counties experiencing distressed are on average larger than counties that did not experience distress. Consistent with this hypothesis, in the second panel of Figure 3, we repeat the same analysis as before now also controlling for the log of population in the county in 1920. Strikingly, this extra control absorbs a large part of the variation along the treatment. For instance, controlling for population we do not find any significant difference in the amount of independent innovation produced in the county in the pre-period.

Note, this effect of size control does not pose a threat to the validity of the difference-in-difference design, since it does not require a covariate balance before the treatment occurs. Instead, the difference-in-difference design requires that: (a) treated and control counties experience the same trends prior to the shock (which is supported by Figure 4); and (b) treated counties would have continued on the same trend as the control counties in the absence of the shock. Since (b) is untestable, in Table 3, we examine empirically whether differential trends post-shock in distressed and not distresses counties can be driven by differential trends due to size differences and other potential co-variates. In column 1, we show that our main result goes through once we also control for the size of population in 1920 interacted with a post-dummy. The same also happens when we control for a measure of the size of the banking sector at

[17] The analysis reports the beta and 95% confidence interval for coefficients that are estimated running a simple regression of the outcome reported - which is z-scored to make it more comparable across variables - on a dummy for counties with bank distress controlling for state fixed-effects.

the county level (column 2).

Building more on this idea, we present two more tests. First, in column 3 we control for the importance of manufacturing in 1929. Also in this case, this adjustment does not significantly affect our estimate. Second, in the next two columns, we control for two variables that should in part also capture the negative effect of the Great Depression. In column 4, we control for the change in sales at the county level between 1929-1933 and the unemployment rate in 1937 in column 5.[18] The logic behind this test is simple: an omitted variable would be a concern only if this variable is correlated with the level of bank distress in the local area. In general, the same factors that may have been correlated with one dimension of the Great Depression—bank failure—may be also be correlated with other dimensions, like the contraction in retail sales or unemployment rates. Therefore, controlling for these alternative proxies for the depth of the Depression can help to gauge the extent to which our result may be capturing other economic forces that we have not controlled for in our main analysis. However, it is also important to keep in mind that these variables may also be endogenous driven by bank distress, and therefore may partially capture the impact of bank failure and the overall funding shocks we are interested in. In general, we find that the addition of these controls do not significantly affect our estimates, therefore providing reassuring evidence for our analysis. Furthermore, the same result also holds when we add all the controls together (column 6). On a related point, we also find that our results are robust to controls for the importance of New Deal funding, therefore suggesting that this government intervention - which likely favoured incumbent firms in the market - does not appear to explain our specific result (Table A.4).[19]

As an alternative way to deal with the heterogeneity between treatment and control, we also implement a matching estimator using a nearest neighbor matching approach. This allows us to deal with concerns about non-linear effects of co-variates acting as possible confounds. In particular, we start by considering all the counties that did not experience distress during the Depression. For each of these counties, we check whether we can find any other county that experienced bank distress, where the following conditions also hold: (a) the county is in the same state; (b) population is within a 25% bandwidth around the

[18] We use 1937 because county-level unemployment data was not available between 1929-1933.

[19] In particular, we follow Fishback et al. (2006) and we proxy the size of New Deal by looking at the total amount of relief grants in the area. The data on relief grants come from Fishback et al. (2003). Using this raw data, we construct two proxies. First in columns 1 and 2 we control for the amount of relief funds divided by the population in 1920. Second, in columns 3 and 4, we also control for the absolute size of the relief grants (log-transformed). In both cases, we find little difference in our inference. Interestingly, the amount of money received by a county during the New Deal positively predict patenting by independent inventors in the post-Depression period.

unaffected county; (c) independent inventors' innovation in the pre-period (1920) is similar.[20] In the end, for this analysis we only analyze counties that are selected using this criterion. As a result, the sample of counties examine is only about a third of the original sample, but on average the firms in treatment and control are much more homogeneous. In Table A.5, we re-estimate our main specification using this matched sample (column 1 and 2). Overall, we are able to replicate our main finding, in terms of both economic and statistical significance: negative result on independent patenting and null result on firm patenting.

4.3 Wealth Shocks and Independent Inventors

Altogether, these tests support the interpretation of our results as evidence of the importance of bank distress in explaining the decline in independent inventors. However, banks may matter for technological entrepreneurs for different reasons. As we discussed previously, one hypothesis is that bank shocks cause a negative shock to the wealth of local investors, therefore reducing their ability to fund new ventures. This idea is consistent with most of the literature on the history of technology firms in the pre-Depression era as well as in line with the novel stylized facts presented in Section 2. If this is an important channel to explain our result, then one implication is that we should expect to find comparable results even using an alternative shock to local wealth.

Indeed, we can show that the drop in independent inventors can be identified also using a different wealth shock measure. In particular, we identify counties experiencing variation in agricultural land values using heterogeneity in the exposure to the 1920 farming crisis, as discussed in Rajan and Ramcharan (2015). In this paper, the authors argue that the boom in the US agricultural sector in the late 1910s—which was a consequence of the disruption in European and Russian food production due to WWI and a sharp increase in the US world exports—caused a large decline in real estate values in the 1920s. Banks loaded with loans underwritten to finance the boom were particularly vulnerable during the Great Depression (Jaremski and Wheelock, 2018). Following this paper, we construct a county-level measure of exposure to the farming shock by looking at the increase in revenue that is induced by the changes in prices in global commodity markets (Haines et al., 2010).[21]

[20]We divide counties in three groups: (a) no independent innovation (zero patents before); (b) moderate independent innovation (between zero and fifty patents); (c) high independent innovation (above fifty patents). We then use this definition to match firms.

[21]To be specific, our treatment is the county-level change from 1917 to 1920 in the international commodity price index calculated for each county, where weights are the crop share of a given farm product out of total county farm output and

To start, we validate this measure relative to the previous literature. In particular, we can show that counties that experienced a larger farming boom during 1917-1920 also experienced higher bank distress during the Depression (in column 1 of Table 5). In line with the discussion in Rajan and Ramcharan (2015), this confirms that the shock to real estate in the 1920s explains part of the weakness of American banks at the onset of the Depression. Then, in Table 5, we replicate the same differences-in-differences model presented before using this alternative treatment. Columns 2 and 3 show results that are consistent with the results using bank distress: an increase in the boom in farm land caused by the WWII is linked to a reduction of independent inventors activity after the beginning of the Depression[22]. Importantly, our results are similar even when adjusting for differences in size by controlling for population in 1920 (Table A.11)

Overall, this result provides some suggestive evidence about the importance of wealth shocks in explaining the contraction in independent inventors documented before. Furthermore, this result helps address reverse causality concerns mentioned earlier, since we exploit variation coming from land suitability that are intrinsic to a location and therefore are determined long before the Great Depression.

4.4 The Effects over the Long-run

The evidence presented so far has confirmed that bank distress during the Great Depression had a significant impact in explaining the contraction in patenting activity by independent inventors. Before moving forward, it is important to understand to what extent this effect was temporary or persistent. This question is particularly important given the context of these results. As Figure 4 shows, the aggregate decline in independent inventors was not a transient phenomenon. While our results confirm that the shock caused by the Depression was a significant factor in triggering this decline, this does not necessarily imply that the effect of our main shock persisted in the long-run.

To examine this issue, we repeat our main analyses using a sample that covers patenting activity by independent inventors up to 1990. One important caveat in this type of analysis is that we are not going to be able to prove that the Depression caused a long-term decline in independent patenting. Instead, we can simply make a statement on whether the short-term effects of the banking shock persisted over time.

prices are international farm product prices.

[22]It is important to be clear here that agricultural land price shocks aren't being used as an instrumental variable for bank distress, but rather both bank distress and agricultural land price shocks are likely to be different measures likely to be associated with wealth shocks to available local capital for financing technological entrepreneurs.

The two things are related but they are not necessarily equivalent.[23] Despite this limitation, which is common in this type of study, understanding how our results persisted is still important, since it may help in clarifying how the effect of the Depression may still explain a large share of changes in the innovation ecosystem years later.

We examine the data with this limitation in mind. In the pre-trend analysis (Figure 4), we have already shown that the contraction in independent inventors' patenting occurred not only in the 1930s but was present in affected areas 1940s as well. In Table 6, we extend this analysis further. In particular, using data at the decade level, as in the previous analyses, we separately estimate a parameter of bank distress for the periods after 1929 and then on top of that an estimate for just those decades post-1939. The estimates suggest that counties that experienced bank distress during the Great Depression appear to be characterized by even lower patenting by independent inventors after the 1939. This evidence suggests that the negative effects of bank distress were still visible decades after the end of the Depression.

5 The Great Depression and the Innovation Ecosystem

5.1 Discussion

So far, we have shown that the Great Depression was followed by a contraction of innovation by independent inventors. Importantly, these effects are persistent over time. There are several ways to interpret this evidence. On the one hand, at face value this result may be consistent with the idea that the financial contraction brought about by the Depression negatively affected the level of dynamism in the economy. In fact, our tests show that the financing contraction led to a sizable reduction in innovation activity that is undertaken outside the firm. In turn, this may suggest the presence of a "missing generation" of highly productive entrants (Gourio et al., 2016).

On the other hand, a reduction in the amount of innovation that is undertaken by technology entrepreneurs do not necessarily imply a reduction in the overall dynamism of the economy. First, the long-run implications of the shock do not only depend on its quantity effect, but also on the quality adjustment that this may generate. As discussed by Caballero et al. (1994), a negative shock may also represent an economic opportunity to the extent that this event also triggers a cleansing dynamic in the

[23]For instance, it is possible that the government explicitly targets areas that were characterized by bank distress. As a result, this intervention—which is correlated with our shock—will affect our estimates.

economy. Second, the actual impact of the shock for the economy also depends on the ability of innovation to shift across different types of organizations. Altogether, a crisis period may also be an opportunity to reshape innovation efforts towards more efficient organizational forms and impactful projects (Manso et al., 2019).

In order to explore these dimensions, we increase the breadth of our analysis by expanding our investigation to the overall ecosystem of innovation at local level. In particular, we present three sets of tests that can help clarifying our initial results. First, we test whether the decline in the quantity of innovation was also accompanied by a decrease in the overall quality of independent innovation, as measured by total and average future citations. This may be particularly interesting in this case, since one of the benefits of the historical context is that the quality of patents filed can be evaluated based on the long-run influence that patents have on future innovations through citations. Second, we examine whether the drop in the quantity of independent innovation also led to a decrease in overall local innovation activity, looking more closely at the role played by firms during this period. Moreover, we build a longitudinally matched data set at the individual-level between the U.S. censuses surrounding the Great Depression and our inventor data. This allows us to examine individual inventor migration across organizational forms of innovation. Third, we examine whether the shock led to a reduction in the stock of human capital in the area - taking advantage of our mapping at an individual-level to the full count U.S. censuses.

5.2 Analyses

First, we look at changes in the quality of innovation. In Table 7 we study this dimension using the same differences-in-differences design but looking at total citations received as the outcome of interest (columns 1 and 2). In stark contrast to our quantity results, we find essentially no differential change in future citations for independent inventors in more distressed counties (column 1). The same holds looking at all patents (column 2). We can also see this in Figure 5, which replicates the design of Figure 4, but looking at total citations for independent inventors. Just like in Figure 4, we find no evidence of pre-trends, but, unlike before, we also do not find any change in behavior after the shock.

How do we reconcile these seemingly disparate findings on the number of future citations in an affected county vs. the number of patents filed in these same counties? In columns 3 and 4 of the same Table 7, we show that the divergent results are driven by a change in the average patent quality. As we can see in Figure 6, the average citations per independent patent rises suddenly in counties that experience more severe economic distress, despite no evidence of differential trends prior the Depression.[24] This evidence—combined with the decline in the quantity of innovation—seems to suggest that the drop in activity by independent inventors is in large part driven by lower quality projects that are dropped. Therefore, while technology entrepreneurs were forced to reduce their activity in response to the shock, inventors with high quality technologies were still able to succeed in the marketplace.

Consistent with this hypothesis, we find that the average increase in the quality of patents is explained by a drop in the number of patents with lower citations, rather than a relative increase in highly cited patents. In Table A.9, we split patents based on the number of citation within the same cohort period (1910-1940) and technology (main CPC). In particular, we split patents between those that belongs to the top 1% and the bottom 99%, as well as top 10% and bottom 90%. Across the two groups, we consistently find that the decline is in large part explained by a decrease in the number of patents that are of lower quality, while highly cited patents remain roughly constant.[25] Importantly, this pattern is not simply driven a decline in patents that are characterized by extreme low quality. To show this, we replicate our main finding regarding the decline in independent patenting using only patents that have received at least one citation. As we show in Appendix Table A.8, we find that the decline in independent inventor activity happens also looking at only patents with positive future citations.

Before moving forward, there are a few things to point out about this increase in average quality. First, following the previous discussion on alternative ways to measure the wealth shock, we can replicate these findings using the land shock discussed in the previous section (Table A.10). Second, the same results are robust to different tests. In this regard, we find that controlling for size does not significantly change our results (Table A.6). Furthermore, we also find that adjusting citations to absorb some of the variation in citation patterns across technologies does not seem to significantly affect our results (Jaffe et al., 1993). In particular, in column 1 of Table A.7, we show that adjusting citations by scaling them

[24] These findings stand in contrast to those Nanda and Nicholas (2014) for firms which are more dependent on external finance. In their paper, they find a substantial reduction in the quantity and quality of patents, which suggests that more than just financial constraints may be driving the observed responses of independent inventors. So while financing constraints may play some role in our setting, the dramatic decline in independent patents, relative to even the largest reductions seen among groups of incumbent firms, and the rise in patent quality, suggests that other mechanisms of more importance for start-ups, such as local equity capital, risk aversion, employment opportunities, and migration, may also be important contributors (Haltiwanger et al. (2012); Adelino et al. (2017)).

[25] This result is presented controlling for population consistent with the rest of the analyses in our paper. It is important to point out that our findings also hold without this control, i.e. we find a larger effect for lower quality patents. However, without the control the effect is also significant for the top patents, suggesting that at the margin high quality patents may have also suffered.

by the average citations in the same technology (i.e. CPC) does not affect the result.[26] Furthermore, we also find a similar and consistent result using average citation without log-transforming as an outcome (column 2).

Second, we find that in contrast to technological entrepreneurs, the aggregate local innovation activity by firms did not seem to be impaired, as shown in Table 2. If anything, patenting by firms seems to actually increase relatively more in distressed areas over the longer-run, as shown in Table 6.[27] Despite the limitation of analyses that look at longer-term response, this evidence may suggest that there is some substitution in the production of innovation between independent inventors and firms. Moreover, we find no changes in the average quality of firm patents in the short-run (unreported) and we find an increase in the long-run (unreported).

To understand what can explain this shift in quality, we turn to individual inventors' data and test whether we find any shift in the incidence of independent inventors to start working for firms in the post-Depression period in distressed regions. In order to run this test, we restrict ourselves to the subset of inventors who can be found in the 1920 Census, patent as independents prior to the Great Depression (1910-1920) and have at least one patent in 1930.[28] Using this cross-section, we then test whether independent inventors within a state were more likely to shift into firms in counties that experienced high bank distress.[29] The idea is to understand the extent to which financial distress caused by the Depression led to a reallocation of inventors into firms. As we show in Table 9, independent inventors operating in high distressed areas were more likely to move into firms in the following decade, and this holds both without any control but also when adding county level (column 2) and individual level controls.

To bolster the interpretation of this result, we present two results. First, in Table A.14 we conduct a placebo analysis looking at whether independent inventors also moved into firms more often in our highly affected counties before the 1930s. In particular, in columns 1 and 2 we examine a sample of independent inventors that were active in the 1910s and check whether they were more likely to move into firms in the

[26] In particular, we scale citation by the average number of citations over the window of time considered in the analysis

[27] Importantly, we also do not find any change in distribution of high-low quality patents for firms (Table A.9).

[28] To assign the location during the Depression we use the location in 1930 Census and, when this is not available, the location in the 1920 Census.

[29] For this analysis, we use a dummy version of the treatment, that split the sample distribution at the median. Our main result also works using a consistent split at the median (Table A.1). The reason is that the previous treatment version (bank distress equal to one when there is some distress event) does not have enough variation using individual level data, as more than 90% of the sample resides in an affected area. In Table A.12, we show the version of the result using the bank distress employed before (null effect). In columns 3 and 4, we show that using a continous version we obtain similar and consistent results.

1920s if they were in counties that experienced more distress during the Great Depression, and in columns 3 and 4 we repeat the same analysis looking at 1900s inventors moving into firms in 1910s. Across all these analyses, we consistently find no evidence of a different likelihood to move into a firm prior to the 1930s. Second, in Table A.13 we repeat the same analysis using a smaller sample but with likely higher matching quality between the inventors' data and Census.[30] Despite the significant decrease in the size of the sample, our result remains significant, and more importantly the magnitude of the effects remain stable.

This cross-organizational migration is consistent with more a muted response for county-level firm patents if innovative workers are re-allocated from more to less external-finance dependent firms in counties with more severe bank distress. Going back to our original county-level data, we show in Table 5 long-run reductions in independent patenting in these distressed counties—that last till the present day. By contrast, firm patenting in distressed counties appears to see a resurgence in the long-run, fully compensating for the long-run decline in independent patenting. This would again be consistent with migrations across organizational forms, some of which are faster and some slower moving. Overall, the movement of inventors across organizational forms might explain why the aggregate county-level firm patenting appears to have been fairly insulated from bank distress, despite the declines observed for some more affected firms Nanda and Nicholas (2014).

An alternative mechanism is that the shock may have affected the local economy in part because of a reduction in the local availability of human capital. This would have been the case if inventors have responded to the shock by moving outside the county. Indeed, the recent literature in economic history highlights the importance of migration to understand the effect of the Depression in the American economy (Feigenbaum 2015). In Table 10, we show that data are not consistent with this hypothesis. In particular, using the longitudinally matched inventor data, we find no evidence that inventors actually were more keen to migrate out of highly distressed areas. This fact is true both for inventors working for firms or independently. This result suggests even more that the shock—while it affected the way innovation was organized—did not significantly impact the stock of human capital in the area, at least in the short run.[31]

[30] In particular, we only consider a match "good" in this robustness if the patent matched was applied for in a two year window (two-before and two-after) around the Census year. This filter increases the likelihood that the location reported in the patent is consistent with the one of the Census. We think this approach significantly decrease the probability of false positive, but we also feel confident that our full sample is likely of a sufficient quality to undertake our inference.

[31] Migration in these regions by inventors certainly could have risen after 1940, but this is the last date at which we have

6 Conclusion

Using a differences-in-differences design comparing counties with different levels of bank distress between 1929 and 1933, we document the important role of the Great Depression in triggering a large reduction in the quantity of patents filed by the largest innovators of that period—independent inventors. However, this decline in the activity of technology entrepreneurs is only one side of the story. First, despite the decline in the quantity of innovation, the average quality of patents filed by independent inventors rose dramatically. Second, the shock on its own did not affect firms negatively. If anything, firms seem to have benefited in the long-run, in part because of a reallocation of inventors into firms. Third, the shock did not seem to reduce the amount of human capital in the area, as inventors did not leave the affected regions in response to the shock.

This evidence on the Great Depression can be thought of as a cautionary tale when examining the impact of shocks to innovation activity by looking at the overall innovation ecosystem. In general, sufficiently large shocks to financing—on top of having a direct effect on one group of innovators—can also lead to a reallocation across more and less affected organizational forms. At the same time, to the extent that the shock actually induces a cleansing effect (Caballero et al., 1994), the overall effect on technological progress could be substantially lower.

These results are particularly useful in the context of the contemporaneous debate regarding a reduction in dynamism in the economy. For instance, these results are consistent with (Guzman and Stern, 2016), that have highlighted the importance of adjusting for the quality of start-ups in order to study dynamism. Clearly, our results, which cover a different historical period, cannot directly speak to whether dynamism declined or not today and in particular after the Great Recession. However, the main intuition from the paper will also apply to modern economies. Furthermore, this paper also provides novel evidence that can help our understanding of the large shift in the organization of innovation that characterized the US economy between 1920 and 1930. In particular, our findings suggest that the relative increase in firm innovation relative to independent innovation does not only reflect a technological change, but it is also explained by the negative effect of the Great Depression.

full count censuses that allow us to observe individual-level migration patterns.

References

Adelino, M., Ma, S., Robinson, D., 2017. Firm Age, Investment Opportunities, and Job Creation. Journal of Finance 72, 999–1038.

Aghion, P., Tirole, J., 1994. The management of innovation. The Quarterly Journal of Economics 109, 1185–1209.

Akcigit, U., Grigsby, J., Nicholas, T., 2017. The Rise of American Ingenuity: Innovation and Inventors of the Golden Age. Working Paper 23047, National Bureau of Economic Research.

Akkoyun, H. C., 2018. Investor protection and financing innovation: Evidence from blue sky laws .

Ante, S. E., 2008. Creative capital: Georges Doriot and the birth of venture capital. Harvard Business Press.

Babina, T., Garcia, D., Tate, G. A., 2017. Friends during hard times: evidence from the great depression. Columbia Business School Research Paper .

Bassetto, M., Cagetti, M., De Nardi, M., 2015. Credit crunches and credit allocation in a model of entrepreneurship. Review of Economic Dynamics 18, 53–76.

Bell, A., Chetty, R., Jaravel, X., Petkova, N., Van Reenen, J., 2019. Who becomes an inventor in america? the importance of exposure to innovation. The Quarterly Journal of Economics 134, 647–713.

Benmelech, E., Frydman, C., Papanikolaou, D., 2017. Financial Frictions and Employment during the Great Depression. Tech. rep., National Bureau of Economic Research.

Berkes, E., 2016. Comprehensive Universe of U.S. Patents (CUSP): Data and Facts. Working Paper.

Bernanke, B. S., 1983. Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression. The American Economic Review 73, 257–276.

Bernstein, S., Giroud, X., Townsend, R. R., 2016. The impact of venture capital monitoring. The Journal of Finance 71, 1591–1622.

Bertrand, M., Duflo, E., Mullainathan, S., 2004. How Much Should We Trust Differences-In-Differences Estimates? The Quarterly Journal of Economics 119, 249–275.

Caballero, R. J., Hammour, M. L., others, 1994. The Cleansing Effect of Recessions. American Economic Review 84, 1350–1368.

Calomiris, C. W., Mason, J. R., 2003. Fundamentals, Panics, and Bank Distress During the Depression. American Economic Review 93, 1615–1647.

Cole, H. L., Ohanian, L. E., 2007. A second look at the us great depression from a neoclassical perspective. Great depressions of the twentieth century. Minneapolis: Federal Reserve Bank of Minneapolis pp. 21–58.

Duval, R., Hong, G. H., Timmer, Y., 2020. Financial frictions and the great productivity slowdown. The Review of Financial Studies 33, 475–503.

Eichengreen, B., 2004. Understanding the great depression. The Canadian Journal of Economics/Revue canadienne d'Economique 37, 1–27.

Feigenbaum, J. J., 2015. Intergenerational mobility during the great depression .

Field, A. J., 2003. The most technologically progressive decade of the century. American Economic Review 93, 1399–1413.

Fishback, P. V., Horrace, W. C., Kantor, S., 2001. The impact of new deal expenditures on local economic activity: An examination of retail sales, 1929-1939. Tech. rep., National Bureau of Economic Research.

Fishback, P. V., Horrace, W. C., Kantor, S., 2006. The impact of new deal expenditures on mobility during the great depression. Explorations in Economic History 43, 179–222.

Fishback, P. V., Kantor, S., Wallis, J. J., 2003. Can the new deal's three rs be rehabilitated? a program-by-program, county-by-county analysis. Explorations in Economic History 40, 278–307.

Friedman, M., Schwartz, A. J., 1963. A Monetary history of the US 1867-1960. Princeton University Press.

Gompers, P. A., Gornall, W., Kaplan, S. N., Strebulaev, I. A., 2019. How do venture capitalists make decisions? Journal of Financial Economics .

Gorton, G., Laarits, T., Muir, T., 2019. 1930: First modern crisis. Tech. rep., National Bureau of Economic Research.

Gorton, G., Metrick, A., 2013. The federal reserve and panic prevention: The roles of financial regulation and lender of last resort. Journal of Economic Perspectives 27, 45–64.

Gourio, F., Messer, T., Siemer, M., 2016. Firm Entry and Macroeconomic Dynamics: A State-Level Analysis. American Economic Review 106, 214–218.

Gromb, D., Scharfstein, D., 2002. Entrepreneurship in equilibrium. Tech. rep., National bureau of economic research.

Guzman, J., Stern, S., 2016. The State of American Entrepreneurship: New Estimates of the Quantity and Quality of Entrepreneurship for 15 US States, 1988-2014. Working Paper 22095, National Bureau of Economic Research.

Haines, M. R., et al., 2010. Historical, demographic, economic, and social data: the united states, 1790–2002. Ann Arbor, MI: Inter-university Consortium for Political and Social Research .

Hall, B. H., Lerner, J., 2010. The financing of r&d and innovation. In: *Handbook of the Economics of Innovation*, Elsevier, vol. 1, pp. 609–639.

Hall, R. E., 2015. Quantifying the lasting harm to the us economy from the financial crisis. NBER Macroeconomics Annual 29, 71–128.

Haltiwanger, J., Jarmin, R. S., Miranda, J., 2012. Who Creates Jobs? Small versus Large versus Young. The Review of Economics and Statistics 95, 347–361.

Hellmann, T., 2007. When do employees become entrepreneurs? Management science 53, 919–933.

Huber, K., 2018. Disentangling the effects of a banking crisis: evidence from german firms and counties. American Economic Review 108, 868–98.

Hughes, T. P., 2004. American genesis: a century of invention and technological enthusiasm, 1870-1970. University of Chicago Press.

Jacoby, N. H., Saulnier, R. J., 1947. Business finance and banking. In: *Business Finance and Banking*, NBER, pp. 221–230.

Jaffe, A. B., Trajtenberg, M., Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. the Quarterly journal of Economics 108, 577–598.

Jaremski, M. S., Wheelock, D. C., 2018. Banking on the Boom, Tripped by the Bust: Banks and the World War I Agricultural Price Shock. Working Paper 25159, National Bureau of Economic Research.

Kelly, B., Papanikolaou, D., Seru, A., Taddy, M., 2018. Measuring technological innovation over the long run. Tech. rep., National Bureau of Economic Research.

Kenney, M., 2011. How venture capital became a component of the us national system of innovation. Industrial and Corporate Change 20, 1677–1723.

Kerr, W. R., Lerner, J., Schoar, A., 2011. The consequences of entrepreneurial finance: Evidence from angel financings. The Review of Financial Studies 27, 20–55.

Kerr, W. R., Lincoln, W. F., 2010. The supply side of innovation: H-1b visa reforms and us ethnic invention. Journal of Labor Economics 28, 473–508.

Lamoreaux, N. R., Levenstein, M., Sokoloff, K. L., 2006. Mobilizing venture capital during the second industrial revolution: Cleveland, ohio, 1870-1920. Capitalism and Society 1.

Lamoreaux, N. R., Sokoloff, K. L., 2001a. Market trade in patents and the rise of a class of specialized inventors in the 19th-century united states. American Economic Review 91, 39–44.

Lamoreaux, N. R., Sokoloff, K. L., 2001b. Market Trade in Patents and the Rise of a Class of Specialized Inventors in the 19th-Century United States. American Economic Review 91, 39–44.

Lamoreaux, N. R., Sokoloff, K. L., 2005. The Decline of the Independent Inventor: A Schumpterian Story? Working Paper 11654, National Bureau of Economic Research.

Lamoreaux, N. R., Sokoloff, K. L., Sutthiphisal, D., 2009. The Reorganization of Inventive Activity in the United States during the Early Twentieth Century. Working Paper 15440, National Bureau of Economic Research.

Landes, D. S., Mokyr, J., Baumol, W. J., 2012. The invention of enterprise: Entrepreneurship from ancient Mesopotamia to modern times. Princeton University Press.

Lee, J., Mezzanotti, F., 2017. Bank Distress and Manufacturing: Evidence from the Great Depression. Tech. rep.

Luttmer, E. G. J., 2012. Technology diffusion and growth. Journal of Economic Theory 147, 602–622.

Manso, G., Balsmeier, B., Fleming, L., 2019. Heterogeneous innovation and the antifragile economy .

Margo, R. A., 1993. Employment and unemployment in the 1930s. Journal of Economic Perspectives 7, 41–59.

Moreira, S., 2016. Firm dynamics, persistent effects of entry conditions, and business cycles. Persistent Effects of Entry Conditions, and Business Cycles (October 1, 2016) .

Moretti, E., 2019. The effect of high-tech clusters on the productivity of top inventors. Tech. rep., National Bureau of Economic Research.

Moser, P., 2005. How do patent laws influence innovation? evidence from nineteenth-century world's fairs. American economic review 95, 1214–1236.

Moser, P., Voena, A., Waldinger, F., 2014. German jewish émigrés and us invention. American Economic Review 104, 3222–55.

Nanda, R., Nicholas, T., 2014. Did bank distress stifle innovation during the Great Depression? Journal of Financial Economics 114, 273–292.

Nicholas, T., 2008. Does innovation cause stock market runups? evidence from the great crash. American Economic Review 98, 1370–96.

Nicholas, T., 2010. The role of independent invention in US technological development, 1880-1930. The Journal of Economic History 70, 57–82.

Rajan, R., Ramcharan, R., 2015. The Anatomy of a Credit Crisis: The Boom and Bust in Farm Land Prices in the United States in the 1920s. American Economic Review 105, 1439–1477.

Richardson, G., 2007. Categories and causes of bank distress during the great depression, 1929–1933: The illiquidity versus insolvency debate revisited. Explorations in Economic History 44, 588–607.

Richardson, G., Troost, W., 2009. Monetary intervention mitigated banking panics during the great depression: quasi-experimental evidence from a federal reserve district border, 1929–1933. Journal of Political Economy 117, 1031–1073.

Romer, C. D., 1993. The nation in depression. Journal of Economic Perspectives 7, 19–39.

Sarada, S., Andrews, M. J., Ziebarth, N. L., 2019. Changes in the demographics of american inventors, 1870–1940. Explorations in Economic History 74, 101275.

Schumpeter, J. A., 1942. Capitalism, socialism, and democracy.

Shane, S., 2008. Fool's Gold?: The truth behind angel investing in America. Oxford University Press.

Siemer, M., 2016. Firm entry and employment dynamics in the great recession. Available at SSRN 2172594 .

Teece David, J., 1988. Technological change and the nature of the firm. Giovanni Dosi .

Temin, P., et al., 1976. Did monetary forces cause the Great Depression? Norton.

Ziebarth, N., 2013. Identifying the Effects of Bank Failures from a Natural Experiment in Mississippi during the Great Depression. American Economic Journal: Macroeconomics 5, 81–101.

Figure 1: Patents Filed by Technology Class

The figure shows the annual number of patents filed by patent technology class. The technology classes correspond to the highest level of Cooperative Patent Classification (CPC) classifications by the U.S. Patent and Trademark Office (USPTO). The sample is the universe of all patents granted by the USPTO to U.S. inventors or firms.

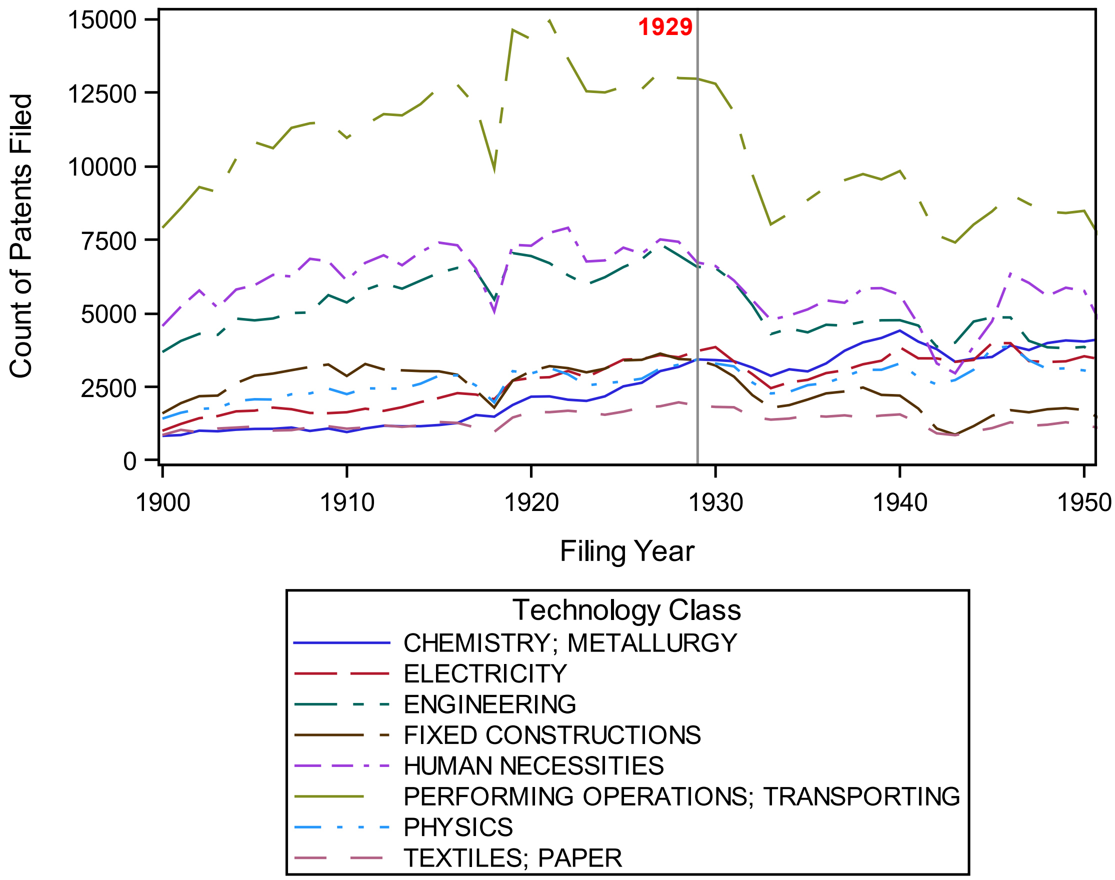


Figure 2: Aggregate Number of Patents by Patent Type

The figure shows the annual number of patents filed by patent type. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO). Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. U.S. Firm are patents that were assigned to a U.S. company at the time of the patent grant date.

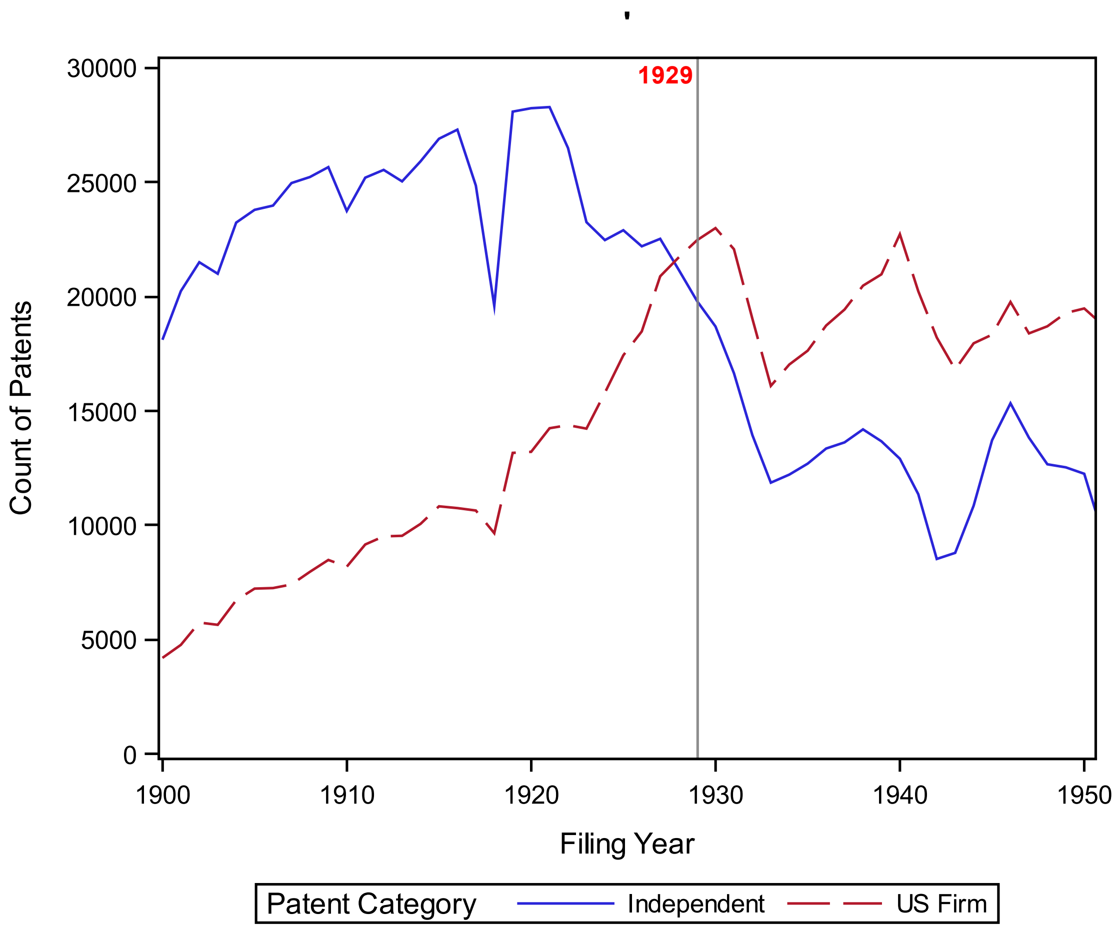


Figure 4: Bank Distress During the Great Depression and Independent Innovation Quantity

The figure shows estimates from a differences-in-differences regression of the number of independent patents on bank distress during the Great Depression. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all independent patents granted by the U.S. Patent and Trademark Office (USPTO). Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. The unit of observation is county-time, where time is five years. The dependent variable is the logarithm of one plus the number of independent patents filed over five-year periods within each county. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on independent innovations are the coefficients on the interaction between Bank Distress and five-year indicators that measure the relative change in patenting in areas with high bank distress relative to the reference period of 1925–1929. Specifically, we plot betas and 95% confidence intervals from a differences-in-differences regression:

$$Ln(NumberPatents + 1)_{cst} = \alpha_c + \gamma_{st} + \sum \beta_t \, 1_t \, BankDistress_{cs} + \epsilon_{cst} \quad (2)$$

where c denotes county, s – state, and t – five-year period. α_c is county fixed effects; γ_{st} is state-time fixed effects; five-year indicators equal 1 for a given time period (e.g., 1900-04), and 0 otherwise. Errors are clustered at county-level.

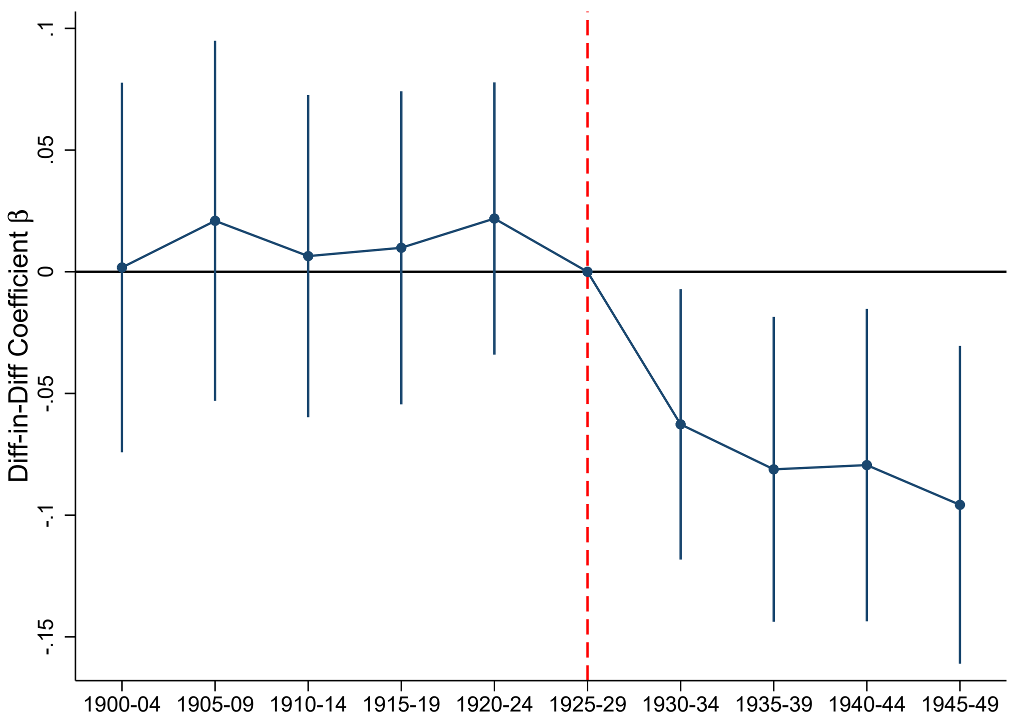
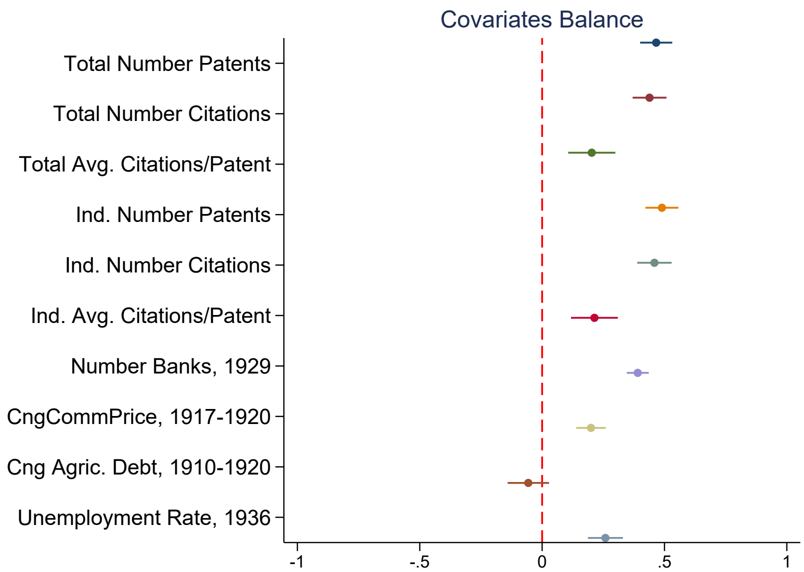


Figure 3: Covariates Across Counties With and Without Bank Distress

The figures report the balance of covariates across two specifications: (1) controlling for state fixed-effects (part a); (2) controlling for both state fixed-effect and (log) population in 1920 (part b). Specifically, the figures report the plot of the coefficients from a regression where our main treatment variable—dummy equal one for a county with distress—on the variable reported in the legend. Each variable is z-scored to facilitate the comparison between variables. For patent counts variables, we also apply a log transformation, consistent with the analyses in the main tables. Coefficient estimates and 95% confidence interval are displayed as well.

(a) Difference within-state



(b) Difference within-state and adjusting for population

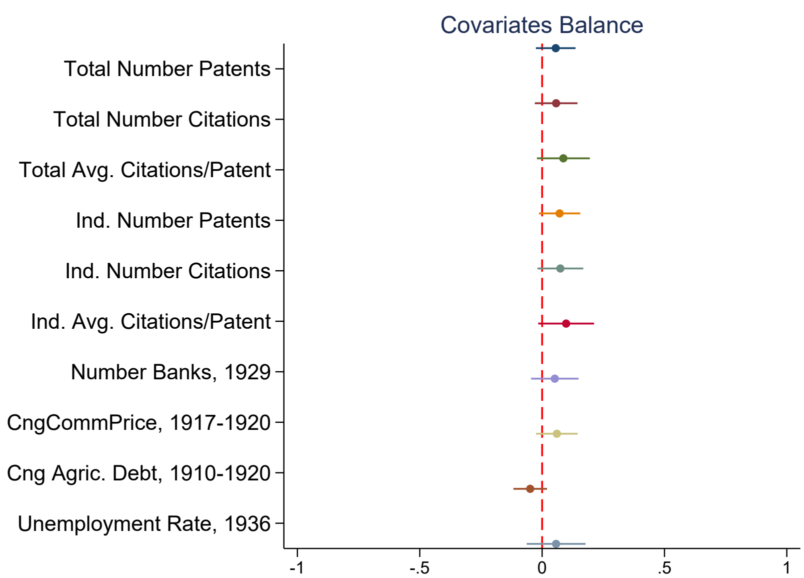


Figure 5: Bank Distress and Independent Patent Quality (Total Citations)

The figure shows estimates from a differences-in-differences regression of the total number of future patent citations citing independent patents on bank distress during the Great Depression. The sample of independent patents is the universe of all independent patents granted by the U.S. Patent and Trademark Office (USPTO). The sample of future patent citations comes from the universe of all citing patents granted by the USPTO, including independent, U.S firm, and non-U.S. patents. The unit of observation is county-time, where time is a five-year period. We start the sample with the 1910--1914 period because citations data start in 1910. The dependent variable is the logarithm of the total number of future patent citations citing independent patents filed over five-year periods within each county. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on independent innovations are the coefficients on the interaction between Bank Distress and five-year indicators that measure the relative change in patenting between areas with higher bank distress relative to the reference period of 1925–1929. Specifically, we plot betas and 95% confidence intervals from the differences-in-differences regression:

$$Ln(NumberPatentCitations + 1)_{cst} = \alpha_c + \gamma_{st} + \sum \beta_t \, 1_t \, BankDistress_{cs} + \epsilon_{cst} \tag{3}$$

where c denotes a county, s – a state, and t – a five-year period. α_c is county fixed effects; γ_{st} is state-time fixed effects; five-year indicators equal 1 for a given time period (e.g., 1910-14), and 0 otherwise. Errors are clustered at county-level.

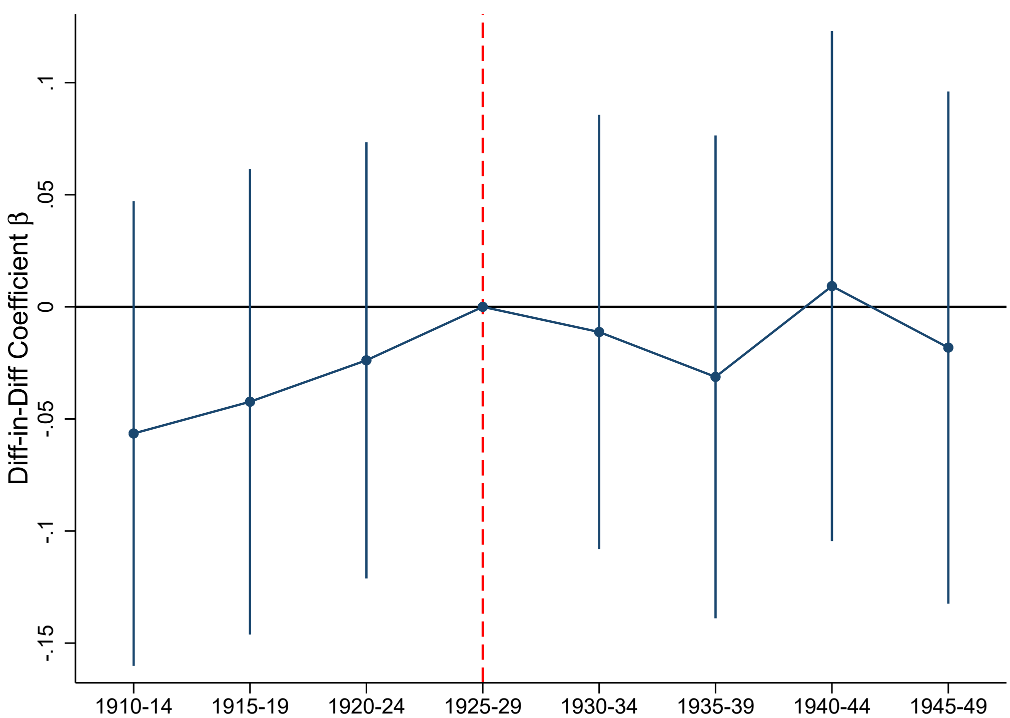


Figure 6: Bank Distress and Independent Patent Quality
(Average Citations/Patent)

The figure shows estimates from a differences-in-differences regression of the average independent patent quality on bank distress during the Great Depression. The sample of independent patents is the universe of all independent patents granted by the U.S. Patent and Trademark Office (USPTO). The sample of future patent citations comes from the universe of all citing patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-time, where time is five-year period. We start the sample with the 1910-1914 period because citations data start in 1910. The dependent variable is the logarithm of one plus the average future patent citations, which is equal to the total number of future patent citations citing independent patents filed over five-year periods within each county divided by the number of independent patents. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on independent innovations are the coefficients on the interaction between Bank Distress and five-year indicators that measure the relative change in patenting between areas with higher bank distress relative to the reference period of 1925–1929. Specifically, we plot betas and 95% confidence intervals from the differences-in-differences regression:

$$Ln(AverageCitations/Patent + 1)_{cst} = \alpha_c + \gamma_{st} + \sum \beta_t \, 1_t \, BankDistress_{cs} + \epsilon_{cst} \quad (4)$$

where c denotes a county, s – a state, and t – a five-year period. α_c is county fixed effects; γ_{st} is state-time fixed effects; five-year indicators equal 1 for a given time period (e.g., 1910-14), and 0 otherwise. Errors are clustered at county-level.

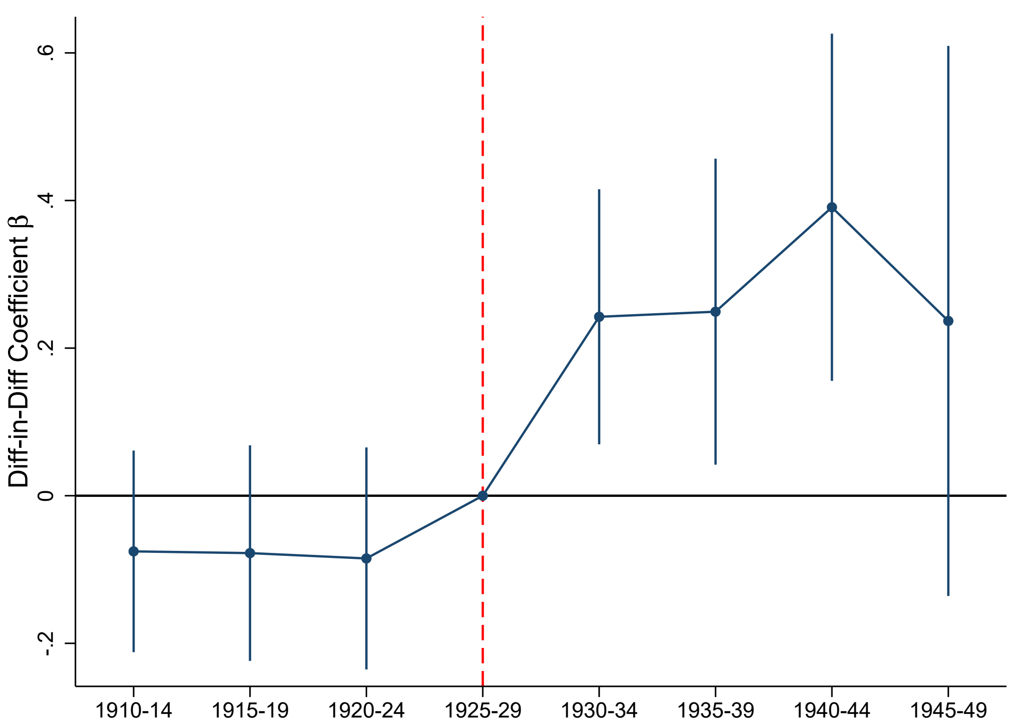


Table 1: County-Level Summary Statistics

The table shows summary statistics across two groups of counties: all and counties distressed during the Great Depression—counties with at least one bank suspension over 1930–1933 (Bank Distress equals one). For patent counts variables, we also apply a log transformation, consistent with the analyses in the main tables. Bank Distress % is calculated as the cumulative number of bank suspensions from 1930 through 1933 as a share of total banks in 1929.

	All Counties			***Counties w/ Suspensions***		
	Mean	Std.Dev.	NumObs	Mean	Std.Dev.	NumObs
1920s Patenting per county (log):						
Number Patents	2.72	1.63	2975	3.04	1.62	2129
Number Citations	3.24	1.96	2975	3.60	1.92	2129
Average Citations/Patent	1.00	0.47	2975	1.04	0.41	2129
Independent:						
Number Patents	2.60	1.50	2975	2.90	1.48	2129
Number Citations	3.10	1.84	2975	3.45	1.79	2129
Average Citations/Patent	0.99	0.48	2975	1.03	0.42	2129
US Firms:						
Number Patents	1.05	1.65	2975	1.25	1.78	2129
Number Citations	1.29	2.01	2975	1.52	2.15	2129
Average Citations/Patent	0.49	0.66	2975	0.56	0.67	2129
Banking County-level Variables:						
Bank Distress	0.72	0.45	2975	1.00	0.00	2129
Bank Distress %	0.30	0.28	2975	0.42	0.24	2129
Number Banks, 1929	8.12	10.28	2975	9.88	11.54	2129
Misc. County-level Variables:						
Population, 1920 (log)	9.81	0.98	2948	9.99	0.94	2116
CngCommPrice, 1917-1920	3.58	2.51	2829	3.90	2.58	2055
Cng Agric. Debt, 1910-1920	2.89	0.74	2418	2.80	0.70	1798
Unemployment Rate, 1936	0.01	0.01	2973	0.01	0.01	2127
Value Crops, 1910 (log)	14.09	1.06	2812	14.29	0.95	2051
Chg Retail Sales, 1929-1933	-0.48	0.23	2941	-0.49	0.21	2105

Table 2: Bank Distress During the Great Depression and Innovation Quantity

The table shows estimates from a differences-in-differences regression of the number of patents by patent type on bank distress during the Great Depression. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The unit of observation is county-decade, for the period 1910-1940. In column 1, the dependent variable is the logarithm of one plus the number of all U.S. patents filed over ten-year periods within each county. In column 2, we limit the sample to patents assigned to U.S. firms and define the dependent variable as the logarithm of one plus the number of U.S. firm patents filed over ten-year periods within each county. In column 3, we limit the sample to independent patents and define the dependent variable as the logarithm of one plus the number of independent patents filed over ten-year periods within each county. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln(# Total Patents+1)	(2) Ln(# Firm Patents+1)	(3) Ln(# Ind. Patents+1)
BankDistress X After1929	-0.105***	0.016	-0.127***
	(-3.42)	(0.60)	(-4.47)
StateXTime FE	Y	Y	Y
County FE	Y	Y	Y
Start Decade	1910	1910	1910
End Decade	1940	1940	1940
Adj R-Sq	0.903	0.896	0.895
Obs	11,900	11,900	11,900

Table 3: Bank Distress, Other Economic Shocks, and Independent Innovation during the Great Depression

The table shows that the results on lower independent patenting in high bank distress counties during the Great Depression remain robust to controlling for other economic shocks. The sample is the universe of independent patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. The unit of observation is county-decade, for the period 1910-1940. In columns 1 through 6, the dependent variable is the logarithm of one plus the number of independent patents filed over ten-year periods within each county. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. In columns 1 and 2, respectively, we control for the size of counties, as proxied by the logarithm of county's population as of 1920 U.S. Census, and a dummy for counties with less than six banks as of 1929. In column 3, we control for the importance of manufacturing proxy by the share of population in manufacturing over total population (times 100). In columns 4 and 5, we control for the county-level demand shocks to make sure the results are not driven by changes in local demand. ChgRtlSales, 1929-1933 is the county-level change in retail sales, defined as log difference in retail sales in 1933 and 1929. Unemployment, 1936 is the county-level unemployment rate during the 1937 recession. All these controls are interacted with the After1929 indicator. Finally, in column 6 we control for all of these variables together. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Ln(# Independent Patents+1)					
	(1)	(2)	(3)	(4)	(5)	(6)
BankDistress X After1929	-0.082***	-0.126***	-0.125***	-0.089***	-0.125***	-0.065**
	(-2.78)	(-4.40)	(-4.35)	(-3.04)	(-4.34)	(-2.22)
Ln(Population, 1920) X After1929	-0.092***					-0.110***
	(-6.00)					(-5.74)
Unemployment, 1936 X After1929		-0.498				1.531
		(-0.31)				(0.80)
Manuf./Pop., 1929 X After1929			0.002			0.006***
			(1.09)			(3.61)
<6 Banks, 1929 X After1929				0.134***		0.040
				(4.92)		(1.30)
Chg Retail Sales, X After1929					-0.041	-0.010
					(-0.64)	(-0.16)
StateXTime FE	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910	1910	1910
End Decade	1940	1940	1940	1940	1940	1940
Adj R-Sq	0.896	0.895	0.892	0.895	0.892	0.894
Obs	11,792	11,892	11,768	11,900	11,764	11,676

Table 4: Bank Distress During the Great Depression and Independent Innovation Across Technology Classes

The table shows estimates from a differences-in-differences regression of the number of independent patents across technology classes on bank distress during the Great Depression. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all independent patents granted by the U.S. Patent and Trademark Office (USPTO). Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. The unit of observation is county-decade-technology class in columns 1 and 2, and county-decade in columns 3 through 7, for the period 1910-1940. In columns 1 through 7, the dependent variable is the logarithm of one plus the number of independent patents. In columns 1 and 2, we count patents within each county-decade-technology class. In columns 3 through 7, we limit the sample to 5 biggest patent technology classes in 1920s: column 3 – human necessities (CPC class A); column 4 – performing operations or transporting (CPC class B); column 5 – fixed constructions (CPC class E); column 6 – mechanical engineering, lighting, heating, weapons, blasting engines or pumps (CPC class F); column 7 – physics (CPC class G). Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Ln(# Independent Patents+1)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BankDistress X After1929	-0.140***	-0.140***	-0.142***	-0.156***	-0.151***	-0.148***	-0.101***
	(-8.78)	(-8.72)	(-5.63)	(-5.79)	(-6.65)	(-6.01)	(-5.30)
StateXTime FE	Y	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y	Y
TechnologyXStateXTime FE	N	Y	N	N	N	N	N
Technology	All	All	A	B	E	F	G
Start Decade	1910	1910	1910	1910	1910	1910	1910
End Decade	1940	1940	1940	1940	1940	1940	1940
Adj R-Sq	0.733	0.830	0.842	0.859	0.789	0.823	0.804
Obs	59,500	59,500	11,900	11,900	11,900	11,900	11,900

Table 5: The 1917-1920 Agricultural Shock and Innovation during the Great Depression

The table presents estimates from a differences-in-differences regression and shows the relationship between the 1917-1920 agricultural shock and subsequent innovation during the Great Depression. The estimation strategy relies on cross-sectional variation in the shock across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The unit of observation is county-decade, for the period 1910-1940. In all columns, the independent variable, CngCommPrice, 1917-1920 X After 1929, is the interaction between After1929 indicator and CngCommPrice, 1917-1920, which is the county-level change from 1917 to 1920 in the international commodity price index calculated for each county, where weights are the crop share of a given farm product out of total county farm output and prices are international farm product prices (Rajan and Ramcharan 2015). In column 1, the dependent variable is the interaction between After1929 indicator, which equals one for the observations starting from the 1930s decade, and Bank Distress indicator, which equals 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. In column 2, we limit the sample to independent patents and define the dependent variable as the logarithm of one plus the number of independent patents filed over ten-year periods within each county. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In columns 3, the dependent variable is the logarithm of one plus the number of all patents filed over ten-year periods within each county. The estimates of the effect of the agricultural shock on patents are the coefficients on the interaction between CngCommPrice, 1917-1920 and After1929. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) BankDistress X After1929	(2) Ln(# Ind. Patents+1)	(3) Ln(# Total Patents+1)
CngCommPrice, 1917-1920 X After1929	0.029***	-0.050***	-0.043***
	(6.53)	(-7.79)	(-6.26)
StateXTime FE	Y	Y	Y
County FE	Y	Y	Y
Start Decade	1910	1910	1910
End Decade	1940	1940	1940
Adj R-Sq	0.767	0.897	0.905
Obs	11,316	11,316	11,316

Table 6: Bank Distress During the Great Depression and Innovation Quantity in the Long Run

The table shows estimates from a differences-in-differences regression of the number of patents on bank distress during the Great Depression in the long-run. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The unit of observation is county-decade, where decades include 1910 through 1990. In column 1, the dependent variable is the logarithm of one plus the number of all patents filed over ten-year periods within each county. In column 2, we limit the sample to patents assigned to U.S. firms. In column 3, we limit the sample to independent patents. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. In the short run, the estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. In the long run, the estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1939 indicator, which equals one for observations starting with the 1940 decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln(# Tot. Pat.+1)	(2) Ln(# Firm Pat.+1)	(3) Ln(# Ind. Pat.+1)
BankDistress X After1929	-0.101***	0.014	-0.116***
	(-3.07)	(0.50)	(-3.70)
BankDistress X After1939	-0.023	0.129***	-0.094***
	(-0.66)	(3.39)	(-3.05)
StateXTime FE	Y	Y	Y
County FE	Y	Y	Y
Start Decade	1910	1910	1910
End Decade	1990	1990	1990
Adj R-Sq	0.875	0.857	0.863
Obs	26,775	26,775	26,775

Table 7: Bank Distress During the Great Depression and Innovation Quality

The table shows estimates from a differences-in-differences regression looking at quality metrics. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The sample of future patent citations includes the universe of all patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-decade, for the period 1910-1940. In column 1, the dependent variable is the logarithm of one plus the total number of future patent citations citing all independent patents filed over each ten-year period within a county. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In column 2, we repeat the same analysis looking at all patents (firms and independent inventors). In column 3, we instead look at the (logarithm plus one) of the average number of citations received by independent patents. In column 4, we repeat the same analysis looking at all patents. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln(Ind. # Cit)	(2) Ln(Total # Cit.)	(3) Ind. Avg Citations	(4) Tot. Avg Citations
BankDistress X After1929	0.013	0.031	0.137***	0.125***
	(0.29)	(0.67)	(4.98)	(4.58)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.802	0.825	0.368	0.398
Obs	11,900	11,900	11,900	11,900

Table 8: Bank Distress During the Great Depression and Quality Distribution

The table shows estimates from a differences-in-differences regression looking at quality metrics. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The sample of future patent citations includes the universe of all patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-decade, for the period 1910-1940. In column 1, the dependent variable is the total number of independent patents in the top 1% of the citation distribution of the corresponding CPC during 1910-1940 that were filed in the county-decade. In column 2, the dependent variable is the total number of independent patents in the bottom 99% of the citation distribution of the corresponding CPC during 1910-1940 that were filed in the county-decade. In column 3 and 4, we construct equivalent outcomes but looking at the top 10% and bottom 90%. The outcome is always transformed as logarithm plus one. We also always control for population in 1920 interacted with a post-dummy Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Top 1%	(2) Bot. 99%	(3) Top 10%	(4) Bot. 90%
BankDistress X After1929	0.012	-0.083***	-0.013	-0.083***
	(1.08)	(-2.82)	(-0.63)	(-2.83)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.753	0.895	0.839	0.892
Obs	11,792	11,792	11,792	11,792

Table 9: Bank Distress During the Great Depression and Individual Inventor Patenting During the 1930s among Independent Inventors of the 1920s

The table examines the potential reallocation of independent inventors into firms during the 1930s in counties with greater bank distress during the Great Depression. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. To test for reallocation, we limit the sample to individual U.S. inventors who: 1) had at least one independent patent granted by the U.S. Patent and Trademark Office (USPTO) during the 1920s; and 2) had at least one patent grant during the 1930s; and 3) we could find the location of operation in 1920 and 1930 censuses. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In all columns, the dependent variable equals 1 if the inventor obtains at least one patent assigned to a U.S. firm in the 1930s, and 0 if he obtains at least one independent patent in the 1930s. Column 1 includes state fixed effects. Column 2 adds additional county-level controls (population 1920) while column 3 adds another set of individual level controls based on the 1920 census (homeownership, inventor age, stauts as an entrepreneur, and gender). Bank Distress % is defined at the county-level and equal to the ratio of bank deposits at banks suspended between 1930 and 1933 divided by total banks deposits in 1929. The results with other definitions of bank distress variable are in Table A.11. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Firm Pat	(2) Firm Pat	(3) Firm Pat
Bank Distress >Med	0.020*	0.025**	0.024**
	(1.69)	(2.07)	(2.05)
State FE	Y	Y	Y
Patent Post	Y	Y	Y
Pre Ind Pat	Y	Y	Y
County Controls	N	Y	Y
Ind. Controls	N	N	Y
Adj R-Sq	0.019	0.020	0.026
Obs	5,295	5,294	5,294

Table 10: Bank Distress During the Great Depression and Individual Inventor Geographic Mobility During the 1930s

The table examines the potential geographic mobility of inventors away from counties with greater bank distress during the Great Depression. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. To test for geographic mobility, we limit the sample to individual U.S. inventors who had at least one patent granted by the U.S. Patent and Trademark Office (USPTO) during the 1930s. In all columns, the dependent variable equals 1 if the inventor' county in the 1940 complete count Census is different from the county where he lived as of the 1920 Census. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. Bank Distress % is defined at the county-level and equal to the ratio of bank deposits at banks suspended between 1930 and 1933 divided by total banks deposits in 1929. Bank Distress > Median is an indicator variable equal to 1 for counties with an above median % of deposits in suspended banks, calculated as the cumulative deposits in bank suspended from 1930 through 1933 as a share of bank deposits in 1929. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Move County	(2) Move County	(3) Move County
Bank Distress >Med	-0.002		
	(-0.21)		
Bank Distress %		0.026	
		(1.30)	
Bank Distress			0.003
			(0.30)
State FE	Y	Y	Y
Patent Pre	Y	Y	Y
Controls	Y	Y	Y
Adj R-Sq	0.030	0.030	0.030
Obs	66,693	66,693	66,693

Internet Appendix

Figure 1: Independent Patents and Employment in Young Firms in Time Series

Figure plots an annual fraction of independent US patents (in red) and the fraction of employment in young firms (in blue), and shows that the two measures are correlated in time-series. The patent data sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The new firm sample is the universe of employer firms covered by the U.S. Census LBD database.

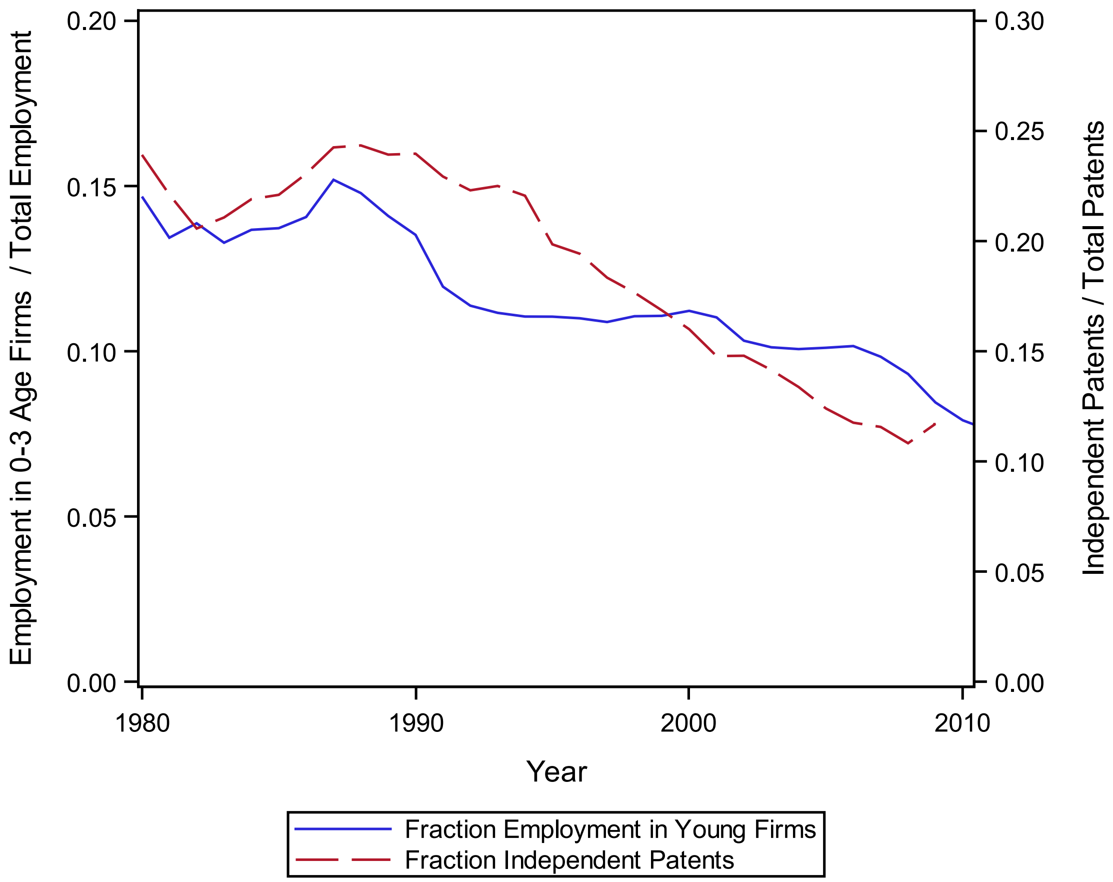
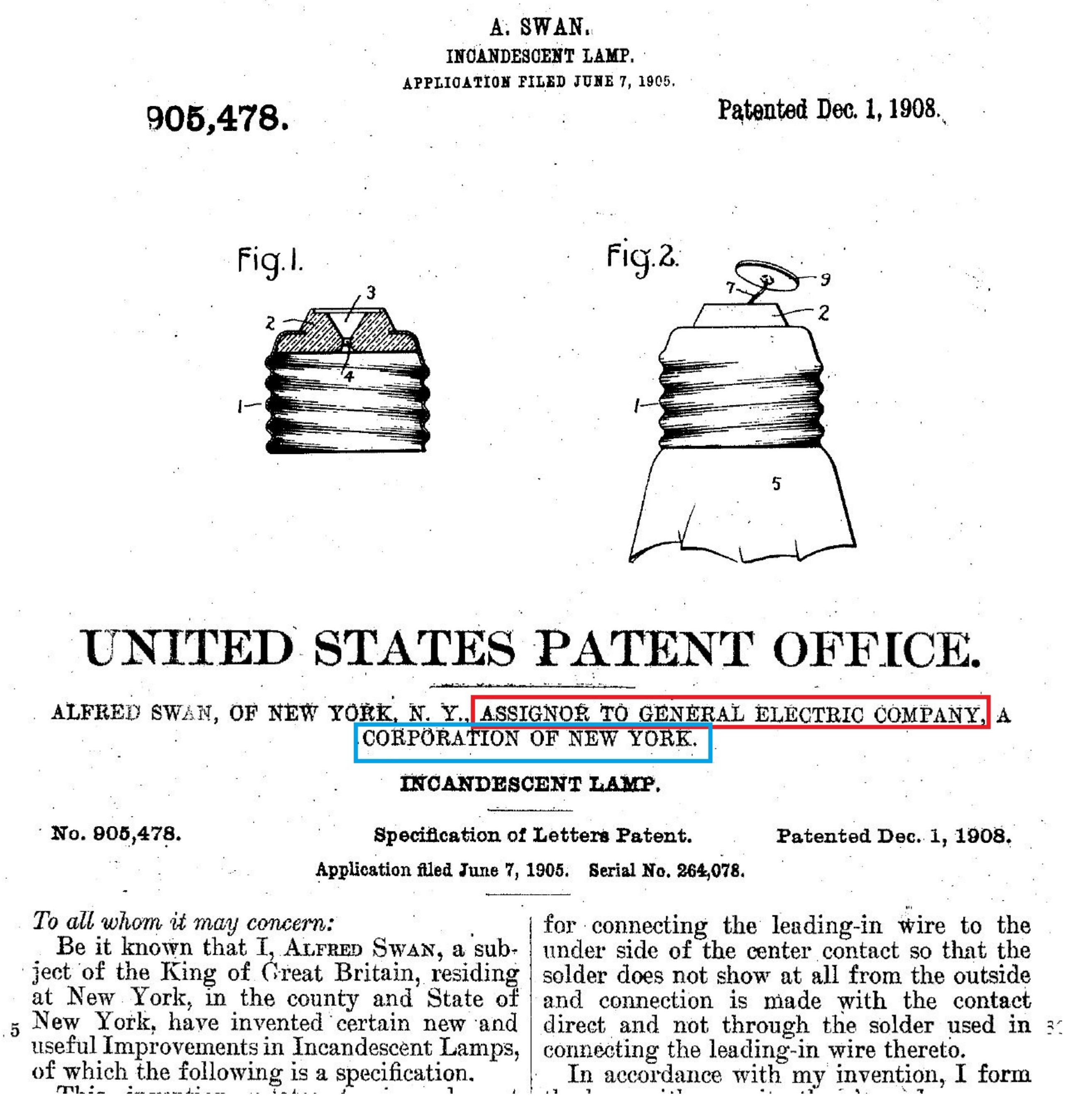


Figure 2: Example Firm Patent

Figure shows an example of a patent assigned to a U.S. firm (e.g., General Electric) by the U.S. Patent and Trademark Office (USPTO) at the time of the patent grant. Patents assigned to firms are usually produced by inventors employed within large firms with in-house R&D labs who would have been contractually obliged to assign their inventions to their employers (Lamoreaux, Sokoloff, and Sutthiphisal 2009; Nicholas 2010).


A. SWAN.
INCANDESCENT LAMP.
APPLICATION FILED JUNE 7, 1905.

905,478. Patented Dec. 1, 1908.

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.

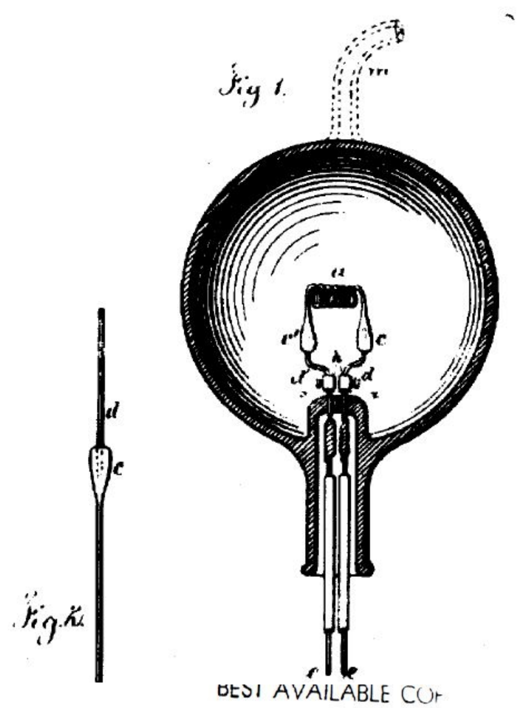
In accordance with my invention, I form

Figure 3: Example Independent Patent

Figure shows an example of an independent issued by the U.S. Patent and Trademark Office (USPTO). The independent inventors produced inventions on their own means or through financing by local angel investors (Lamoreaux, Sokoloff, 2005; Lamoreaux, Sokoloff, and Sutthiphisal 2009; Nicholas 2010). These patents are usually either unassigned, assigned to the inventor, or other individuals (e.g., investors). Independent inventors usually either sold off their patents to large firms for commercialization or founded own startups for commercialization. The patent displayed in this figure is the famous light-bulb invention by Thomas Edison, who in 1880 founded a Edison Electric Light Company to market his hew invention.

T. A. EDISON.
Electric-Lamp.

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



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.

The object of this invention is to produce

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.

The use of a gas in the receiver at the at-

Table A.1: Robustness: Different Measures of Bank Distress and Innovation Quantity

The table shows that the results on independent patenting remain robust when using different measures of distress. The sample is the universe of independent patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. The unit of observation is county-decade, for the period 1910-1940. In all columns, the dependent variable is the logarithm of the number of independent patents filed over ten-year periods within each county. In columns 1 and 4, we use the standard treatment variable, defined as one if there is any bank suspension in the county from 1930 through 1933. In columns 2 and 4, Bank Distress > Median is an indicator variable equal to 1 for counties with an above median % of deposits in suspended banks, calculated as the cumulative deposits in bank suspended from 1930 through 1933 as a share of bank deposits in 1929. In columns 3 and 6, we measure bank distress splitting at the bottom quartile, with a variable that is one is above the bottom quartile of the share of bank deposit affected. While columns 1-3 use the standard specification, columns 4-6 also include controls for size (population) interacted with the After1929 indicator. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Ln(# Independent Patents+1)					
	(1)	(2)	(3)	(4)	(5)	(6)
Bank Distress X After1929	-0.127***			-0.082***		
	(-4.47)			(-2.78)		
Bank Distress>Med X After1929		-0.053**			-0.053**	
		(-2.24)			(-2.28)	
depsusp33_top75Xafter1929			-0.127***			-0.082***
			(-4.47)			(-2.78)
Ln(Population, 1920) X After1929				-0.092***	-0.103***	-0.092***
				(-6.00)	(-6.98)	(-6.00)
StateXTime FE	Y	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910	1910	1910
End Decade	1940	1940	1940	1940	1940	1940
Adj R-Sq	0.895	0.894	0.895	0.896	0.895	0.896
Obs	11,900	11,900	11,900	11,792	11,792	11,792

Table A.2: Robustness: Different Transformations of Innovation Outcomes

The table shows estimates from a differences-in-differences regression of the number of patents by patent type on bank distress during the Great Depression. The specification, sample, and analyses are exactly the same as the main table in the paper. There are only two differences here. First, we focus only on independent patent count. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In odd columns, we do have not controls, while in even columns we add pre-population control interacted with the post-dummy. Second, the variable independent patenting is transformed differently across columns, as reported at the bottom of the table. In particular, in columns (1) we do the main transformation using log and adding a unit. In column (2), we use only log-transformation without adding a unit. In columns (3), the data is transformed using inverse hyperbolic sine transformation (IHS). Lastly, in column (4) we log transform adding 0.5. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ind. Pat.	(2) Ind. Pat.	(3) Ind. Pat.	(4) Ind. Pat.
BankDistress X After1929	-0.127***	-0.142***	-0.119***	-0.108***
	(-4.47)	(-4.20)	(-3.48)	(-3.17)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
LHS	ln(x+1)	Ln(x)	IHS(x)	Ln(x+.5)
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.895	0.882	0.878	0.874
Obs	11,900	10,666	11,900	11,900

Table A.3: Robustness: Weighting by size

The table shows estimates from a differences-in-differences regression of the number of patents by patent type on bank distress during the Great Depression. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The unit of observation is county-decade, for the period 1910-1940. In column 1, the dependent variable is the logarithm of one plus the number of all U.S. patents filed over ten-year periods within each county. In column 2, we limit the sample to patents assigned to U.S. firms and define the dependent variable as the logarithm of one plus the number of U.S. firm patents filed over ten-year periods within each county. In column 3, we limit the sample to independent patents and define the dependent variable as the logarithm of one plus the number of independent patents filed over ten-year periods within each county. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. We weight observations by the (log) population in 1920, therefore giving more weight to large counties. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln(# Ind. Patents+1)	(2) Ln(# Firm Patents+1)	(3) Ln(# Total Patents+1)
BankDistress X After1929	-0.121***	0.013	-0.099***
	(-4.28)	(0.48)	(-3.24)
StateXTime FE	Y	Y	Y
County FE	Y	Y	Y
Start Decade	1910	1910	1910
End Decade	1940	1940	1940
Adj R-Sq	0.905	0.907	0.913
Obs	11,792	11,792	11,792

Table A.4: Bank Distress, Independent Innovation and the New Deal

The table shows that the results on lower independent patenting in high bank distress counties during the Great Depression remain robust to controlling for variable that proxy the New Deal intensity by county. The sample is the universe of independent patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. The unit of observation is county-decade, for the period 1910-1940. In columns 1 through 4, the dependent variable is the logarithm of one plus the number of independent patents filed over ten-year periods within each county. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. In columns 1 and 2, respectively, we control for the size of the New Deal program in the county proxy by the amount of relief grants in the county per unit of population in 1920. In columns 3 and 4, we repeat the same analysis by instead of using the scaled version, we control for the total amount (log-transform) of relief funds. The data comes from Fishback et al. (2003). Even columns also control for population. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Ln(# Independent Patents+1)			
	(1)	(2)	(3)	(4)
BankDistress X After1929	-0.128***	-0.077***	-0.108***	-0.076***
	(-4.52)	(-2.66)	(-3.73)	(-2.64)
Relief/Pop X After1929	0.001***	0.001**		
	(2.85)	(2.36)		
Ln(Population, 1920) X After1929		-0.095***		-0.237***
		(-6.43)		(-8.98)
Ln(Relief)X After1929			-0.028**	0.134***
			(-2.50)	(6.54)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.893	0.894	0.893	0.895
Obs	11,764	11,764	11,860	11,764

Table A.5: Robustness: Matching Model

The table shows that the results on lower independent patenting in high bank distress counties during the Great Depression remain robust when we employ a matching model based on location, population, and pre-crisis patenting activity. The matching model is described in the text, and the sample considered is the one that is identified following the model discussed. The unit of observation is county-decade, where decades include 1920 and 1930. In columns 1 and 2, the dependent variable is the logarithm of the number of independent patents filed over ten-year periods within each county. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In columns 3 and 4, the dependent variable is the logarithm of the number of firm patents filed over ten-year periods within each county. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. In odd columns there are no controls, while in even columns we control for population in 1920, unemployment rate in 1936, the log difference in retail sales in 1933 and 1929, a dummy for counties with fewer than 6 banks all interacted with the post dummy. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Ln(# Independent Patents+1)		Ln(# Firm Patents+1)	
	(1)	(2)	(3)	(4)
BankDistress X After1929	-0.128***	-0.130***	-0.019	-0.046
	(-3.02)	(-3.05)	(-0.49)	(-1.10)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Controls	N	Y	N	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.832	0.835	0.802	0.801
Obs	3,836	3,712	3,836	3,712

Table A.6: Robustness: Bank Distress and Innovation Quality. Control for Size

The table shows estimates from a differences-in-differences regression looking at differences in patent quality metrics, where we also control for differences in (log) population size in 1920 interacted with post indicator. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The sample of future patent citations includes the universe of all patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-decade, for the period 1910-1940. In column 1, the dependent variable is the logarithm of one plus the total number of future patent citations citing all independent patents filed over each ten-year period within a county. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In column 2, we repeat the same analysis looking at all patents (firms and independent inventors). In column 3, we instead look at the (logarithm plus one) of the average number of citations received by independent patents. In column 4, we repeat the same analysis looking at all patents. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The bank treatment and controls are interacted with After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln(Ind. # Cit)	(2) Ln(Total # Cit.)	(3) Ind. Avg Citations	(4) Tot. Avg Citations
BankDistress X After1929	-0.021	-0.012	0.058**	0.061**
	(-0.45)	(-0.25)	(2.04)	(2.17)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.802	0.825	0.375	0.401
Obs	11,792	11,792	11,792	11,792

Table A.7: Robustness: Bank Distress and Quality of Independent Innovation

The table shows estimates from a differences-in-differences regression looking at changes in patent quality metrics of independent patents, where we use different methods to construct the quality metrics for robustness. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample focuses on independent patents being cited. The sample of future patent citations includes the universe of all patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-decade, for the period 1910-1940. In all columns, the dependent variable is the log (plus one) of a patent quality average. However, across columns, citations are adjusted in different ways. In column 1, citations are adjusted by the average number of citations in the same CPC class over the period 1910-1940. In column 2, we use average citation without the log-transformation. Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The bank treatment is interacted with After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ind. Avg. Citations, CPC	(2) ind_avecit
BankDistress X After1929	0.058***	0.475***
	(4.23)	(3.79)
StateXTime FE	Y	Y
County FE	Y	Y
Start Decade	1910	1910
End Decade	1940	1940
Adj R-Sq	0.248	0.245
Obs	11,900	11,900

Table A.8: Bank Distress During the Great Depression and Innovation: Non-zero citation patents

The table shows estimates from a differences-in-differences regression looking at quality metrics. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The sample of future patent citations includes the universe of all patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-decade, for the period 1910-1940. In these analyses, we examine the effect on patent measures by independents (columns 1 and 2) and firms (columns 3 and 4) focusing only on patents with non-zero citations. The outcome is always transformed as logarithm plus one. We also control for population in 1920 interacted with a post-dummy in even columns (2 and 4). Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ind. Non-zero Cit	(2) Ind. Non-zero Cit	(3) Firm. Non-zero Cit	(4) Firm. Non-zero Cit
BankDistress X After1929	-0.087***	-0.058**	0.061**	0.008
	(-3.23)	(-2.04)	(2.36)	(0.30)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Pop 1920 x Post Control	N	Y	N	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.884	0.885	0.893	0.893
Obs	11,900	11,792	11,900	11,792

Table A.9: Bank Distress During the Great Depression and Quality Distribution: firm analysis

The table shows estimates from a differences-in-differences regression looking at quality metrics. The estimation strategy relies on cross-sectional variation in bank distress across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The sample of future patent citations includes the universe of all patents granted by the USPTO, including independent, U.S firm and non-U.S. patents. The unit of observation is county-decade, for the period 1910-1940. In column 1, the dependent variable is the total number of firm patents in the top 1% of the citation distribution of the corresponding CPC during 1910-1940 that were filed in the county-decade. In column 2, the dependent variable is the total number of firm patents in the bottom 99% of the citation distribution of the corresponding CPC during 1910-1940 that were filed in the county-decade. In column 3 and 4, we construct equivalent outcomes but looking at the top 10% and bottom 90%. The outcome is always transformed as logarithm plus one. We also always control for population in 1920 interacted with a post-dummy Bank Distress is an indicator variable equal to 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. The estimates of the effect of bank distress on patents are the coefficients on the interaction between Bank Distress and After1929 indicator, which equals one for the observations starting from the 1930s decade. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Top 1%	(2) Bot. 99%	(3) Top 10%	(4) Bot. 90%
BankDistress X After1929	-0.002	0.003	-0.004	0.001
	(-0.20)	(0.11)	(-0.27)	(0.03)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.799	0.896	0.883	0.896
Obs	11,792	11,792	11,792	11,792

Table A.10: The 1917-1920 Agricultural Shock and the Quality of Independent Innovation

The table presents estimates from a differences-in-differences regression and shows the relationship between the 1917-1920 agricultural shock and subsequent innovation during the Great Depression. The estimation strategy relies on cross-sectional variation in the shock across U.S. counties within a state. The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The unit of observation is county-decade, for the period 1910-1940. In all columns, the independent variable, CngCommPrice, 1917-1920 X After 1929, is the interaction between After1929 indicator and CngCommPrice, 1917-1920, which is the county-level change from 1917 to 1920 in the international commodity price index calculated for each county, where weights are the crop share of a given farm product out of total county farm output and prices are international farm product prices (Rajan and Ramcharan 2015). In column 1, the dependent variable is the interaction between After1929 indicator, which equals one for the observations starting from the 1930s decade, and Bank Distress indicator, which equals 1 for counties with at least one bank suspension during the Great Depression years of 1930 through 1933, inclusive. In column 2, similar to the analysis with bank distress, we look at the effect on the logarithm of average citations by independent inventors. Independent are patents by inventors residing in the U.S. that were either unassigned or assigned to individuals at the time of the patent grant date. In column 3, we repeat the same analysis as column 2 but looking at the whole patent sample. The estimates of the effect of the agricultural shock on patents are the coefficients on the interaction between CngCommPrice, 1917-1920 and After1929. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) BankDistress X After1929	(2) Ind. Avg Citations	(3) Tot. Avg Citations
CngCommPrice, 1917-1920 X After1929	0.029***	0.036***	0.030***
	(6.53)	(5.78)	(5.15)
StateXTime FE	Y	Y	Y
County FE	Y	Y	Y
Start Decade	1910	1910	1910
End Decade	1940	1940	1940
Adj R-Sq	0.767	0.374	0.404
Obs	11,316	11,316	11,316

Table A.11: Robustness: The 1917-1920 Agricultural Shock and Innovation. Control for Size

The table presents estimates from a differences-in-differences regression and shows the relationship between the 1917-1920 agricultural shock and subsequent innovation during the Great Depression. The only difference with the main analysis presented before is that each column now also controls for log of population in 1920 interacted with After 1929, to show that our results are not driven by differences across counties in size. The estimation strategy relies on cross-sectional variation in the shock across U.S. counties within a state, using as a treatment CngCommPrice, 1917-1920 X After 1929, which is the interaction between After1929 indicator and CngCommPrice, 1917-1920, which is the county-level change from 1917 to 1920 in the international commodity price index calculated for each county, where weights are the crop share of a given farm product out of total county farm output and prices are international farm product prices (Rajan and Ramcharan 2015). The sample is the universe of all patents granted by the U.S. Patent and Trademark Office (USPTO) to either U.S. inventors or U.S. firms. The unit of observation is county-decade, for the period 1910-1940. In column 1, we look at total innovation by independent inventors as outcome. In column 2, we instead look at the (log) of average independ citations. Columns 3 and 4, repeat the same outcomes but for all US patents (3 is the patent count and 4 is the citation measure). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln(# Ind. Patents+1)	(2) Ind. Avg Citations	(3) Ln(# Total Patents+1)	(4) Tot. Avg Citations
CngCommPrice, 1917-1920 X After1929	-0.039***	0.016***	-0.040***	0.015***
	(-5.97)	(2.69)	(-5.57)	(2.66)
StateXTime FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y
Start Decade	1910	1910	1910	1910
End Decade	1940	1940	1940	1940
Adj R-Sq	0.898	0.380	0.905	0.407
Obs	11,308	11,308	11,308	11,308

Table A.12: Robustness: Individual Inventor Analyses with Alternative Treatment

The table provides a robustness test to the analysis that examines the potential reallocation of independent inventors into firms during the 1930s in counties with greater bank distress during the Great Depression. The estimation strategy is the same as in Table 9, using the same sample and same structure of the analysis. The only difference is that the definition of bank distress variable. In columns 1 and 2, we define the treatment as a dummy which is equal to one if the county had experienced any bank distress episode during the Depression. In columns 3 and 4, Bank Distress > Median is an indicator variable equal to 1 for counties with an above median % of deposits in suspended banks, calculated as the cumulative deposits in bank suspended from 1930 through 1933 as a share of bank deposits in 1929. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Firm Pat	(2) Firm Pat	(3) Firm Pat	(4) Firm Pat
Bank Distress	-0.006	-0.019		
	(-0.18)	(-0.57)		
Bank Distress %			0.078**	0.090**
			(2.00)	(2.27)
State FE	Y	Y	Y	Y
Patent Post	Y	Y	Y	Y
Pre Ind Pat	Y	Y	Y	Y
Controls	N	Y	N	Y
Adj R-Sq	0.019	0.026	0.020	0.027
Obs	5,295	5,294	5,295	5,294

Table A.13: Robustness: the Great Depression and Individual Inventor Patenting

The table provides a robustness test to the analysis that examines the potential reallocation of independent inventors into firms during the 1930s in counties with greater bank distress during the Great Depression. The estimation strategy is the same as in Table 9, but using a smaller sample which should be characterized by higher matching quality, as discussed in the paper. Across the three columns, we run the main analysis with full controls using the three treatment variables used in this analysis. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Firm Pat	(2) Firm Pat	(3) Firm Pat
Bank Distress >Med	0.033*		
	(1.79)		
Bank Distress %		0.174**	
		(2.56)	
Bank Distress			-0.007
			(-0.15)
State FE	Y	Y	Y
Patent Post	Y	Y	Y
Pre Ind Pat	Y	Y	Y
County Controls	Y	Y	Y
Ind. Controls	Y	Y	Y
Adj R-Sq	0.041	0.043	0.040
Obs	2,091	2,091	2,091

Table A.14: Placebo analysis: Bank Distress During the Great Depression and Individual Inventor Patenting Before the Great Depression

The table provides a robustness check for the result studying the reallocation of independent inventors into firms during the 1930s in counties with greater bank distress during the Great Depression. In particular, we try to replicate the result as identified for 1930s in Table 9 for periods that came before the depression, akin to a placebo analysis. In columns 1 and 2, we examine whether inventors that were independent in 1910s and still patenting in 1920s were more likely to move into firms in the 1920s in counties that were subsequently affected by the banking shock. In columns 3 and 4, we examine whether inventors that were independent in 1900s and still patenting in 1910s were more likely to move into firms in the 1920s in counties that were subsequently affected by the banking shock. In other words, apart from the timing, the set up is consistent with one of the main analyses. Odd columns include state fixed effects, while even columns add additional county-level controls (population 1920) and individual level controls based on the pre census (homeownership, inventor age, stauts as an entrepreneur, and gender). Bank Distress % is defined at the county-level and equal to the ratio of bank deposits at banks suspended between 1930 and 1933 divided by total banks deposits in 1929. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) Firm Inventor 1920	(2) Firm Inventor 1920	(3) Firm Inventor 1910	(4) Firm Inventor 1910
Bank Distress >Med	0.001	0.006	-0.010	0.017
	(0.13)	(0.61)	(-1.07)	(1.38)
State FE	Y	Y	Y	Y
Patent Post	Y	Y	Y	Y
Pre Ind Pat	Y	Y	Y	Y
Controls	N	Y	N	Y
Adj R-Sq	0.018	0.025	0.006	0.016
Obs	11,650	11,207	5,995	2,213