# Labor Scarcity, Finance, and Innovation: Evidence from Antebellum America*

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**Abstract**

This paper establishes labor scarcity as an important economic channel through which access to finance shapes technological innovation. We exploit antebellum America, a unique setting with (1) staggered passage of free banking laws across states and (2) sharp differences in labor scarcity between slave and free states. We find that greater access to finance spurred technological innovation as measured by patenting activities, especially in free states and the previously unbanked Midwest. Furthermore, in slave states where slave labor was prevalent, access to finance encouraged technological innovation that substituted for slave labor, but discouraged technological innovation that substituted for free labor.

*Keywords*: antebellum America, free banking laws, finance and innovation, labor scarcity

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## 1 Introduction

While technological innovation is important for economic growth (Solow (1957)) and firms' competitive advantage (Porter (1992)), it is difficult to achieve. Pioneered by Schumpeter, a large literature has established a well-functioning financial market as a driver of technological innovation (King and Levine, 1993; Brown, Fazzari, and Petersen, 2009; Hall, 2010; Hsu, Tian, and Xu, 2014; Kerr and Nanda, 2015). However, the role of finance is rarely examined in connection with the fundamental incentive of innovation—reducing production costs. As argued by Rosenberg (1969) and Spence (1984), among others, the major incentive for firms to develop new technology is to gain competitive advantage by spending less on production.[1] While financial market development contributes to higher capital supply, the degree to which firms utilize capital to advance innovation remains a question. In this paper, we fill a gap in the literature by examining the marginal effect of finance on innovation in the presence of cost reduction incentives. In particular, we focus on labor scarcity, which leads to high factor prices for labor in production and hence to strong incentives among firms to reduce costs.[2]

We study a unique historical episode, antebellum America. This fascinating period in the 19th century, from just after the War of 1812 up to the Civil War, provides a unique laboratory for our test. First, this period witnessed the staggered passage of the free banking laws across eighteen states, a unique setting in which to identify banking shocks. In early 1800s, banks were mainly local businesses, owing to information frictions, costs in transportation, and the dearth of interstate branching. Access to banks was difficult because the approval of a charter was not only tedious but aimed at protecting the interests of incumbent banks. Between 1837 to 1860, eighteen states passed the free banking laws. The laws replaced individual charters with "free entry" upon a bank's satisfaction of standard requirements. The passage of the free banking laws encouraged bank entry and was a positive shock to states' access to local finance. Second,

[1]Rosenberg (1969) argues what motivate inventors to invent certain things appearing throughout the 1800s and early 1900s is that firms tried to invent labor-saving technology when labor was dear, and likewise when capital was dear. Spence (1984) establishes the importance of cost-reducing R&D by showing that firms compete by expending resources with the purpose of reducing their costs. Mokyr (2010) documents the cost reduction of many goods due to technological innovation during the period 1750–1914, such as fuel cost, steel cost, energy consumption cost with the advance of electricity, and transportation cost. Another example is the role of innovation in computer technology in reducing computational cost and labor cost, as documented and predicted by Moore's law (Schaller, 1997).

[2]As wages constitute about two-thirds of aggregate disposable income, labor is as an essential factor in production, especially in the early stage of Industrial America.

labor scarcity differed significantly between the slave states in the South and the free states in the North. At the margin, slave labor in the South was less expensive than paid labor in the North. In other words, labor scarcity was more severe in the free states than in the slave states. The sharp contrast in labor scarcity was reinforced by the immobility of labor across regions during that time—another feature of antebellum America that is distinct from today's world.

To understand how access to finance affects innovation and the role of labor scarcity, we propose a stylized model. The model follows Acemoglu (2010) and links the equilibrium innovation level with labor and finance. The economy has a monopolistic innovator who supplies technologies to final goods producers. The representative final goods producer combines labor and technology in production and maximizes profit by optimally choosing factor demand. To capture the relevant innovations in antebellum America, we model the technology as a labor substitute such that labor scarcity increases producers' demand for technology. Given producers' demand for technology and the development cost for innovation, the monopolistic innovator then optimally chooses the level of innovation and the monopolistic technology price. In particular, greater access to finance reduces the costs of innovation for the innovator. The model predicts that the equilibrium patenting activity is jointly determined by labor scarcity and financing costs. The model has three hypotheses. First, greater access to finance spurs innovation. Second, with greater access to finance, if labor scarcity remains constant or becomes more severe, the equilibrium innovation level increases. Finally, with greater access to finance, if labor scarcity becomes less severe, then equilibrium innovation can actually decrease.

We combine several novel data sources to test the hypotheses. First, using digitalized historical patent filings from the United States Patent and Trademark Office, we collect data on the historical patenting activities to proxy for technological innovation in the antebellum period. From the patent filings, we are able to identify the state of the inventor who files the patent and the technology class of the patent. Second, we collect data about the banks operating during the period from historical bank records. These historical records provide the name of the bank, its charter type, the location of operation, entry and exit dates, as well as detailed balance sheets. These detailed records allow us to directly observe changes in banking activities following the passage of the new banking laws. Finally, we obtain social and economic variables at the state level from the decennial census and the census of agriculture and manufacturing.

In the baseline analysis, we examine whether access to finance spurred innovation in antebellum America. We employ a difference-in-differences (DID) approach, taking advantage of the staggered passage of the free banking laws. Our baseline result shows that, after the passage of the free banking laws, the number of patents filed in a state increased in the subsequent three years. The economic magnitude is sizable. On average, a state that passed the free banking law generates 9.53 more patents in the three years following free banking, which accounts for 13.52% of the state-level patent variability. The results are robust to controlling for state fixed effects, year fixed effects, and state-level labor composition.

We then conduct a series of tests to investigate whether our baseline results indeed show a causal impact of free banking on innovation. First, although the staggered passage of free banking laws created exogenous changes to access to finance, state-level factors that manifest differently across states could have affected the timing of the free banking laws in different states. To mitigate the reverse causality concern, we employ the methodology of Bertrand and Mullainathan (2003) to examine the dynamics of innovation surrounding the free banking laws. The results show no prior trend in innovation output. The findings indicate that reverse causality is unlikely to explain our baseline results.

Second, another potential concern for our study is that some omitted variables coinciding with free banking laws' passage are driving the results. While employing staggered passage of free banking laws largely mitigates the concern, we further address the issue by conducting placebo tests and including additional control variables. In the placebo tests, we randomly assign states to each of these free banking passage years (without replacement) following the empirical distribution of years when states passed free banking laws. If an unobservable shock occurred at approximately the same time as free banking, it should still reside in the testing framework, and thus could drive the results. However, we find these falsely assigned free banking events to have no effect on innovation. In addition, we control for contemporaneous events such as usury laws and the presiding political party in a state, and find that our baseline results continue to hold with these controls. Overall, the findings corroborate that baseline results are not driven by some contemporaneous omitted factors.

Having established that access to finance spurred innovation, we turn our attention to the labor scarcity channel. Following our theoretical model, labor scarcity spurs demand for innovation and strengthens the positive relation between finance and innovation. To test this hypothesis, we first take advantage of the sharp difference in labor scarcity between the free and slave states. In free states where slavery was prohibited, production was carried out by "wage labor" and labor was relatively scarce. In contrast, in slave states, slaves not only provided a labor source that could not resign or demand higher wages, but ensured a source of labor for generations. In other words, the labor supply in slave states was not scarce, unliked in the free states. We hypothesized that the impact of free banking was higher in free states, where labor was relatively scarce. This is indeed what we find.

Next, motivated by the model and also by the concern that slave states and free states differ in many dimensions other than labor scarcity, we compare differences in innovation in the slave and free states. In particular, we exploit differences in labor scarcity across slave labor and free labor in the free states and slave states, respectively. In the free states, there was no slave labor, only free labor; in the slave states, there was a relatively higher scarcity of free labor. Using the agricultural industry as a proxy for the industry in which slaves constituted the major workforce, and the manufacturing industry as a proxy for the industry in which free labor constituted the major workforce, we conduct a triple difference-in-differences study. We find that, following the passage of free banking laws, the manufacturing industries in the free states experienced the highest increase in innovation. The agricultural industry in the slave states experienced a slight decline in innovation.

The findings are consistent with our intuition. Given the high demand for manufactured goods and expensive labor, the manufacturing industry in the free states likely faced extreme labor scarcity. Meanwhile, one possible explanation for the decline of innovation in the agricultural industry is that access to finance further increased the slave labor population either through slave purchases or migration. With greater supply of slave labor, incentives for innovation were further reduced. Indeed, we find an increase in slave labor following the passage of the free banking law in a state. The results generally follow our model's conjecture that finance promotes innovation when labor is scarce, and may impede innovation when labor becomes more abundant.

Finally, although we have compared innovation across industries within the free and slave states, we are concerned that different states might have vastly different industry concentrations, which could render innovation not comparable for these states. Therefore, we further restrict the sample to states with similar industry concentrations in manufacturing and agriculture. Our results continue to hold in these subsample states.

After exploring the role of labor scarcity in how finance affects innovation, we take a step back and examine whether the passage of free banking laws did improve access to finance. We find that there was a significant increase in the number of free banks and the number of loans issued by free banks after the passage of the free banking laws. In addition, we find that the increase in innovation was more pronounced in previously unbanked regions. The county-year level regressions also show a positive and significant association between the number of free banks and innovation. Overall, the results indicate that there was indeed an improvement in access to finance after the passage of free banking laws.

Taken together, our research provides new insights into factors driving innovation. The insights are useful today in explaining, for example, why some regions are more innovative than others, and under what conditions additional financing resources are able to spur innovation.

Our paper adds to the literature on the finance-growth nexus King and Levine (1993). In particular, there are several studies of bank deregulation and innovation that focus on banking deregulation in the 1980s and 1990s (Chava, Oettl, Subramanian, and Subramanian (2013), Amore, Schneider, and Zaldokas (2013), Cornaggia, Mao, Tian, and Wolfe (2015), Hombert and Matray (2016)). In contrast to these studies, we take a historical approach and examine the antebellum setting using the staggered passage of the free banking laws as an exogenous shock to finance. Moreover, we introduce labor scarcity as a new channel that is absent from previous studies of the finance-innovation nexus.

Second, we provide empirical evidence linking labor scarcity and technology adoption. The idea dates back to Hicks (1932): "A change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind directed to economizing the use of a factor which has become relatively expensive." Following this insight, (Acemoglu, 2002, 2010) formalize the role of factor price in directing innovation and technical change. Neat historical settings, such as the sudden drop in labor supply due to the Great Mississippi Flood of 1927 employed in Hornbeck and Naidu (2014), and the reduction in cotton exports to Britain due to the U.S. Civil War used in Hanlon (2015), provide empirical evidence in support of the theory.

Adding to this literature, we provide new evidence confirming the role of the labor supply in shaping innovation. Unlike earlier studies, our empirical setting features the interaction between labor scarcity and access to finance.

Finally, this study contributes to an assessment of the effect of free banking. The economic value of free banking, which some have nicknamed wildcat banking, has been debated by economic historians.[3] In particular, Jaremski and Rousseau (2013) study the effect of free banking on economic growth using decennial census data. Conclusions drawn from such studies are subject to data limitation since the law's passage was clustered in two decades and economic growth measures are only available at a decennial frequency. In contrast, patenting activity can be measured annually, which provides a more accurate reflection of economic development resulting from technological innovation.

This paper proceeds as follows. Section 2 presents a historical discussion of antebellum America and the free banking laws. Section 3 sets up a model to analyze the effect on innovation of greater access to finance under different labor supply conditions. Section 4 describes our data. Section 5 presents the main empirical results on free banking and innovation, and Section 6 highlights labor scarcity as the key economic channel. Robustness and extensions are in Section 7. Section 8 concludes.

# 2 Historical Background

## 2.1 Antebellum America

The antebellum period in the United States refers to the period from after the War of 1812 until the beginning of the Civil War in 1861. During this period, the country experienced dramatic economic growth and innovation activity. The economy differed greatly across regions, especially between the North and the South.

The North enjoyed early industrialization, a rise in manufacturing, and urbanization. Manufacturing advances occurred in many industries, including textiles, machinery, and furniture. Industrialization also changed the concept of labor. For example, textile factories trained employees to run the looms, giving rise to the concept of wage labor, which gradually began overtaking apprenticeships and family members as workforce sources.

[3] See for example Rockoff (1972), Rockoff (1974), and Rolnick (1983).

In the agricultural South, the cotton boom made plantations profitable. Farmers obtained cheap land and used slave labor to grow and harvest the crops. Cotton growing became so profitable for the planters that it greatly increased their demand for both land and slave labor. In fact, most plantation owners' investments and wealth were in their slaves. With this continuing demand, the number of slaves in America grew from 700,000 in 1790 to 4 million in 1860.

Because slaves were denied formal education, slave labor contributed primarily to the low-skilled labor force. Unlike wage laborers, slaves could not resign or demand higher wages, and their progeny ensured a supply of labor for generations (Conrad and Meyer, 1958; Fogel, 1974, 1977). The supply of slave labor was allocated by a system of regional specialization that produced slaves on the worn-out land of the Old South and the border states for export to the high-yield cotton fields of the Mississippi and Red River Valleys.[4] Far from stagnating, the economy of the antebellum South grew rapidly. Between 1840 and 1860, per capita income increased more rapidly in the South than in the rest of the nation. By 1860 the South had attained a level of per capita income that was high by the standards of the time.

Innovation in the antebellum era was radical and unparalleled. Major innovations included the steam engine (1825), the mechanical reaper (1834), the telegraph (1837), and the sewing machine (1845) (see Thomson, 2004). These fundamental innovations reshaped transportation, communications, agriculture, and manufacturing in and after the middle third of the nineteenth century. Notably, the growth in patenting during the beginning of American industrialization was marked by a disproportionate increase in inventions by ordinary citizens operating with relatively common skills and knowledge rather than by an elite with technical expertise or extensive financial resources (Sokoloff and Khan, 1990).[5]

Behind the strong innovation activity was a solid patenting system that transmitted knowledge of technological problems and solutions and that provided avenues for commercializing innovations. Early American inventors benefited from the existence of a patent system and

[4]In the first decade the selling states include Virginia, Maryland, Delaware, North Carolina, Kentucky, and the District of Columbia; the buying states are assumed to be South Carolina, Georgia, Alabama, Mississippi, Tennessee, and Missouri. In 1830, Florida, and in 1850, Texas were added to the buying group. Tennessee, Missouri, and North Carolina are difficult to categorize; some parts of those states imported while other parts exported during the period (Collins (1904)).

[5] Using U.S. patent records from 1790 to 1846, Sokoloff and Khan (1990) find shifts in the distributions of patentees from merchants/professionals to artisans/tradesmen and from urban to rural residents and a rising share of patents to patentees with no specialization and few patents over their careers.

from laws that provided strong protection for private property in any form. The Patent Act of 1790 was the first federal U.S. patent statute, enacted one year after the new government was organized. The amendment of the act expedited the examining process: on average, it took several months for a patent to be examined once a written application was submitted. Cases of infringement were dealt with by a jury, which assessed the damages determined the appropriate punishment. The person who infringed was made to hand over all of the infringing devices to the owner of the patent.

### 2.2 The Free Banking Laws

In the early 19th century, access to banks difficult. Banks were state-chartered and issued their own notes. There were usually only a few charter banks in each state. Unlike modern institutions, early banks rarely provided financial services to ordinary households in peripheral areas. Since traveling was relatively costly at that time, charter banks operated only in major cities. Except in a few southern states with statewide branch bank networks, new bankers entered local markets and banking was both legally and economically a local affair. Charters and corporate bylaws that restricted a bank's office to a specific place did not restrict its lending to that place, but information asymmetries narrowed the field of potential borrowers. Familiarity with customers was closely associated with geographic proximity because proximity lowered the cost of gathering information, monitoring borrowers, and enforcing the terms of the lending agreement. In 1836, a legislative committee from Rhode Island reported that "by far the greater part of the banks are, properly speaking, local, and managed for the accommodation of the people residing in or near the places of their location."

Several factors contributed to the limited access to finance. First, the chartering process was tedious and delayed. Second, the approval of a charter often depended on political influence and was aimed at protecting the interests of incumbent banks. Most of them enjoyed monopoly power and were able to charge high rates. As Hammond (1957) wrote, "It had long been difficult to get new bank charters in New York, because the [Albany] Regency kept the number down conservatively." Third, the early charter banks conducted extensive insider lending: they lent a large proportion of their funds to members of their own boards of directors or to others with

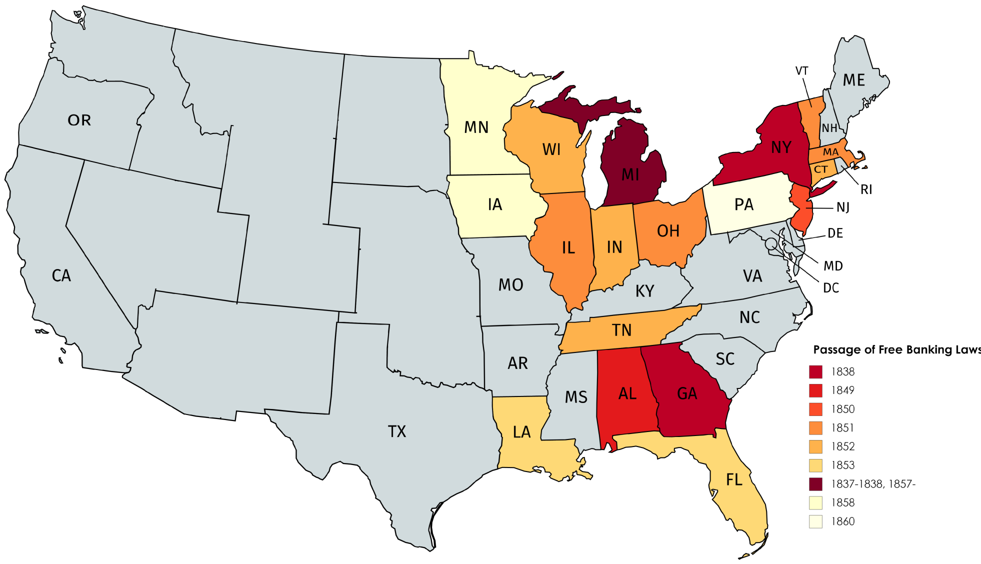



**Figure 1. The Passage of the Free Banking Laws across States**

close personal connections to the boards (see Lamoreaux, 1986, 1996).[6]

The free banking laws initiated banking system reforms. Starting with Michigan in 1837 and continuing through Pennsylvania in 1860, the free banking laws were passed in a staggered fashion in 18 states. Figure 1 shows a timeline of the staggered passage of the free banking laws.[7] The laws replaced individual legislative charters with "free entry" upon a banks satisfaction of standard requirements. The term "free" means that anyone who had the required paid-in capital could start a bank at any time and in any place. In particular, there was no longer political influence involved, allowing speedy bank entry with lower costs.

A state's passage of the free banking laws led to greater access to finance by merchants and manufacturers in that state. Bank entry accelerated after the passage of the laws. The new banks had wider geographic coverage and a larger customer base than the existing charter banks. In particular, to avoid direct competition with the existing banks, the new banks entered rural, previously unbanked areas, and encouraged the establishment of commercial businesses, manufacturing, and small businesses.[8]

[6]Lamoreaux (1996) traces the early history of the banking system to the antebellum era and documents the pervasiveness of insider lending.

[7]The states shown in the map were established as states or territories either before or during the free banking era and their economic data were included in the census beginning in 1850. For example, statehood was granted to California, Oregon, and Texas in 1850, 1859, and 1846 respectively.

[8]In its encouragement of small business, free banking advocates believed they had simultaneously addressed the issues of corruption, privilege, equality of opportunity, and protection of the public against incompetent

Importantly, the exogenous nature of the law's passage across states provides us an identification strategy for access to finance. While historians have not yet reached consensus on the factors that determined where and when the laws were passed, the widespread conclusion is that the staggered passage was not driven by endogenous economic demand for finance. In some states, the passage of the law was largely a response to political interference, corruption, and bargaining power between different political parties, whereas in other states, it seemed to be initiated by random events.

An interesting example is the state of New York. The law's passage in 1838 was triggered by an unlikely event, the kidnapping of a man named William Morgan after he threatened to reveal the secrets of the Masons. Investigations into the kidnapping implicated several famous Masons who were politically connected with the Regency. Legislative debates on banking policy became anti-Masonic. When the Regency lost support, the law was passed. In this regard, economist Bodenhorn refers to the "serendipitous nature of economic reform" (Bodenhorn (2006)).

In our empirical analysis, we formally test and show that the passage across states cannot be explained by economic demand, political factors, or other demographic features of the state.

# 3 Model and Implications

The model follows Acemoglu (2010). The goal is to understand the influence of greater access to finance on innovation, especially in conjunction with labor scarcity.

## 3.1 Model Setup

**Environment** The economy has a monopolistic innovator who supplies technologies to final good producers. The representative final goods producer has access to production function

$$AF(L,\theta)^{\alpha}q(\theta)^{1-\alpha}$$

where $A=\alpha^{-\alpha}(1-\alpha)^{-1}, \alpha\in(0,1)$ is a scalar conveniently set for the derivation. The final goods production involves labor input and technology. Labor supply is fixed at $\bar{L}$. The term $F(L,\theta)^{\alpha}$ is combined with an intermediate good embodying technology (such as mechanical reaper and sewing machine). The quantity of the intermediate technology is $q(\theta)$, conditioned on $\theta$ to

bankers through the 100 percent note-collateral provision.

emphasize that it embodies innovation $\theta$. To capture the relevant technologies in antebellum America, we model the innovation as a labor-substitute (or as labor-saving). Specifically, an innovation that substitutes for labor decreases the marginal product of labor — i.e. $\frac{\partial^2 F}{\partial L \partial \theta} < 0$. Moreover, the production function $F$ satisfies the usual conditions that $F$ is increasing and concave with both arguments.

This intermediate technology is supplied by the monopolistic innovator. The innovator can patent innovation $\theta_2$ which protects her with monopolistic power. The initial innovation and manufacturing cost is $C(\gamma, \theta)$.[9] The cost is increasingly convex with innovation $\theta$. Here $\gamma$ is a parameter summarizing the innovator's access to finance. With greater access to finance (greater $\gamma$), the cost of initial patent development decreases. The innovation is non-rival and can be produced at relatively low marginal cost once invented. Let the marginal cost be $1-\alpha$ unit of the final good. The unit price for the intermediate technology charged by the monopolistic innovator is denoted as $\chi$.

**Optimization** Taking wage $w$ and technology price $\chi$ as given, the representative final goods producer optimally chooses labor and technology to maximize profit.

$$\max_{L, q(\theta)} AF(L, \theta)^{\alpha} q(\theta)^{1-\alpha} - wL - \chi q(\theta) \tag{1}$$

The first-order condition with respect to $q$ gives the optimal technology demand, an inverse demand curve with constant elasticity,

$$q^*(\theta) = \alpha^{-1} F \chi^{-\frac{1}{\alpha}}. \tag{2}$$

The innovator then takes the producer's demand curve $q^*(\theta)$ as given and chooses innovation level $\theta$ and monopolistic price $\chi$ to maximize profit

$$\max_{\theta, \chi} \left(\chi - (1-\alpha)\right) q(\theta) - C(\gamma, \theta) \tag{3}$$

**Equilibrium** An equilibrium in this economy consists of: the final goods producer's decisions $\{L^*, q^*(\theta)\}$, the innovator's decision $\{\theta^*, \chi^*\}$, and wage $w$, such that: (1) $\{L^*, q^*(\theta)\}$ solves (1)

[9] A greater access to finance could also reduce the financing and manufacturing cost of the final good producer. Similar implications would arise although the derivation becomes more convoluted.

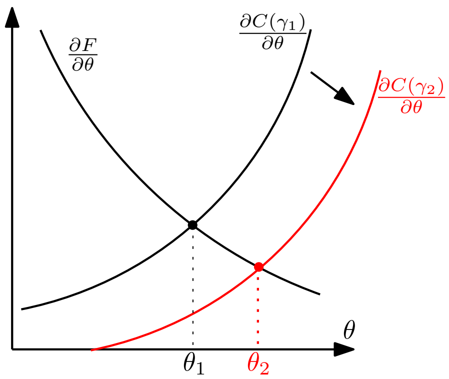



**Figure 2. The Effect of a Greater Access to Finance**

given $w$, $\theta$, and $\chi$. (2) $\{\theta^*, \chi^*\}$ solves (3) given the inverse demand curve (2). (3) $w$ satisfies labor market clearing such that $L = \bar{L}$.

**Factors driving innovation** After plugging the technology demand function (2) into the innovator's problem (3), we obtain the profit maximizing price of the innovator, $\chi^* = 1$. After plugging the optimal monopolistic price and the technology demand function into the innovator's problem, the innovators decision further reduces to $\max_{\{\theta\}} F(\bar{L}, \theta) - C(\gamma, \theta)$; i.e., the equilibrium innovation $\theta^*$ satisfies

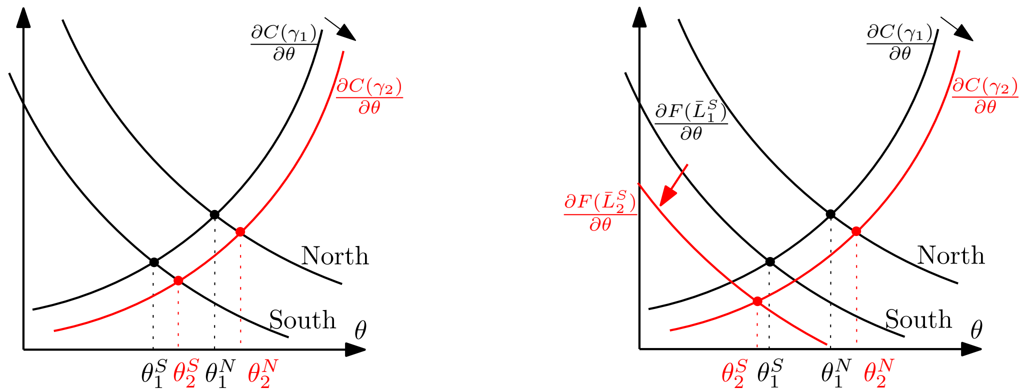
$$\frac{\partial F(\bar{L}, \theta)}{\partial \theta} = \frac{\partial C(\gamma, \theta)}{\partial \theta}. \tag{4}$$

From equation (4), access to finance and access to labor supply are two factors determining innovation.

### 3.2 Comparative Statics

The comparative statics of the equilibrium have the following model implications. The first implication is the effect of greater access to finance. Equation (4) implies that in the model, $\frac{\partial \theta^*}{\partial \gamma} > 0$. Other things equal, greater access to finance reduces the financing cost of innovation and spurs innovation. The effect is shown in Figure 2.

The implications are more subtle when labor supply interacts with access to finance. If the labor supply decreases or remains unchanged following greater access to finance, then innovation increases. However, a more interesting case is, if the labor supply increases following greater access to finance, then greater access to finance could actually decrease innovation.




(a) Labor scarcity

(b) Labor excess

**Figure 3. Labor Supply and a Greater Access to Finance**

Let us apply the model's implications to antebellum America. In the industrial North, there was no significant change in the labor supply following the entry of free banks; hence, the positive effect on innovation is unambiguous. The effect on innovation that substituted for free labor in the South is similar. Figure 3a demonstrates the positive effect of greater access to finance on innovation in the North as well as on free labor-saving innovation in the South.

In contrast, the innovation that substitutes for slave labor in the South is an exception. Our empirical evidence shows that slaves moved to the states that passed the free banking laws through trade or migration. In this case, the labor supply channel and the financing channel interact and drive the equilibrium level of innovation that is slave labor-saving. While greater access to finance leads to more innovation, a larger labor supply reduces the marginal productivity of innovation and drives innovation lower. As a result, slave labor-saving innovation in the South could decrease. This effect is shown in Figure 3b.

# 4 Data and Summary Statistics

We use a combination of data sources to study how access to finance affects innovation, and the role of labor scarcity in shaping this relation. We next describe the data sources and provide summary statistics.

## 4.1 Patents

We use historical patenting activity to proxy for technological innovation in the antebellum period. The source is digitalized historical patent filings from the United States Patent and

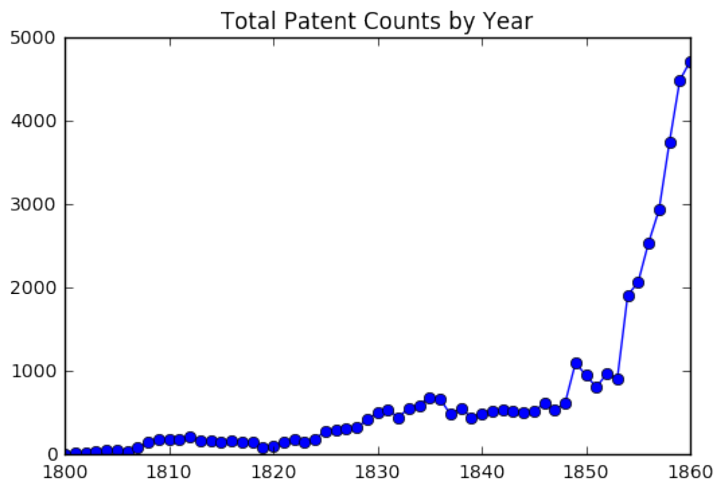



**Figure 4. The Total Number of Patents Granted**

Trademark Office. The historical records provide the year in which the patent was granted, the county and state where the inventor resided, and the technology class the patent belonged to.[10] Figure 4 shows the total patent counts by year from 1800 to 1860. The initial growth was slow around the War of 1812 and during the long contraction that followed. A span of rapid growth in patenting coincided with the economic recovery of the early 1820s. As the upturn in the economy continued, patenting increased steadily until a change in the patent system in July 1836 introduced more stringent requirements (Sokoloff and Khan, 1990). The number of patents awarded fell immediately and then stabilized at this lower level for nearly eight years. The economic contraction that began with the Panic of 1837 and persisted through the early 1840s played some role in accounting for a second spell of stagnation in patenting starting in the late 1830s. Notably, the growth rate of patent counts beginning in 1850 exceeds any modern-day growth.

While we acknowledge that simply counting the number of patents could miss certain valuable inventions, it seems to be a reasonable and the best available measure of antebellum innovation. Economic historians studying pre-Civil War invention and productivity look primarily at patent counts. They argue that patenting, though an imperfect measure, should be qualitatively representative of the resources consumed in inventive activity (Griliches (1990)). For example, using census data, Sokoloff (1992), shows that patenting was a major driver of antebellum total

[10]Information regarding patent citation is not available for historical patents in the Antebellum era.

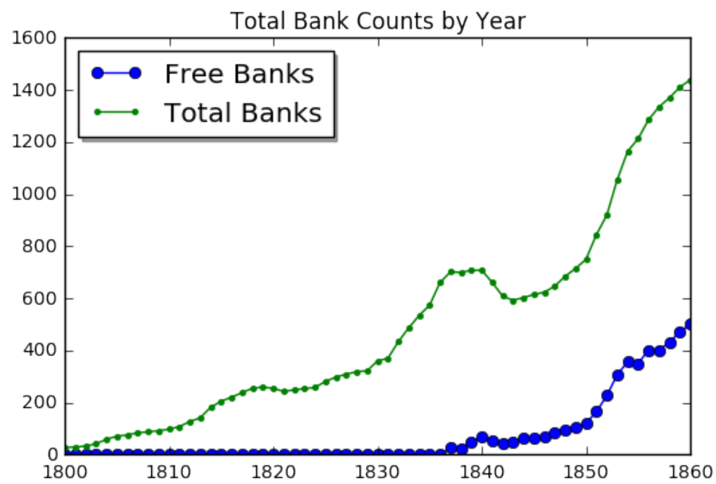



**Figure 5. The Total Number of Banks Operating**

factor productivity at the cross section. Moreover, Lamoreaux and Sokoloff (2000) use industry directories to map the location of the firms using the most advanced technologies. They also use trade journal accounts to track the geographic origins of the most important inventions in an industry. They confirm that both sources correspond closely with the distribution of patents.

### 4.2 Historical Bank Records

We obtain information for banks from historical bank records—i.e., Archived Reported Balance Sheets of State Banks to state authorities. These historical records provide the name of the bank, its charter type, location of operation, entry and exit dates, and detailed balance sheets. Figure 5 shows the total number of all banks and the number of free banks by year, for the period 1800–1860. From the figure, we can make the following observations. First, charter banks constituted the majority of the bank population. Second, free banks began to appear in 1837 (the year the free banking law was passed) and increased sharply in number as the law was approved in subsequent states. Finally, after the implementation of the free banking laws, the increase in the total number of banks was driven mostly by the entry of the free banks.

Conditional on passing the free banking laws, ten states had significant free banking activity, whereas eight states had relatively little free bank entry (Rockoff (1974). The estimated growth rate of free banks is nineteen per year when including controls and year and state fixed effects. When comparing the balance sheets of the free banks with the charter banks, the average size of free banks in total assets and loans was slightly smaller than that of the charter banks, but comparable.

### 4.3 Historical Census Records

Finally, from the decennial census of 1810–1860, we obtain social and economic variables at the state level. In particular, we use the following variables: population, urban population, slave population, white population. We include population and urbanization following Higgs (1971). In the absence of a mass communications system, the locational distribution of actual inventive opportunities coincided with that of the population. Moreover, Higgs (1971) shows that the proportion of the population in urban areas and the number of inventions per capita were closely associated during the 1870-1920 period for a cross section of American states. The slave and white populations reveal, to a large extent, the local educational attainment, social class structure, and division of labor.

Using these controls on state demographic features, we show that for the eighteen states that passed the free banking laws, the year of passage had no correlation with population size, or urbanization, suggesting that the most developed states did not pass the laws earlier than others.

In our robustness analysis, we control for economic and industrial characteristics at the state level by using measures from the Census of Manufacturing in 1850, 1860, and 1870, and from the Census of Agriculture in 1840, 1850, and 1860.

### 4.4 Summary Statistics

The list of variables is provided in Appendix A. The summary statistics are provided in Table 1 Panel A.

## 5 Free banking and Innovation

### 5.1 Empirical Strategy and Baseline Results

To assess the impact of access to finance on innovation, we estimate the following empirical model:

$$Ln(Patents)_{i,t+s} = \alpha + \beta \text{Free banking}_{i,t} + \gamma Z_{i,t} + State_i + Year_t + \epsilon_{i,t}, \quad (5)$$

where i indexes state and t indexes time. The dependent variable in Eq. (5) is the natural logarithm of the total number of patents generated in a state in the following one, two, and three years respectively. We use a dummy variable, *Free* $banking_{i,t}$ to capture the status of passage of the free banking laws in state i year t. Z is a vector of controls that includes total state population, white population ratio, urban population ratio, and slave population ratio. $Year_t$ and $State_i$ capture year and state fixed effects, respectively. We cluster standard errors by year in our baseline tests.

We include state fixed effects in the baseline regression. This approach addresses the concern that unobservable variables omitted from Eq. (5) that generate variation in a state's stance toward openness to free banking law might be correlated with innovativeness, rendering our findings spurious. For example, if states with vibrant economic activity and strong growth opportunities were more likely to pass free banking laws, then the state-level economic activity and growth opportunities were unobservable that correlated with both innovativeness and *Free banking*, which could bias our coefficient estimate of *Free banking* downward. Including state fixed effects will strip out any persistent differences across states. We report the OLS regression results estimating Eq. (5) in Table 2.

The coefficient estimates of *Free banking* were positive and significant at the 1% level. This finding suggested that the passage of free banking laws led to an increase in the number of patents in the first three subsequent years. To be more concrete, based on the coefficient estimate of *Free banking* in column (6), states that passed the free banking law generated a total of 57.7% more patents in the subsequent three years than states that did not pass the free banking laws.

The effect of free banking laws on patent quantity was economically sizable: the above increase translates to an increase of 9.53 patents three years after the passage of the free banking law. (Table 1 shows the average number of patents produced in a state was 16.51. The product of 16.51 and 57.7% was 9.53.) This increase in patent quantity accounted for 13.52% (=9.53/70.48) of the state-level patent variability.

## 5.2 Threats to Validity

### 5.2.1 Reverse Causality

Although the staggered passage of free banking laws in the U.S. represented a plausibly exogenous shock to credit constraints, it is likely that state-level factors that manifest differently across states could have affected the timing of the passage of free banking laws in different states.

A reverse causality concern may arise if the states also differ in their innovation intensity and such differences triggered the passage of free banking law. To further explore the possibility of reverse causality, we follow Bertrand and Mullainathan (2003) to examine the dynamics of innovation prior to the free banking laws. We decompose *Free banking* into six dummy variables associated with four periods around the free banking laws: all years up to and including three years prior to free banking, two years prior to free banking, one year prior to free banking, one year after free banking, two years after free banking, and three years or more after free banking. The year in which the free banking law was passed was the reference year in this setting. We estimate the following model:

$$\begin{aligned} Ln(Patents)_{i,t+s} =& \alpha + \beta_1 Before^{3+}_{i,t} + \beta_2 Before^{2+}_{i,t} + \beta_3 Before^{1}_{i,t} + \beta_4 After^{1}_{i,t} + \beta_5 After^{2+}_{i,t} \\ &+ \beta_6 After^{3}_{i,t} \gamma Z_{i,t} + State_i + Year_t + \epsilon_{i,t}, \end{aligned} \tag{6}$$

In Panel B of Table 3 we report the regression results estimating Eq. (6). The coefficient estimates of $Before^{2+}_{i,t}$ and $Before^{1+}_{i,t}$ were not significant, suggesting that state-level innovation showed no significant change prior to the passage of free banking laws. The coefficient estimate of $After^{3+}$ was positive and significant, consistent with our baseline findings. These results mitigated concerns about reverse causality.

### 5.2.2 Falsification Test

Another concern that prevents us from drawing a causal interpretation of free banking laws on innovation from our baseline regressions is an omitted variables problem: unobserved shocks or variables that are omitted from our analysis but coincide with state-level free banking events could drive our results. To address this concern, we conduct placebo tests to check whether our results disappear when we artificially assume free banking laws occurred in years other than the actual free banking passage year. We do this by first obtaining an empirical distribution of years when states passed the free banking law. We then randomly assign states to each of these free banking law years (without replacement) following the empirical distribution. This approach maintains the distribution of free banking years from our baseline specification, but it disrupts the proper assignment of free banking years to states. Therefore, if an unobservable shock occurs at approximately the same time as the free banking law, it should still reside in the testing framework and thus have an opportunity to drive the results. However, if no such shock exists, then our incorrect assignments of free banking years to states should weaken our results when we re-estimate our baseline regressions in Eq. (5). We report the results in Table 4. The coefficient estimates of *Free banking* were statistically insignificant and not different from zero in all columns.

#### 5.2.3 Alternative Interpretations

Although our falsification test mitigates concerns about confounding effects from contemporaneous events, we conduct additional robustness tests to rule out the potential sources of confounding effects.

One event that could have taken place simultaneously with the passage of free banking laws was a change in state usury laws. Usury laws limit the maximum interest rate banks can charge on loans. As argued by Benmelech and Moskowitz (2010), usury laws, by limiting the maximum legal interest rate, cause credit rationing. They show that usury laws in the 19th century reduced credit and economic activity when they were binding. The alternative hypothesis is that it was the relaxation of usury laws rather than the free banking laws that led to an increase in innovation: in states with a higher maximum legal interest rate, banks lent with lower restrictions to high-risk entrepreneurs, encouraging innovation. Data on the maximum legal rates come from Holmes (1892). We control for the effect of usury laws in estimating Eq. (5) and examine whether they absorbed the impact of the free banking law. Panel C of Table 3 reports the results with usury laws controls in columns 4-6. The results indicate that the impact of free banking on innovation was not absorbed by usury laws.

Another factor potentially related to both innovation and banking was the alternation of state-level political parties in power. In particular, the Whig Party, a political party active in the middle of the 19th century, favored modernization, banking, and economic protectionism to stimulate manufacturing. It appealed to entrepreneurs, planters, reformers, and the emerging urban middle class, but had little appeal to farmers or unskilled workers.[11] Potentially, the Whig Party's election in a state led to both the passage of the free banking law and other regulations that encouraged entrepreneurship. To understand this issue, we control for state-level political party in columns 1-3 of Panel C of Table 3. The data are from the historical record on the governors of the states in *The Tribune Almanac and Political Register*.[12] The dummy variable equals 1 if the state governor belonged to any of the following parties: Whig, Anti-Masonic, Republican, American, Know-nothing, Constitutional Union Party, National Union Party. Results show that the impact of the free banking laws on innovation remained positive and significant after controlling for political party.

Overall, the results confirm the causality that greater access to finance brought by free banking spurred innovation.

# 6 Labor Mechanism

Our evidence so far shows a robust, positive effect of state-level free banking laws on innovation, which did not appear to be driven by pre-existing trends in innovation output prior to free banking or by omitted shocks coinciding with the free banking laws. In this section we explore an important underlying mechanism that shapes how free banking laws affect companies' innovation output: labor scarcity.

## 6.1 Free States and Slave States

As demonstrated in our theoretical model, labor scarcity is an important factor that shapes how access to finance affects innovation. However, it is difficult to empirically test it in today's world given that labor is relatively mobile across regions. The antebellum period provides a unique laboratory in which to test the importance of labor scarcity. During this historical episode, free states and slave states coexisted. At the margin, slave labor was much cheaper

[11] The Whig Party emerged in the 1830s as the leading opponent of Jacksonians, supporters of the policies of President Andrew Jackson (in office 1829–37) and his Democratic Party. It included former members of the National Republican and Anti-Masonic Parties. Along with the rival Democratic Party, it was central to the Second Party System from the early 1840s to the mid-1860s.

[12] The Tribune Almanac and Political Register kept a record of the name, party, year elected, and salary of the governor in each state since statehood.

than free labor and hence led to higher labor scarcity in the free states. This historical setting provides us with natural heterogeneities in labor scarcity across regions.

Table 4 reports the summary statistics of labor conditions in the free states and slave states. Free states and slave states had similar levels of population, but the composition of the population was very different. Free states had a higher ratio of urban population to total population and a higher ratio of white people to total population; they also paid a higher daily average wage to individual laborers. The evidence is consistent with our conjecture that free states had higher labor scarcity than free states.

To examine how being a free state or not affects the marginal impact of free banking laws on innovation, we estimate the following model:

$$
\begin{aligned}
Ln(Patents)_{i,t+s} = & \alpha + \beta_1 \mathit{Free\ banking}_{i,t} \times \mathit{Free\ state}_{i,t} + \beta_2 \mathit{Free\ banking}_{i,t} + \beta_3 \mathit{Free\ state}_{i,t} \\
& + \gamma Z_{i,t} + State_i + Year_t + \epsilon_{i,t}, \qquad (7)
\end{aligned}
$$

where i indexes state, t indexes year. The dependent variable captures state innovation outcomes as measured by patent counts. We add the new variable, $\mathit{Free\ state}_{i,t}$, and the interaction term between $\mathit{Free\ banking}_{i,t}$ and $\mathit{Free\ state}_{i,t}$. The coefficient estimate of $\mathit{Free\ banking}_{i,t}$ captures the effect of the free banking laws on innovation in free states. The coefficient estimate on the interaction term reflects the different effects of the free banking laws on innovation in slave states. If our conjecture is correct—i.e, if higher labor scarcity in free states encourages innovation—then we expect $\beta_1$ to be positive and significant.

We report the results estimating Eq. (7) in Table 5. The coefficient estimates of $\mathit{Free\ banking}_{i,t} \times \mathit{Free\ state}_{i,t}$ were positive and significant at the 1% level, which suggests that access to finance had a higher impact on innovation in free states than in slave states. Based on the coefficient estimate reported in column (3), free states with free banking laws generated a total of 58.1% more patents in the subsequent three years than firms in slave states with free banking. These findings suggest that free banking enhanced innovation for both slave and free states, with the effect on free states being higher.

## 6.2 Triple Difference-in-differences

Free states and slave states differed in many dimensions in addition to labor. Therefore one potential concern about the above results is that we capture a factor that does not pertain to labor scarcity. To address this concern, we further conduct tests that compare innovation within free states and slave states. We make use of the differences in relative labor scarcity across free labor and slave labor in free states and slave states, respectively. There is only free labor and no slave labor in free states; there is relatively abundant slave labor and relatively less free labor in slave states. If labor scarcity indeed affects the marginal impact of access to finance on innovation, we should expect to see a difference between the innovation that mainly substitutes for slave labor and the innovation that mainly substitutes for free labor across free states and slave states.

To examine this idea, we use industry classifications to separate slave labor and free labor. Given that slave laborers tended to work in the agricultural industry, there is higher labor scarcity in the manufacturing in slave states. Given that free labor is more expensive than slave labor, labor scarcity is higher in free states than in slave states. In addition, because the demand for labor in manufacturing is high, labor scarcity is relatively higher in manufacturing industries. Therefore we conjecture that free states experienced a greater increase in innovation in the manufacturing industries and slave states experienced a greater increase in innovation in agriculture.

We test the above hypothesis by estimating the following triple difference-in-differences model:

$$\begin{aligned} Ln(Patents)_{i,j,t+s} =& \alpha + \beta_1 \textit{Free banking}_{i,t} \times \textit{Free state}_{i,j,t} \times \textit{Manufacturing patent}_j + \\ & \beta_2 \textit{Free banking} \times \textit{Free state}_{i,j,t} + \beta_3 \textit{Free state}_{i,t} \times \textit{Manufacturing patent}_j \\ & + \beta_4 \textit{Free banking}_{i,t} \times \textit{Manufacturing patent}_j + \beta_5 \textit{Free banking}_{i,t} \\ & + \beta_6 \textit{Free state}_{i,t} + \beta_7 \textit{Manufacturing patent}_j + \gamma Z_{i,t} + State_i + Year_t + \epsilon_{i,t}, \end{aligned} \tag{8}$$

where i indexes state, t indexes year, j indexes patent category. We report the regression results estimating Eq. (8) in Table 5. The coefficient estimate $\beta_1$ on $\textit{Free banking}_{i,t} \times \textit{Free state}_{i,j,t} \times$

*Industrial patent*$_j$ was positive and significant. Consistent with our conjecture, the results suggest free banking encouraged innovation the most when labor was most scarce—in free states where manufacturing labor was scarce.

Interestingly, the coefficient estimate $\beta_5$ on *Free banking*$_{i,t}$ was negative, suggesting that free banking laws discouraged innovation where labor was prevalent—in the agricultural industry of slave states. This could happen for two reasons. First, better access to finance might induce slave owners to buy more slave labor instead of engaging in innovation. Second, better access to finance in a slave state might attract more slave holders and slaves to a state that passed the free banking laws. In both cases, free banking increased slave labor and further discouraged innovation. To verify the channel, we examine total changes in the slave population across states and find an increase in the slave population after free banking passage in Table 7.[13]

### 6.3 Robustness

One potential concern about the current results is that slave and free states are vastly different in economic conditions and industry composition, and these factors, rather than the difference in labor scarcity, could drive our results. Although we examined innovation differences within states by employing a triple interaction in the last section, we conduct additional robustness tests to ensure that our results are not driven by the difference in industry concentration between free and slave states.

Table 8 reports results estimating Eq. (8) in subsamples. Panel A imposes the restriction that all states included have agricultural output that is higher than manufacturing output. This restriction selects states with similar industry concentration in agriculture and manufacturing output ratio. As we can see in the panel, the results are qualitatively similar to those in Table 7. While the coefficient estimates $\beta_1$ on *Free banking*$_{i,t}$ $\times$ *Free state*$_{i,j,t}$ $\times$ *Manufacturing patent*$_j$ were insignificant because there were fewer observations, they remained economically sizable. The coefficient estimates on *Free banking*$_{i,t}$ were still negative and significant, suggesting that the negative impact of free banking laws on agricultural innovation in slave states prevails.

Panel B imposes the restriction that all states included have agricultural output that is less than half of the manufacturing output. As we can see in the panel, the results are qualitatively

[13] Given that the census reports slave population per state decennially, the data points in our regression are for the slave populations in 1810, 1820, 1830, 1840, 1850, and 1860.

similar to those in Table 7. The coefficient estimate $\beta_1$ on $\textit{Free banking}_{i,t} \times \textit{Free state}_{i,j,t} \times \textit{Manufactural patent}_j$ was positive and significant, suggesting a positive impact of access to finance on innovation when labor was scarce. The coefficient estimates on $\textit{Free banking}_{i,t}$ were dropped due to a lower power of the tests with fewer state observations.

# 7 Extensions and Robustness

## 7.1 Free banking and Access to Finance

In this section, we directly document the impact of free banking on access to finance. We hypothesize that passage of free banking law increases access to finance and therefore encourages innovation by increasing the capital supply needed to conduct innovation.

We estimate the following model:

$$Y_{i,t} = \alpha + \beta \textit{Free banking}_{i,t} + \gamma Z_{i,t} + State_i + Year_t + \epsilon_{i,t}, \tag{9}$$

where $Y_{i,t}$ is a measure of access to finance at state i in year t. We use the counts of free banks, the ratio of free bank counts to total bank counts, the amount of loans lent by free banks, and the ratio of loan amounts from free banks to loan amounts from all banks. Table 9 reports the results estimating Eq. (9). As shown in the table, there was a significant increase in free bank counts and loans, in either magnitude or ratio. The evidence is consistent with the hypothesis that the passage of free banking laws improved access to finance.

## 7.2 Previously Unbanked Region

If free banking laws indeed promoted innovation, we should expect to see the most pronounced effect in regions with relatively less access to finance. To test the hypothesis, we estimate the following model:

$$Ln(Patents)_{i,t} = \alpha + \beta_1 \textit{Free banking}_{i,t} \times X_i + \beta_2 \textit{Free banking}_{i,t} + \beta_3 X_i + \gamma Z_{i,t} + State_i + Year_t + \epsilon_{i,t}, \tag{10}$$

where $X_i$ is an indicator variable that takes the value of one if the region is likely to have less access to finance. Panel A of Table 10 uses *Midwest* as $X_i$. *Midwest* takes the value of one if the state is in the Midwest and zero otherwise. Given that the Midwest region is relatively undeveloped and have few banks, states in this region should benefit more from access to finance.

The coefficient estimate of interest, $\beta_1$, is positive and significant. It confirms our conjecture.

Panel B of Table 10 uses *Unbanked before 1837* and *Unbanked before free banking* as direct measures of access to finance. *Unbanked before 1837* takes the value of one if the state is unbanked before 1837 and zero otherwise; *Unbanked before free banking* takes the value of one if the state is unbanked before the passage of free banking laws and zero otherwise. Therefore, *Unbanked before 1837* captures the extensive margin, and *Unbanked before free banking* captures the intensive margin. As shown by the panel, the coefficient estimate, $\beta_1$, is positive and significant no matter which measure we use.

Panel C of Table 10 uses county-year level regressions that estimate Eq. (5) with *Free bank counts* replacing *Free banking*. Given that finance was local during the antebellum period, the effect of access to finance on innovation would be likely to manifest itself at the county level. This is indeed what we find. While free banking laws are state-level events, we use free bank counts to capture access to finance at the county level. The results show that free bank counts were positively and significantly associated with innovation at the county level, which implies that free banking laws spurred innovation by improving local access to finance.

## 8 Conclusion

In this paper, we establish labor scarcity as a novel and important economic channel for the finance–growth nexus. We take a historical approach and examine antebellum America from 1812 to 1860. This period witnessed the staggered passage of free banking laws across eighteen states, which provides us a unique setting in which to identify banking shocks. Furthermore, the sharp contrast in labor scarcity between slave and free states makes antebellum America a perfect setting in which to examine the labor scarcity channel.

We confirm that access to finance, as identified by the staggered passage of the free banking laws, spurred innovation, especially in the previously unbanked Midwest. To understand the economic mechanism, we exploit wide variations in the economy and labor scarcity between slave and free states. We find that improved access to finance is not sufficient to encourage innovation; importantly, the finance–growth nexus is more pronounced when one factor of production—i.e., labor—was scarce. In fact, slavery in the South led to a low marginal cost of slave labor, which discouraged technological innovation that aimed to substitute for slave labor. Our research sheds new light on the factors that drive innovation. Our findings suggest why some regions are more innovative than others, and under what conditions additional financing in the form of bank loans is able to spur innovation.

# Appendix

## A Variable Definitions

| Variable | Definition |
|---|---|
| *Innovation Measure* | |
| *Ln(Patents)* | Natural logarithm of one plus state i's total number of patents filed (and everything granted) in a given year. |
| *Free banking* | An indicator variable that takes the value of zero prior to free banking act passage. |
| $Before^1$ | A variable that takes the value of one the year prior to the passage of free banking act and zero otherwise. |
| $Before^2$ | A variable that takes the value of one two years prior to the passage of free banking act and zero otherwise. |
| $Before^{3^-}$ | A variable that takes the value of one from the beginning of the window up to three years prior to the passage of free banking act and zero otherwise. |
| $After^{3^+}$ | A variable that takes the value of one in the third year following the passage of free banking act until the end of the window and zero otherwise. |
| $After^2$ | A variable that takes the value of one two years after the passage of free banking act and zero otherwise. |
| $After^{1+}$ | A variable that takes the value of one in the year following the passage of free banking act and zero otherwise. |
| *State Characteristics* | |
| *Ln(Population)* | Natural logarithm of total number of people that reside at a state in a given year. |
| *Urban ratio* | Ratio of urban population to total population at a state in a given year. |
| *Slave ratio* | Ratio of slave population to total population at a state in a given year. |
| *White ratio* | Ratio of white population to total population at a state in a given year. |
| *Free state* | An indicator variable that takes the value of one if state i is free in a given year. |
| *Slave* | An indicator variable that takes the value of one if state i is a slave state in a given year. |
| *Manufacturing patent* | A variable that takes the value of one if a patent used for manufacturing and zero otherwise. |
| *Max rate* | The maximum interest rate limit in a state imposed by usury laws. |
| *Political party* | A variable that takes the value of one if the presiding party in a state is Whig party or Republican and zero otherwise (for example, Democratic party). |
| *Midwest* | An indicator variable that takes the value of one if state i is in the Midwest. |
| *Unbanked before 1837* | An indicator variable that takes the value of one if state i does not have any bank before 1827. |
| *Unbanked before free banking* | An indicator variable that takes the value of one if state i does not have any bank before the passage of free banking act. |

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**Table 1**
Summary statistics.
This table gives an overview of this paper's sample. Panel A reports summary statistics for the state-year observations, including dependent, independent, and control variables. Panel B reports the passage year of free banking laws in each affected state. Definitions of the variables are in Appendix A.

Panel A: Summary statistics

| | P25 | P50 | Mean | P75 | SD | N |
|---|---|---|---|---|---|---|
| Patents | 0 | 0 | 16.51 | 7 | 70.48 | 2499 |
| Patents(agriculture) | 0 | 0 | 2.12 | 1 | 9.23 | 2,499 |
| Patents(manufacture) | 0 | 0 | 12.27 | 3 | 61.41 | 2,499 |
| Population (thousands) | 57.682 | 310 | 740 | 1,100 | 1,000 | 2,352 |
| Urban ratio | 0 | 0.04 | 0.10 | 0.13 | 0.16 | 2,352 |
| Slave ratio | 0 | 0 | 0.12 | 0.22 | 0.17 | 2,058 |
| white ratio | 0.71 | 0.96 | 0.84 | 0.99 | 0.19 | 2,352 |
| Political party | 0 | 0 | 0.38 | 1 | 0.48 | 868 |
| Max rate | 0.06 | 0.06 | 0.09 | 0.08 | 0.07 | 1,439 |
| Free bank counts | 0 | 0 | 1.81 | 0 | 15.12 | 2,499 |
| Free ratio | 0 | 0 | 0.02 | 0 | 0.11 | 2,499 |
| Free bank loans (thousands) | 0 | 0 | 750 | 0 | 10,000 | 2,499 |
| Free bank loan ratio | 0 | 0 | 0.02 | 0 | 0.12 | 2,499 |

Panel B: Passage of free banking laws

| State | Year of passage |
|---|---|
| Michigan* | 1837, 1857 |
| New York | 1838 |
| Georgia | 1838 |
| Alabama | 1849 |
| New Jersey | 1850 |
| Vermont | 1851 |
| Ohio | 1851 |
| Massachusetts | 1851 |
| Illinois | 1851 |
| Connecticut | 1852 |
| Indiana | 1852 |
| Wisconsin | 1852 |
| Tennessee | 1852 |
| Louisiana | 1853 |
| Florida | 1853 |
| Minnesota | 1858 |
| Iowa | 1858 |
| Pennsylvania | 1860 |

*Michigan passed the free banking law in 1837, then abolished in 1840, then reinstated in 1857.

**Table 2**

Baseline regressions.

This table reports OLS regression estimates of Eq. (5). The dependent variable in columns 1-2, 3-4, and 5-6 is the natural logarithm of one plus the sum of the patents generated in a state in year t+1, t+2, and t+3, respectively. Definitions of variables are in Appendix A. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

| | Ln(Patents) | | | | | |
|---|---|---|---|---|---|---|
| | t+1 | | t+2 | | t+3 | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Free banking* | 1.018*** | 0.555*** | 1.069*** | 0.596*** | 1.068*** | 0.577*** |
| | (0.125) | (0.070) | (0.117) | (0.071) | (0.112) | (0.069) |
| *Ln(Population)* | | 0.527*** | | 0.564*** | | 0.611*** |
| | | (0.022) | | (0.023) | | (0.026) |
| *Urban ratio* | | 3.086*** | | 3.365*** | | 3.594*** |
| | | (0.377) | | (0.447) | | (0.465) |
| *Slave ratio* | | -4.514*** | | -6.229*** | | -8.245*** |
| | | (1.021) | | (1.269) | | (1.551) |
| *White ratio* | | -2.394*** | | -3.766*** | | -5.112*** |
| | | (0.838) | | (0.938) | | (1.054) |
| Constant | -0.604*** | -4.693*** | -0.593*** | -4.092*** | -0.680*** | -3.637*** |
| | (0.072) | (0.621) | (0.073) | (0.633) | (0.075) | (0.676) |
| Observations | 2,499 | 2,058 | 2,499 | 2,058 | 2,499 | 2,058 |
| R-squared | 0.873 | 0.908 | 0.869 | 0.906 | 0.865 | 0.905 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes | Yes | Yes | Yes |

**Table 3**
Robustness checks.
This table reports robustness tests of the baseline regressions. Panel A reports OLS regression estimates of Eq. (6). Dependent variables in columns 1-3 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Panel B reports OLS regression estimates of Eq. (5) with randomized state free banking passage. Dependent variables in columns 1-3 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Panel C reports OLS regression estimates of Eq. (5) with additional controls. Columns 1-3 have *Political party* as the additional control variable. Dependent variables in columns 1-3 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Columns 4-6 have *Max rate* as the additional control variable. Dependent variables in columns 4-6 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

Panel A: Endogeneity tests

| | Ln(Patents) | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| $Before^{3-}$ | -0.210 | -0.269** | -0.377*** |
| | (0.151) | (0.110) | (0.107) |
| $Before^{2}$ | 0.096 | -0.065 | -0.298 |
| | (0.152) | (0.149) | (0.190) |
| $Before^{1}$ | 0.079 | -0.290 | 0.012 |
| | (0.145) | (0.183) | (0.117) |
| $After^{1}$ | 0.230 | 0.129 | 0.158 |
| | (0.207) | (0.148) | (0.124) |
| $After^{2}$ | 0.233 | 0.303* | 0.182 |
| | (0.224) | (0.157) | (0.148) |
| $After^{3+}$ | 0.451*** | 0.373*** | 0.241** |
| | (0.162) | (0.118) | (0.112) |
| *Ln(Population)* | 0.492*** | 0.532*** | 0.576*** |
| | (0.026) | (0.025) | (0.028) |
| *Urban ratio* | 3.056*** | 3.389*** | 3.618*** |
| | (0.385) | (0.462) | (0.472) |
| *Slave ratio* | -4.748*** | -6.291*** | -8.344*** |
| | (1.009) | (1.268) | (1.546) |
| *White ratio* | -2.778*** | -4.019*** | -5.414*** |
| | (0.803) | (0.943) | (1.015) |
| Constant | -3.981*** | -3.568*** | -3.043*** |
| | (0.594) | (0.623) | (0.638) |
| Controls | Yes | Yes | Yes |
| Observations | 1,502 | 1,502 | 1,502 |
| R-squared | 0.894 | 0.889 | 0.889 |
| State FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

Panel B: Randomization of free banking

| | Ln(Patents) | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| *Free banking* | 0.101 | 0.052 | 0.006 |
| | (0.066) | (0.061) | (0.052) |
| *Ln(Population)* | 0.495*** | 0.528*** | 0.569*** |
| | (0.023) | (0.024) | (0.026) |
| *Urban ratio* | 4.786*** | 4.931*** | 4.950*** |
| | (0.436) | (0.460) | (0.438) |
| *Slave ratio* | -3.776*** | -4.446*** | -5.361*** |
| | (0.820) | (0.831) | (1.011) |
| *White ratio* | -2.661*** | -3.219*** | -3.849*** |
| | (0.821) | (0.740) | (0.744) |
| Constant | -5.885*** | -5.922*** | -5.712*** |
| | (0.666) | (0.601) | (0.559) |
| Observations | 2,562 | 2,562 | 2,562 |
| R-squared | 0.886 | 0.887 | 0.891 |
| State FE | YES | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

Panel C: Are other factors driving the results?

| | Ln(Patents) | | | | | |
|---|---|---|---|---|---|---|
| | t+1 | t+2 | t+3 | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Free banking* | 0.227*** | 0.329*** | 0.347*** | 0.402*** | 0.467*** | 0.478*** |
| | (0.058) | (0.086) | (0.094) | (0.071) | (0.086) | (0.089) |
| *Political party* | 0.022 | 0.080 | 0.128** | | | |
| | (0.051) | (0.062) | (0.059) | | | |
| *Max rate* | | | | 0.423* | 0.039 | -0.047 |
| | | | | (0.249) | (0.475) | (0.341) |
| *Ln(Population)* | 0.517*** | 0.574*** | 0.633*** | 0.567*** | 0.625*** | 0.703*** |
| | (0.107) | (0.101) | (0.114) | (0.050) | (0.062) | (0.070) |
| *Urban ratio* | 1.302 | 2.636* | 3.249** | 2.129*** | 2.885*** | 3.413*** |
| | (0.862) | (1.379) | (1.508) | (0.503) | (0.857) | (0.918) |
| *Slave ratio* | -5.593** | -9.298*** | -13.144*** | -5.000** | -5.947** | -6.469*** |
| | (2.556) | (3.266) | (4.016) | (1.917) | (2.221) | (2.135) |
| *White ratio* | -5.330** | -8.068*** | -10.076*** | -2.241 | -2.717 | -2.195 |
| | (2.090) | (2.455) | (2.213) | (1.957) | (2.135) | (1.849) |
| Constant | -0.529 | 1.819 | 3.619 | -4.855*** | -4.734** | -5.545*** |
| | (2.760) | (2.726) | (2.282) | (1.810) | (1.892) | (1.617) |
| Observations | 868 | 868 | 868 | 1,439 | 1,439 | 1,439 |
| R-squared | 0.919 | 0.914 | 0.913 | 0.897 | 0.892 | 0.889 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes | Yes | Yes | Yes |

**Table 4**

Labor difference: Slave states vs. free states

This table presents summary statistics for labor in slave states and free states. Definitions of variables are in Appendix A.

| | P25 | P50 | Mean | P75 | SD | N |
|---|---|---|---|---|---|---|
| | | | Free states | | | |
| Ln(Population) | 13 | 13.40 | 13.42 | 14.26 | 1.29 | 732 |
| Urban ratio | 0.030 | 0.09 | 0.13 | 0.17 | 0.14 | 732 |
| Slave ratio | 0 | 0 | 0 | 0 | 0 | 732 |
| White ratio | 0.97 | 0.99 | 0.98 | 1 | 0.02 | 732 |
| Daily average wage (with board) | 0.62 | 0.68 | 0.74 | 0.76 | 0.37 | 732 |
| Daily average wage (without board) | 0.85 | 0.93 | 1.01 | 1 | 0.47 | 732 |
| | | | Slave states | | | |
| Ln(Population) | 12.17 | 13.70 | 13.26 | 14.16 | 1.17 | 758 |
| Urban ratio | 0.010 | 0.040 | 0.12 | 0.13 | 0.22 | 758 |
| Slave ratio | 0.17 | 0.30 | 0.29 | 0.44 | 0.16 | 758 |
| White ratio | 0.56 | 0.65 | 0.66 | 0.77 | 0.14 | 758 |
| Daily average wage (with board) | 0.31 | 0.38 | 0.44 | 0.47 | 0.35 | 758 |
| Daily average wage (without board) | 0.43 | 0.54 | 0.62 | 0.65 | 0.46 | 758 |

**Table 5**

Labor scarcity and innovation

This table presents regression coefficient estimates of Eq. (7). Dependent variables in columns 1-3 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

| | Ln(Patents) | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| *Free banking* × *Free state* | 0.466*** | 0.487*** | 0.581*** |
| | (0.087) | (0.151) | (0.177) |
| *Free banking* | 0.096 | 0.157* | 0.098 |
| | (0.093) | (0.091) | (0.099) |
| *Free state* | 0.619** | 0.997** | 1.221*** |
| | (0.263) | (0.387) | (0.389) |
| *Ln(Population)* | 0.433*** | 0.498*** | 0.564*** |
| | (0.043) | (0.050) | (0.057) |
| *Urban ratio* | 1.031** | 1.757** | 2.243*** |
| | (0.473) | (0.676) | (0.708) |
| *Slave ratio* | -2.086 | -3.618** | -4.892** |
| | (1.472) | (1.726) | (1.859) |
| *White ratio* | -0.180 | -1.439 | -2.061 |
| | (1.419) | (1.618) | (1.513) |
| Constant | -6.534*** | -5.947*** | -6.143*** |
| | (1.247) | (1.371) | (1.246) |
| Observations | 1,490 | 1,490 | 1,490 |
| R-squared | 0.895 | 0.892 | 0.891 |
| State FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

**Table 6**
Labor scarcity and innovation: Patent category
This table presents regression coefficient estimates of Eq. (8). Dependent variables in columns 1-3 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

| | Manufacture vs. Agriculture | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| *Free banking* × *Free state* × *Manufactural patent* | 0.351*** | 0.342*** | 0.366*** |
| | (0.113) | (0.113) | (0.122) |
| *Free banking* × *Manufacturing patent* | 0.330*** | 0.305** | 0.267** |
| | (0.113) | (0.116) | (0.121) |
| *Manufacturing patent* × *Free state* | 0.463*** | 0.480*** | 0.498*** |
| | (0.042) | (0.044) | (0.043) |
| *Free banking* × *Free state* | 0.654*** | 0.697*** | 0.765*** |
| | (0.128) | (0.162) | (0.161) |
| *Free banking* | -0.213* | -0.156 | -0.177 |
| | (0.117) | (0.117) | (0.120) |
| *Free state* | -0.116 | 0.174 | 0.372 |
| | (0.218) | (0.278) | (0.277) |
| *Manufacturing patent* | 0.480*** | 0.499*** | 0.521*** |
| | (0.049) | (0.050) | (0.051) |
| Constant | -3.160*** | -2.468** | -2.378** |
| | (0.951) | (1.068) | (0.973) |
| Controls | Yes | Yes | Yes |
| Observations | 2,980 | 2,980 | 2,980 |
| R-squared | 0.813 | 0.813 | 0.816 |
| State FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

**Table 7**

Slave population.

This table presents OLS regression coefficient estimates of regressing *Slave ratio* on *Free banking*. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

| | Slave ratio | |
|---|---|---|
| | (1) | (2) |
| *Free banking* | 0.806* | 0.881** |
| | (0.326) | (0.303) |
| *Ln(Population)* | | 0.320 |
| | | (0.185) |
| *Urban ratio* | | -3.293 |
| | | (1.707) |
| *White ratio* | | -69.393** |
| | | (15.588) |
| Constant | 18.939*** | 61.145*** |
| | (2.964) | (9.458) |
| Observations | 210 | 210 |
| R-squared | 0.988 | 0.996 |
| State FE | Yes | Yes |
| Year FE | Yes | Yes |
| Cluster by Year | Yes | Yes |

**Table 8**

Labor scarcity and innovation: Controlling for industry concentration

This table presents OLS regression coefficient estimates. Panel A restricts the sample to manufacture-prone states. Manufacture-prone states are the states with annual manufacture output higher than agriculture output. Panel B restricts the sample to agriculture-prone states. Agriculture-prone states are the states with annual manufacture output higher than agriculture output. Dependent variables in columns 1-3 are the natural logarithm of one plus the sum of the patents generated in year t+1, t+2, and t+3, respectively. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

Panel A: Manufacture-prone states

| | Manufacture vs. Agriculture | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| *Free banking* × *Free state* × *Manufactural patent* | 0.108 | 0.107 | 0.106 |
| | (0.109) | (0.120) | (0.125) |
| *Free banking* × *Manufacturing patent* | 0.459*** | 0.442*** | 0.408*** |
| | (0.113) | (0.115) | (0.119) |
| *Manufacturing patent* × *Free state* | 0.191*** | 0.214*** | 0.239*** |
| | (0.035) | (0.036) | (0.037) |
| *Free banking* × *Free state* | 0.676*** | 0.710*** | 0.829*** |
| | (0.120) | (0.183) | (0.180) |
| *Free banking* | -0.317*** | -0.223** | -0.205* |
| | (0.104) | (0.101) | (0.104) |
| *Free state* | 1.096** | 1.303*** | 1.445*** |
| | (0.410) | (0.373) | (0.356) |
| *Manufacturing patent* | 0.350*** | 0.362*** | 0.380*** |
| | (0.041) | (0.042) | (0.043) |
| Constant | -3.293 | -0.270 | 2.167 |
| | (2.559) | (2.847) | (2.857) |
| Controls | Yes | Yes | Yes |
| Observations | 1,834 | 1,834 | 1,834 |
| R-squared | 0.791 | 0.787 | 0.790 |
| State FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

Panel B: Agriculture-prone states

| | Manufactural vs. Agricultural | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| *Free banking* × *Free state* × *Manufactural patent* | 0.955*** | 0.905*** | 0.913*** |
| | (0.104) | (0.097) | (0.112) |
| *Manufacturing patent* × *Free state* | 0.313*** | 0.306*** | 0.307*** |
| | (0.088) | (0.091) | (0.091) |
| *Free banking* × *Free state* | 0.157* | 0.228*** | 0.208*** |
| | (0.079) | (0.064) | (0.074) |
| *Free state* | -3.393*** | -3.291*** | -3.242*** |
| | (0.949) | (1.082) | (1.095) |
| *Manufacturing patent* | 0.919*** | 0.964*** | 0.998*** |
| | (0.101) | (0.103) | (0.102) |
| Constant | -15.527*** | -14.102*** | -14.488*** |
| | (3.908) | (4.130) | (3.898) |
| Controls | Yes | Yes | Yes |
| Observations | 1,146 | 1,146 | 1,146 |
| R-squared | 0.866 | 0.869 | 0.874 |
| State FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

**Table 9**

Free Banking and Access to Finance

This table presents OLS regression coefficient estimates for Eq. (9). Panel A examines free banks. Dependent variables in columns 1-3 are the natural logarithm of one plus free bank counts at a state in year t+1, t+2, t+3, respectively. Dependent variables in columns 4-6 are the ratio of free bank counts and total bank counts at a state in year t+1, t+2, t+3. Panel B examines loans lent by free banks. Dependent variables in columns 1-3 are the natural logarithm of one plus free bank loans at a state in year t+1, t+2, and t+3, respectively. Dependent variables in columns 4-6 are the ratio of free bank loans and total bank loans at a state in year t+1, t+2, and t+3, respectively. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

Panel A: Free banks

| | Ln(Free bank counts) | | | Free bank ratio | | |
|---|---|---|---|---|---|---|
| | t+1 | t+2 | t+3 | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Free banking* | 1.499*** | 1.302*** | 1.109*** | 0.227*** | 0.186*** | 0.148*** |
| | (0.144) | (0.190) | (0.216) | (0.026) | (0.032) | (0.034) |
| *Ln(Population)* | 0.061** | 0.083** | 0.103** | 0.042*** | 0.045*** | 0.046*** |
| | (0.029) | (0.037) | (0.044) | (0.011) | (0.013) | (0.015) |
| *Urban ratio* | 2.313*** | 2.027*** | 1.755*** | 0.196*** | 0.183*** | 0.169*** |
| | (0.486) | (0.553) | (0.576) | (0.046) | (0.053) | (0.057) |
| *Slave ratio* | -1.568*** | -1.649*** | -1.745*** | -0.537*** | -0.492*** | -0.459*** |
| | (0.515) | (0.495) | (0.467) | (0.120) | (0.127) | (0.131) |
| *White ratio* | -1.264*** | -1.208*** | -1.178*** | -0.286*** | -0.246*** | -0.218*** |
| | (0.409) | (0.388) | (0.369) | (0.068) | (0.072) | (0.075) |
| Constant | -1.571** | -1.600* | -1.606* | -0.355*** | -0.404*** | -0.438*** |
| | (0.684) | (0.824) | (0.892) | (0.117) | (0.142) | (0.158) |
| Observations | 2,058 | 2,058 | 2,058 | 2,058 | 2,058 | 2,058 |
| R-squared | 0.617 | 0.565 | 0.520 | 0.512 | 0.459 | 0.418 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes | Yes | Yes | Yes |

Panel B: Free bank loans

| | Ln(Free bank loans) | | | Free bank loan ratio | | |
|---|---|---|---|---|---|---|
| | t+1 | t+2 | t+3 | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Free banking* | 7.416*** | 7.190*** | 6.882*** | 0.179*** | 0.167*** | 0.150*** |
| | (0.616) | (0.588) | (0.738) | (0.015) | (0.017) | (0.026) |
| *Ln(Population)* | 0.331*** | 0.493*** | 0.673*** | 0.063*** | 0.068*** | 0.074*** |
| | (0.119) | (0.137) | (0.149) | (0.010) | (0.012) | (0.013) |
| *Urban ratio* | 9.630*** | 10.004*** | 10.629*** | 0.483*** | 0.482*** | 0.479*** |
| | (2.473) | (2.434) | (2.394) | (0.084) | (0.084) | (0.083) |
| *Slave ratio* | -2.501 | -2.534 | -3.125 | -0.294 | -0.280 | -0.305 |
| | (2.394) | (2.833) | (3.550) | (0.217) | (0.218) | (0.219) |
| *White ratio* | -5.070 | -5.084 | -5.851 | -0.179 | -0.196 | -0.242 |
| | (3.717) | (4.043) | (4.549) | (0.245) | (0.246) | (0.266) |
| Constant | -8.092** | -10.236*** | -12.200*** | -0.663* | -0.638* | -1.036* |
| | (3.460) | (3.728) | (4.011) | (0.338) | (0.369) | (0.525) |
| Observations | 2,016 | 1,974 | 1,932 | 2,016 | 1,974 | 1,932 |
| R-squared | 0.585 | 0.561 | 0.535 | 0.463 | 0.455 | 0.445 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes | Yes | Yes | Yes |

**Table 10**

Region effect

This table presents OLS regression coefficient estimates fore Eq. (10). Panel A examines the geographic region effect. *Midwest region* is an indicator that takes value of 1 if the state is in Midwest region. Panel B examines the previously unbanked region. *Unbanked before 1837* is an indicator variable that takes the value of 1 if the state does not have any bank before 1837. *Unbanked before free banking* is an indicator variable that takes the value of 1 if the state does not have any bank before passing free banking act. Panel C report county-level regressions. Robust standard errors clustered at the year level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Definitions of variables are in Appendix A.

Panel A: Midwest region

| | Ln(Patents) | | |
|---|---|---|---|
| | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) |
| *Free banking × Midwest* | 0.486*** | 0.543*** | 0.628*** |
| | (0.077) | (0.147) | (0.159) |
| *Free banking* | 0.408*** | 0.432*** | 0.388*** |
| | (0.065) | (0.065) | (0.065) |
| *Midwest* | 1.327*** | 1.200*** | 1.017*** |
| | (0.359) | (0.366) | (0.371) |
| *Ln(Population)* | 0.481*** | 0.513*** | 0.552*** |
| | (0.022) | (0.025) | (0.028) |
| *Urban ratio* | 3.200*** | 3.492*** | 3.740*** |
| | (0.384) | (0.475) | (0.502) |
| *Slave ratio* | -3.763*** | -5.389*** | -7.273*** |
| | (0.955) | (1.097) | (1.322) |
| *White ratio* | -2.014** | -3.342*** | -4.622*** |
| | (0.816) | (0.870) | (0.958) |
| Constant | -4.665*** | -4.060*** | -3.600*** |
| | (0.632) | (0.658) | (0.706) |
| Observations | 2,058 | 2,058 | 2,058 |
| R-squared | 0.909 | 0.908 | 0.907 |
| State FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes |

Panel B: Previously unbanked region

| | Ln(Patents) | | | | | |
|---|---|---|---|---|---|---|
| | Extensive margin | | | Intensive margin | | |
| | t+1 | t+2 | t+3 | t+1 | t+2 | t+3 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Free banking* × *Unbanked before 1837* | 0.310** | 0.483*** | 0.634*** | | | |
| | (0.125) | (0.156) | (0.129) | | | |
| *Unbanked before 1837* | 0.857** | 1.295** | 1.704*** | | | |
| | (0.406) | (0.503) | (0.542) | | | |
| *Free banking* × *Unbanked before free banking* | | | | 0.505*** | 0.644*** | 0.790*** |
| | | | | (0.147) | (0.151) | (0.120) |
| *Unbanked before free banking* | | | | -0.327 | -0.839 | -1.367** |
| | | | | (0.447) | (0.578) | (0.613) |
| *Free banking* | 0.513*** | 0.531*** | 0.492*** | 0.098 | 0.143* | 0.091 |
| | (0.074) | (0.072) | (0.069) | (0.074) | (0.084) | (0.077) |
| *Ln(Population)* | 0.503*** | 0.528*** | 0.564*** | 0.347*** | 0.397*** | 0.436*** |
| | (0.022) | (0.023) | (0.024) | (0.038) | (0.038) | (0.036) |
| *Urban ratio* | 3.123*** | 3.421*** | 3.668*** | 2.722*** | 3.251*** | 3.743*** |
| | (0.377) | (0.460) | (0.485) | (0.549) | (0.699) | (0.789) |
| *Slave ratio* | -4.250*** | -5.817*** | -7.704*** | -6.492 | -9.393* | -12.399** |
| | (1.015) | (1.194) | (1.434) | (3.943) | (4.678) | (4.639) |
| *White ratio* | -2.299*** | -3.619*** | -4.920*** | -4.554 | -6.403 | -8.228** |
| | (0.840) | (0.919) | (1.019) | (3.769) | (4.108) | (4.059) |
| Constant | -4.578*** | -3.911*** | -3.400*** | 0.990 | 2.795 | 4.630 |
| | (0.619) | (0.664) | (0.723) | (3.643) | (4.117) | (4.088) |
| Observations | 2,058 | 2,058 | 2,058 | 882 | 882 | 882 |
| R-squared | 0.908 | 0.907 | 0.906 | 0.934 | 0.934 | 0.934 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes | Yes | Yes | Yes |

Panel C: County-level regressions

| | Ln(Patents) | | | | | |
|---|---|---|---|---|---|---|
| | t+1 | | t+2 | | t+3 | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Free bank counts* | 0.156*** | 0.102*** | 0.166*** | 0.110*** | 0.173*** | 0.115*** |
| | (0.012) | (0.008) | (0.010) | (0.007) | (0.009) | (0.006) |
| *Ln(Population)* | | 0.048*** | | 0.063*** | | 0.080*** |
| | | (0.009) | | (0.010) | | (0.014) |
| *Urban ratio* | | 1.877*** | | 1.892*** | | 1.923*** |
| | | (0.153) | | (0.140) | | (0.127) |
| *Slave ratio* | | 1.093*** | | 1.001*** | | 0.882** |
| | | (0.303) | | (0.343) | | (0.352) |
| *White ratio* | | 1.786*** | | 1.736*** | | 1.677*** |
| | | (0.332) | | (0.359) | | (0.352) |
| Constant | 0.021*** | -2.080*** | 0.023*** | -2.147*** | 0.020*** | -2.248*** |
| | (0.000) | (0.341) | (0.000) | (0.349) | (0.000) | (0.332) |
| Observations | 153,223 | 52,925 | 153,223 | 52,925 | 153,223 | 52,925 |
| R-squared | 0.582 | 0.649 | 0.587 | 0.656 | 0.590 | 0.662 |
| County FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Cluster by Year | Yes | Yes | Yes | Yes | Yes | Yes |