How does investor protection affect innovation? Historical Evidence from Blue Sky Laws

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Abstract

This paper investigates the effect of investor protection on innovation. In the early twentieth century, states passed investor protection statutes called Blue Sky Laws when there was no federal regulation. These laws required companies to disclose information before selling their stocks, increased penalties in case of financial fraud, and setup local institutions regulating security issues. We find that private firms, with limited access to external capital markets, located in early adopting states produced 15-20% more patents. These results highlight the role of institutions and financial development in the economic growth.

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1 Introduction

Why do we observe differences in economic development across regions and countries? Finance literature stress the role of financial markets in economic growth [Levine and Zervos (1998)]. Other studies discuss factors such as contracting institutions and investor protection playing role in the development of financial markets [Porta et al. (1998); Acemoglu and Johnson (2005)]. However, convincing empirical evidence is hard to find since institutions, laws, stock markets and economy develop together. We utilize the introduction of the first form of investor protection laws, called Blue Sky Laws[1], by the states in the early twentieth century when there was no federal regulation to address this problem.[2]. Then, we show the effect of investor protection law and institutions on the innovation activity of private firms located in early adopting states.

In the early twentieth century, the US economy was growing rapidly. Since the US had unit banking system, companies, especially the small ones, started to use stock markets to finance their investments. Although obtaining a company stock was a privilege for wealthy people at the end of the nineteenth century, unsophisticated small investors started to take part in the growing stock markets. However, the presence of small investors increased the number of fraud cases as well. In response to that, Kansas was the first state that passed Blue Sky Law in 1911 to regulate the public sale of securities. Kansas statute distinguished ordinary fraud from financial fraud, and increased the penalties for financial fraud. In addition, it required registration of brokers and dealers selling securities to Kansas citizens. Beside these two fundamental changes, Kansas statute required information disclosure before public sale of stocks. [3] In particular, companies started to disclose their business plan, directors, shareholders, and financial statements [Macey and Miller (1991)].

Kansas statute gained popularity and spread to other states. Even Canada, England and Germany requested copies of Kansas statute. After adopting Blue Sky Laws, most

[1] Although the source of Blue Sky term is speculative, the term refers to securities that has no more basis than so many feet of "blue sky". (Hall v. Geiger-Jones Co., 242 U.S. 539 (1917))

[2] SEC established in 1934 during the Great Recession

[3] There were several stock exchanges spread through the country in addition to New York Stock Exchange and Curb Exchange in the early twentieth century. These exchanges had their own disclosure requirements but only large companies could be listed on those exchanges. [Hilt (2014)]

of the states established new institutions [4] to enforce the law, and these institutions had authority to introduce new rules e.g. granting voting rights to shareholders and requesting regular reports. Moreover, some of the states granted authority to evaluate the soundness of the securities and reject the ones with potential fraud. These early institutions inspired Securities Act of 1933 and establishment of Security Exchange Commission that regulates the stock markets at federal level [Macey and Miller (1991)].

Using historical patent data covering the population of all firms, we estimate the effect of Blue Sky Laws on the innovation performance. In particular, we use diff-in-diff-in-diff methodology and first compare the firms located in the states enacted the law in 1913 with the firms located in states passed similar statutes after 1918. Then, we compare the private firms with the public firms in early adopting states. Consistent with the view that investor protection and contracting institutions encourage investors to provide more funds, we find that private firms started to produce more patents and these patents received more citations. In other words, the positive effect of investor protection outweighs the possible negative effect due to compliance costs such as registration with the securities department, hiring public accountants, and producing regular reports.

The formation and the spread of Blue Sky Laws help us to address the problem that these laws passed earlier in some states since these states have different characteristics than the states passed the law after 1918. First, the formation and early adoption wave of Blue Sky Statutes were something unexpected. Kansas Banking Commissioner J.N. Dolley lobbied in favor of a securities regulation starting from 1910. He wrote columns about fraud cases in local newspapers and told public and local politicians the necessity of securities regulations to protect widows and orphans from fraud. Based on his suggestion, the Kansas House of Representatives passed the Blue Sky Law with a narrow margin, 63 votes out of 125. After the approval of the state senate and the governor, the law went into effect in 1911 [Fleming (2010)]. Kansas Blue Sky Law gained popularity and almost all states and some foreign governments requested copies of the statute. The reasons behind the interest were the promises made during the presidential election of 1912 against the security swindlers

[4]States either formed separate institutions called Securities Department, or formed Securities Divisions operating under departments such as State Banking Commission and Railroad Commission.

and "investment bankers" who held responsible for misusing nation's resources [Macey and Miller (1991); Brandeis (2009)]. As a result, half of the states had Blue Sky Laws similar to Kansas statute by the end of 1913.

In addition to the formation and early adoption, the late enactment of Blue Sky Statutes by some states was unexpected. When states were passing these laws, legislators never thought about their constitutionality. Investment Bankers Association (IBA) challenged the constitutionality of states authority to reject the securities they found "unsound" and initiated a process that would last until 1917 [Macey and Miller (1991); Spilman (1915)]. Although Supreme Court upheld the states authority in rejecting "unsound" securities, many states waited the dissolution of the uncertainty before taking action. With the end of World War I, the remaining states passed Blue Sky Statutes. To use these unexpected features of timing, we set the treatment group as firms located in states enacted the law in 1913 and the control group as firms located in states enacted the law after 1918 between the years 1907 and 1918.[5]

We use the empirical setting to investigate the effect of the Blue Sky Laws on "innovation" for two reasons. First, these laws mostly target issues of small and private firms which raise external finance through stock markets. However, it is impossible to reach the financial data including information about the investment and R&D expenditures of these firms.[6] Firm-level patent data enables to study the population of firms and address this problem. Second, the Blue Sky Laws have a first order effect on equity financing which is more convenient for R&D investment than debt financing (Brown et al., 2013).[7] In particular, innovation relies on intangible assets that cannot be used as collateral in debt contracts, and promises long-run and uncertain returns that is not convenient for debt contracts usually asking fixed short-term payments (Hall and Lerner, 2010).

[5]In deed late adopters had two different kind of statutes. We only used the states enacted similar laws to Kansas and exclude the other states mostly located in New England States. We discuss the details of laws and political economy behind in Section 2.

[6]Moody's Manual of Industrial includes financial data about firms but it has limited scope

[7] Hall and Lerner (2010) argues that R&D intensive firms have lower leverage. However, this does not necessarily mean that equity financing is the only option. Firms can use debt financing to fund innovation projects if equity financing is inadequate. For instance, Nanda and Nicholas (2014) show that debt financing plays an important role in quantity and quality of innovation during the Great Depression when stock markets collapsed.

We find that private firms located in early adopting states generated 15-20% more patents on average in the period between 1913 and 1918 than similar firms in states passed the investor protection laws after 1918. This number is large given that average growth rate of patents is 3-4% in that period. Although number of patents is a good proxy for level of R&D, one concern is that some companies could have manipulated their patent filings to attract more investors. In other words, they could file patents for incremental improvements. In order to relieve this concern, we use the number of total citations that a firm received from its patents in a given year and show that citations increased around 20% as well. These results confirm that the investor protection has significant positive effect on firm-level innovation reducing monitoring costs of investors and increasing the enforcement of contracts. The presence of the effect on private firms further highlight the financial channel and the role of stock markets in funding R&D expenditure.

We do several robustness check to address the potential concerns about the empirical strategy. To address the concern that these laws were enacted earlier in treatment states in response to lobbying efforts of innovative firms, we check the parallel trends assumption and show that there was no statistically significant difference between the innovation level of treatment and control group between 1907 and 1912. The other concern is that treated states specialized in particular sectors, and these sectors diverged positively after 1913. To address this, we divide the number of patents issued by each firm to total number of patents in the same three-digit patent class for each year. The results are still statistically significant with the new dependent variable. Aside from these robustness, we include firm fixed effects to control for the persistent firm level heterogeneity.

We investigate the political economy of the Blue Sky Laws and possible biases it could imply. Mahoney (2003) discusses three driving force behind. First, he argues that laws were passed in response to increasing fraud. This will generate downward bias for our results since securities based on patents were listed among the "speculative securities" in those times.[8]. The second view behind the legislation is that the lobbying efforts of small banks that tried to stop the flow from bank deposits to stock markets. If this is the case, then the funds granted to innovative firms should decline since banks ask for collateral before lending. This

[8]see Minnesota Securities Division, Annual Report of 1917

will again generate a downward bias in results. To control for the bank finance, we include annual bank loans in each state in our regression. The last hypothesis behind the legislation is the strength of the progressive movement. In order to address this, we select our control group among the states that the progressive movement is strong and disregard the states, mostly in New England, that investment banks managed to modify the statutes in favor of themselves.

In order to gain more insight about the mechanism, I visited Illinois State Archives and collected evidence about the institution. The archival records reveal that firms which had limited access to external finance had to comply with the Blue Sky Law. However, firms listed in stock exchanges and access to large investment banks as underwriters were exempt from registration to Securities Division. In addition, application documents of innovative firms in order to sell security reveal that they plan to use external finance to setup laboratories, pay wages of engineers, and produce patents. Moreover, these firms financed themselves with equity and most of them did not have long-term debt liabilities. In addition, intangible assets such as patents, goodwill, trademarks, and intellectual property hold a large portion in their assets. These are consistent with the view that investor protection eased the access of small private firms to external finance.

This paper contributes to different strands of the literature. First, we contribute the literature studying the impact of investor protection and contracting institutions on stock market development (La Porta et al. (1997) ; Porta et al. (1998); Acemoglu and Johnson (2005) ; Porta et al. (2006)). Besides, we contribute to the literature showing the impact of stock market development on growth and firm-level innovation (Levine and Zervos (1998) ; Brown et al. (2013)). The studies in these literatures mostly exploit the cross-country variation, and use the instrumental variable strategy to address endogeneity concerns. In particular, they argue that common law countries have better investor protection than civil laws countries. Using legal origin as instrument receives criticism for different reasons. First one is related with the exclusion restriction: stock market development and legal origin are both decisions of political agents (Pagano and Volpin, 2005). Second one is the monotonicity assumption: common law does not necessarily predict better investor protection compared to civil law. We address these concerns using

diff-in-diff strategy in which we exploit variation in the level of investor protection across time and states that have the same legal origin. [9] Moreover, we provide micro-level evidence that highlights the mechanism how investor protection can spur quantity and quality of innovation in firms and stimulate long-run economic growth.

Our study is closely related with Brown et al. (2013) showing that stock market development stimulates R&D expenditure of firms but has no effect on investment. Our study differs in two dimensions from theirs: (i) They take the average R&D expenditure between years 1990-2007 and focus on the long-term effect. However, we focus on the short-term effect comparing the innovation activity just before and after the introduction of Blue Sky Laws; (ii) In order to address endogeneity in stock market development, they use legal origin as an instrument. In other words, they setup an two-step relation with legal framework and innovation. However, we set up a direct relation with investor protection laws and firm patenting.

Our study is related to the literature that explores the role of financial constraints on firm-level innovation. This literature shows that bank finance (Nanda and Nicholas, 2014), equity issue (Brown et al. (2009), Brown et al. (2013), hsu2014financial) , equity finance (Brown et al. (2009)), venture capital ((Kerr and Nanda, 2015), (Kortum and Lerner, 2000) , (Bernstein et al., 2015)), government grants (Howell) play an important role in innovation.

2 Blue Sky Laws - Incomplete

Stock markets gained large momentum in early twentieth century. There was a surge in the number of brokers selling company stocks and bonds to general public. Even small investors started to invest in stock markets which were previously a privilege for only rich investors. However, these developments in security markets brought the increase in fraud cases. In response to that Kansas was the first state that passed the first investor protection statute (Mahoney (2003)) to regulate these markets. The law gained popularity and spread to other

[9]The first study that uses Blue Sky Laws for identification is Agrawal (2013). Instead of innovation, he focuses on dividend payments, stock market price and equity issue for a small sample of mining firms. Moreover, he only uses public firms which the law has minimal effect since the stock markets have their own protection rules close to Blue Sky Laws.

states quickly (Reed and Washburn (1921)). All states except Nevada adopted a form of Blue Sky Laws between the years 1911 and 1931 (the time line given in Table 1).

The early forms of statutes differed from state to state. For instance, Kansas law (i) required registration of broker and dealers (ii) required issuers (firms) need to file an application disclosing their financial condition, shareholder structure, management, and business plan[10] (iii) introduced harsh penalties for financial fraud (Macey and Miller (1991)). (iv) granted authority to reject the public sale of securities which the State Banking Commissioner finds speculative. These set of rules aimed to reduce information asymmetry between the external inventors and company insiders, and provide extra protection for the expropriation risk.

We can classify Blue Sky Statutes into two groups. Both groups increased the penalties against financial fraud, and required registration of brokers and dealers. In addition to these measures, some states took a more paternalistic stance to protect investors. These states required information disclosure before public issue. In addition, institutions responsible from the enforcement of the law did pre-clearing and reject the securities having signs of potential fraud. Mahoney (2003) investigates the political economy behind the laws and try to understand why states passed different types of laws. He argues that investment banks lobbied against paternalistic statutes since they think that pre-clearing could harm their business. So, the states, mostly located in New England region, where investment bankers have powerful lobbies, avoided information disclosure and pre-clearing. Figure 1 shows the types of laws across states.

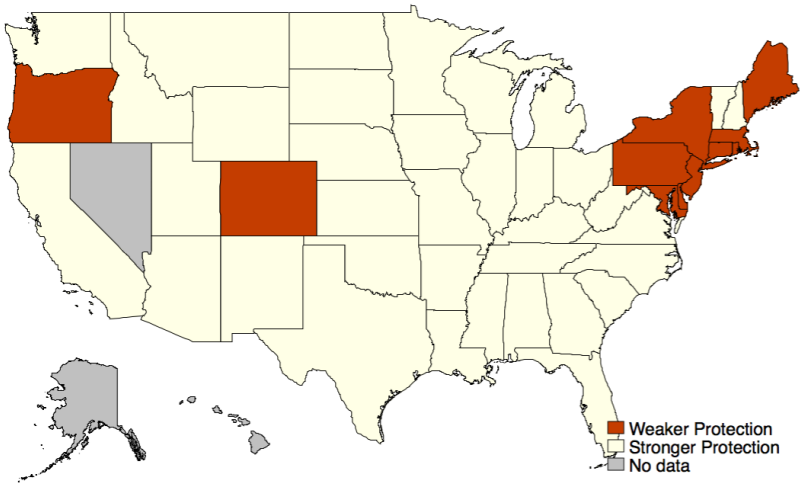
We visited Illinois State Archives to gain more insight about the application of the law. Securities Division was in charge of the enforcement of the law in Illinois. The Security Division required to fill an application document that includes firm information. Firms need to file extra 25 copies of the application document, and investors could reach these documents upon request. Firms need to update their information in every six months until they sell off the issued securities. Security Division investigates these documents to detect possibility of fraud. During this investigation, they collect information from experts, and persons doing business with the company. Securities division could ask for an update in the terms and

[10]This mandatory disclosure requirement inspired the Securities Act of 1933 (Smith (1936)).

conditions of the offered security to protect external investors e.g. requiring voting rights for common shares.[11].

We can summarize the history of stock market regulations after Blue Sky Laws as follows. United States faced with Great Depression and in order to restore investor confidence Securities Act of 1933 passed at federal level. After that time, companies need to compile both with state and federal regulation. Supreme Court favored state laws over federal regulation in case of conflict. Blue Sky regulations are still active, e.g. New York Attorney General open cases against mortgage backed security underwriters referring to Blue Sky statute.[12]

Figure 1: Types of Blue Sky Laws



The map shows the types of Blue Sky Statutes across states. New England States enacted weaker version of investor protection laws because of strong investment bank lobby

[11]see Appendix B for a discussion about voting rights

[12]see recent law suit against Credit Suisse: `https://ag.ny.gov/press-release/ag-schneiderman-sues-credit-suisse-fraudulent-residential-mortgage-backed-securities`

Table 1: **Blue Sky Laws**

Kansas	1911	South Carolina	1915
Arizona	1912	Mississippi	1916
Louisiana	1912	Virginia	1916
Arkansas	1913	Minnesota	1917
California	1913	New Hampshire	1917
Florida	1913	Alabama	1919
Georgia	1913	Illinois	1919
Iowa	1913	Oklahoma	1919
Idaho	1913	Utah	1919
Maine	1913	Wyoming	1919
Michigan	1913	Indiana	1920
Missouri	1913	Kentucky	1920
Montano	1913	Maryland	1920
Nebraska	1913	New Jersey	1920
North Carolina	1913	Massachusetts	1921
North Dakota	1913	New Mexico	1921
Ohio	1913	New York	1921
Oregon	1913	Rhode Island	1921
South Dakota	1913	Colorado	1923
Tennessee	1913	Pennsylvania	1923
Texas	1913	Washington	1923
Vermont	1913	Connecticut	1929
Wisconsin	1913	Delaware	1931
West Virginia	1913		

Source: Mahoney (2003)

3 Data - Incomplete

We collect data for Blue Sky Laws from two sources. The first one is Reed and Washburn (1921) who includes the initial versions of statutes until 1921. We can observe that statutes differed from state to state, and geographically close states had similar statutes. The second source is Mahoney (2003) who gives information about the legislation dates.

We construct innovation measures by using the original patent filings. Specifically, US Patent Office release a detailed document after the patent is approved. This document includes information about the filing date, the issue date, inventors and their location, assignee and its location if the patent is assigned to someone other than inventors. The assignee is usually a firm that shares the intellectual property rights of the patent. The location information of the assignee is defined at county and state level.[13]

US patent office provides digital records of patents after 1976, and for the period before we only have hardcopy documents. Berkes (2017) extracts information from the hardcopy documents using optical character recognition (OCR) techniques and provides patent number, assignee (firm), and location of each patent. Moreover, he provides information about the citations, and technology classes of patents given by the US patent office.

3.1 Machine Learning

We want to obtain firm-year innovation measures using the patent data. However, company names in the data set has many typos since it is obtained by OCR techniques. For instance, a firm name could appear in multiple forms. For instance, "Singer Manufacturing" could appear as "Singer Mfg", "Singer Manufhctng", "Siager Mfg" in different patent files. We would like to obtain a unique identifier for each of these names.

We use machine learning techniques to correct typos and obtain unique firm name - identifier. Instead of using only string distance between names of two company names, we benefit from state of incorporation, existence of a common inventor, and average filing year difference. Using existence of common inventor is particularly importants since inventors are

[13]We construct our sample so that there is one-to-one matching with firm and assignee. If we observe the same firm name in multiple states, we consider each of the firms as distinct firms

likely to assign their patents to the same firms over time.

Our method for correcting names is similar to methodology used by Feigenbaum (2016). We can summarize the machine learning steps as follows:

Step 1: There are 8,943,611 patents between 1835 and 2011. 4,186,550 of them are assigned. We keep only the patents assigned to the US firms and left with 4,069,090 patents. Then we collapse the data at firm level and end up with 665,004 distinct firm names that includes typos

Step 2: We standardize company names e.g. from "manufacturing" to "mfg" or from "national" to "nat" since we do not want to get high string distance just because two companies are sharing the same standard term such as "manufacturing".

Step 3: We group our sample into ten according to states and find top-10 candidate matches for each firm if the string distance is greater than 0.5. After this step, we end up with pairs e.g. "Singer Mfg-Singer Manufhctng" or "Singer Mfg-Spring Mfg" where the former is a correct match, and the latter is a wrong match .

Step 4: We calculate the inputs for the machine learning for each pair: (i) Jaro-Winkler Distance between company names which gets value between 0 and 1, (ii) dummy for the existence of common inventors, (iii) average filing year difference of all patents.

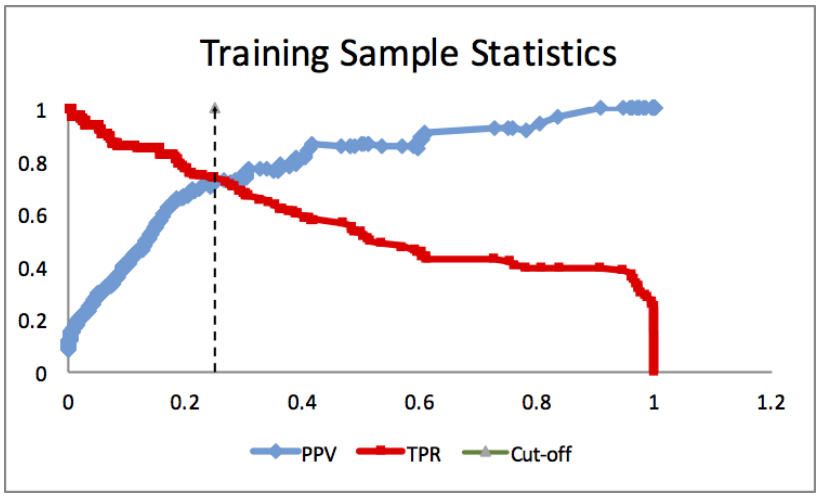
Step 5: We have 5,106,181 pairs. We randomly select 1,059 pairs, it is called training sample, and check each to determine whether it is a correct match or not.We get 88 correct matches out of 1,059. Then, following Feigenbaum (2016), we run a probit on the training data where the left-hand side variable is 0-1 variable takes value 1 if the match is correct and takes value 0 otherwise. Probit results are given in Table 2. First column reports the coefficients for Jaro-Winkler distance, common inventor dummy, and file year difference. Second column reports the marginal effects keeping the other variables at their mean. For instance, the cofficient for inventor dummy is 0.16 indicating that sharing common inventor increases the probability of having a true match by 16%. As expected, if Jaro-Winkler distance is 1 then the probability of true match is 100%.

Table 2: **Probit Results**

	Probit	dy/dx
JW	15.37***	1.03***
Inventor	2.32***	0.16***
File Year	-0.015**	-0.001***
Constant	-14.86***	

Step 6: We calculate propensity scores for each pair using the coefficients in Table 2. After this, we need to set a threshold to distinguish between correct and wrong match. For each threshold level, we need to consider both type-I and type-II errors. Type-I error is called as "True Positive Rate (TPR)" and defined as $TPR = \frac{TP}{TP+FN}$ where TP refers to true positive and FN refers to false negative. In other words, TPR shows the share of true matches we catch. On the other hand, Type-2 error is called as "Positive Predictive Value (PPV)" and defined as $PPV = \frac{TP}{TP+FP}$ where FP refers to false positive. PPV measures the share of correct matches above the threshold. Figure 2 shows TPR and PPV for different thresholds.

Figure 2: Probit Performance



The graph shows the True Positive Rate (TPR) and Positive Predictive Value (PPV) in training sample for different thresholds.x-axis refers to propensity scores. y-axis refers to values of TPR and PPV

We choose the threshold 0.25 that maximizes the product $TPRxPPV$. At this threshold, TPR = 0.74 and PPV = 0.73. Note that true values of TPR and PPV will

be higher since we will select the best match - the one with highest propensity score - among many candidates for each firm.

Step 7: We calculate the propensity scores for all 5,106,181 pairs and drop the ones which have propensity score less than 0.25. Then we left with 165,973 true matches out of 5,106,181. Among 165,973 true matches, we handle the symmetric pairs, such as "Firm A-Firm B" and "Firm B-Firm A", by only keeping the pair if Firm B has higher number of patents than Firm A. Finally, we get rid of loops, such as "Firm A-Firm B" and "Firm B-Firm C". At the end, we end up with 101,766 pairs.

Figure 3: Machine Learning Output

OCR	FINAL	jw
AMER CYANAETID	AMER CYANAMID	0.96
AMER CYANAMID	AMER CYANAMID	1.00
AMER CYNAMID	AMER CYANAMID	0.97
AMER CVANAMID	AMER CYANAMID	0.97
AMER CYANAMED	AMER CYANAMID	0.97
AMER CYAMAMID	AMER CYANAMID	0.95
AMER CYNAMID	AMER CYANAMID	0.97
AMER MAGNESIUM MTLS	**AMER CYANAMID**	**0.80**
AMCRICAN CYANAMID	**AMER CYANAMID**	**0.80**
AMER CYANDMID	AMER CYANAMID	0.94
AMER CYANAMID CO & BACTEX	**AMER CYANAMID**	**0.90**
AMER CYANMID	AMER CYANAMID	0.99
AMER CYANAMID	AMER CYANAMID	1.00
AMR CYANAMID	AMER CYANAMID	0.98
AMER CYAN AMID	AMER CYANAMID	0.99
AMER CYANAIMID	AMER CYANAMID	0.97
AMPERICAN CYANAMID	**AMER CYANAMID**	**0.85**

The graph shows the output of machine learning algorithm for "American Cyanamid Company". Left column shows the optical character recognition (OCR) output, middle column shows the corrected name, and right column shows the Jaro-Winkler distance. Machine learning helps to catch matches with low string distance benefiting from the existence of common inventors.

Figure 3 illustrates the importance of machine learning. If we have used only string distance to obtain unique firm identifier, we would miss a true "AMCRICAN CYANAMID" since Jaro-Winkler distance is 0.8.

3.2 Firm Level Data

From the previous step, we have patent level data with the corrected assignee names. To see the effect of investor protection on firms, we collapse the data at firm-year level. We end up with 1,653 firms after keeping the firms which patented at least once before and after the legislation. We obtain 3 different measures for each firm-year:

1 total number of patents filed

2 total number of citations received by the all patents filed in each year

3 weighted number of patents filed using the 3-digit USPTO patent classes

We fill each cell with zero if the firm did not file any patents in that year.

In addition to firm level innovation measures, we obtain annual data for total amount of loans given in each state from the book "All Bank Statistics" published by Federal Deposit Insurance Commission (FDIC).

4 Methodology

We construct firm-year data for the period 1907-1918. We use historical patent data and obtain firm level innovation measures such as number of patents and citations [Berkes, 2017]. In addition, we get the list of public firms listed in stock exchanges from "Manual of Statistics". To control for bank financing, we use the annual bank loans in each state from "All Bank Statistics". In our final sample, we have 128 public and 1525 private firms spread through 25 states.

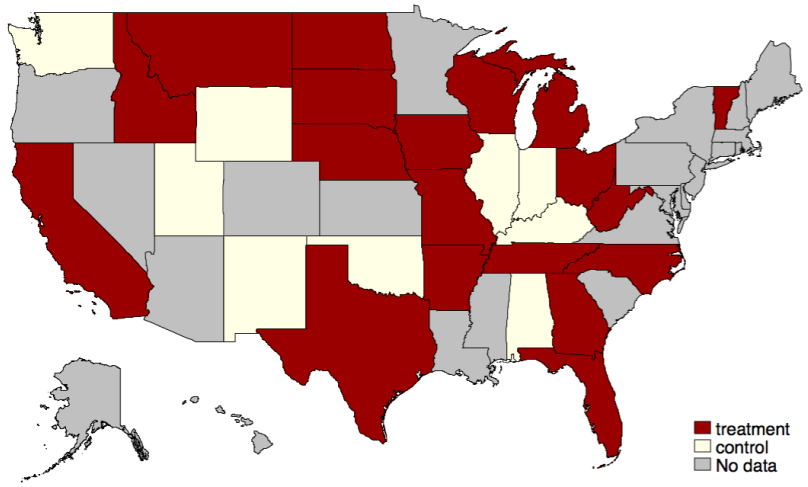
We use diff-in-diff-in-diff (DDD) strategy and measure the effect of Blue Sky Laws on innovation:

$$y_{ist} = \delta\ Post_t \text{ x } Treatment_s \text{ x } Private_i + \gamma_t + \gamma_i + \beta\ Bank\ Loan_{st} + \text{other DDD terms} + \epsilon_{ist}$$

where y_{ist} is the dependent variable such as $log(1 + n_{patents})$ and $log(1 + n_{citations})$ for the firm i located in state s at year t. $Post_t$ takes value 1 for the period between 1913 and 1918.

$Treatment_s$ is 1 if a state passed Blue Sky statute in 1913 and 0 otherwise. $Private_i$ takes value 1 if company is private and 0 if it is public. We cluster all standard errors at state level.

Figure 4: Treatment and Control States



The map shows the treatment and control states. The treatment states are the ones enacted the Blue Sky Laws in 1913. The control states are the ones enacted after 1918.

5 Results

First, we show the effect of investor protection on the level of innovation and do robustness and placebo tests. Then we investigate its effect on quality using the citations.

5.1 Innovation Level

In our first specification, we use the number of patent filings in order to proxy for the level of innovation activity for two reasons. First, Griliches (1990) provide evidence showing that R&D spending is highly correlated with the number of patent filings. Second, it is impossible to find R&D data at firm level since there is no distinction between the accounting of investment and R&D expenditures in the early twentieth century. Moreover, it is impossible to reach data for small firms.

We use the $log(1 + \#$ of patents) to measure the effect of investor protection as a

percentage change in our first specification. The first and second column in Table 3 show the results under different specifications. The results shows that investor protection increased the innovation around 14% significant at 5% level.[14] This increase is large given that average growth rate of patents in our period of interest is 3-4%.

One problem about our sample is the high share of "zero" observations. In order to address this problem we use hyperbolic-sine transformation ($log(x + \sqrt{1 + x^2})$) instead of natural logarithm. In that case, we still get significant results at 5% level and the coefficient in front of Blue Sky dummy increase from 14.1% to 16.4%. As a last exercise, we run Poisson regression since the distribution of patent numbers for each cell follows a power-law. We report the marginal effect of increasing investor protection when the other variables are kept at their means. The marginal effect is 34.2% and significant at 5% level. From all these analysis, we can conclude that our results are robust under different models, and here on we only report the model with log specification.

Table 3: **Investor Protection and Firm Innovation**

dep. var.	patents	patents	patents	patents	patents	patents
Model	OLS	OLS	OLS	Poisson	OLS	hyperbolic
Blue Sky	0.143**	0.145**	0.141**	0.342**	0.141**	0.164*
Bank Loan	0.058***	-0.021	0.14*	0.242	0.14*	0.185*
Year			x	x	x	x
State		x	x	x		
Firm					x	x
N	19836	19836	19836	19836	19836	19836
Cluster	25	25	25	25	25	25
R^2	0.04	0.04	0.06	0.08	0.49	0.48

This table reports the effect of the investor protection laws on innovation measures. Data set covers the years between 1907 and 1918. The dependent variables are log(1+# of patents) and log(1+# of total citations). Blue Sky is the dummy variable equal to 1 for private firms located in treatment states after 1913. Bank Loans are the logarithm of annual loans granted in a state. Standard errors are clustered at state level. ***, ** and * indicate statistical significance at the 1%, 5% and 10% (two-tail) test levels, respectively.

To address the concerns about the sample selection, we cut the sample in various ways and repeat the same exercise. In our baseline case, we keep the firms patented at least once both before and after the legislation. From second and third column in Table 4, we increase this threshold to 5 and 10 and get similar results. The results get stronger since we may have noise for the firms with small number of patents since we extracted data from original

[14]Since we do not have firm level controls in our regression, replacing the state fixed effects with the firm fixed effects does not change the estimated coefficient. The reason is that state and firm fixed effect vectors span the same space.

patents documents and machine learning algorithm fail to address some typos.

One other concern about our sample could be the effects of patent growth in certain sectors. To address this, we divide the number of patents issued by each firm to total number of patents in the same three-digit patent class for each year. As a final check in columns five and six, we look at the number of citations since firms may over-patented for incremental innovations in order to attract investors. We find a statistically significant increase in citations which is even larger than number of patents. This suggest that private firms located in early adopting states not only produced more patents but they produced high quality patents.

Table 4: **Investor Protection and Firm Innovation**

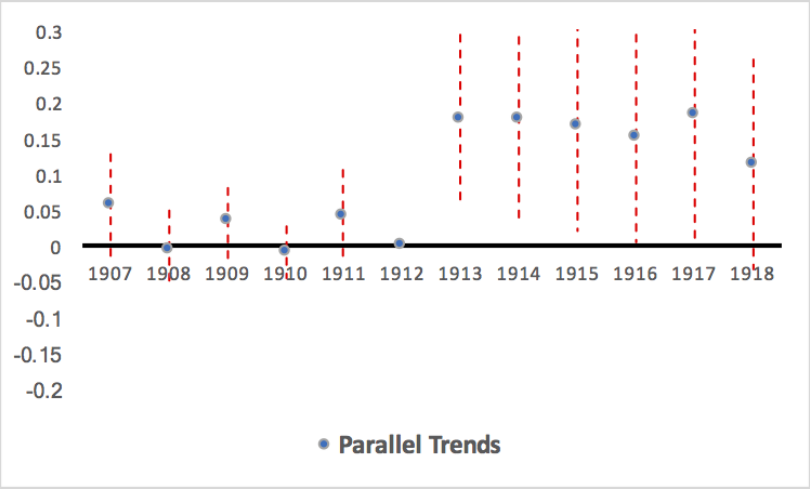
dep. var.	patents	patents	patents	patents	citations	citations
Model	OLS	OLS<5	OLS<10	weighted	OLS	OLS<10
Blue Sky	0.141**	0.158**	0.213**	0.099*	0.205**	0.28***
Bank Loan	0.140*	0.173*	0.319**	0.064	-0.151	0.048
Year	x	x	x	x	x	x
Firm	x	x	x	x	x	x
N	19836	15408	11016	19836	19836	11016
Cluster	25	23	21	25	25	25
R^2	0.49	0.48	0.48	0.48	0.40	0.41

This table reports the effect of the investor protection laws on innovation measures. Data set covers the years between 1907 and 1918. The dependent variables are log(1+# of patents) and log(1+# of total citations). Blue Sky is the dummy variable equal to 1 for private firms located in treatment states after 1913. Bank Loans are the logarithm of annual loans granted in a state. Standard errors are clustered at state level. ***, ** and * indicate statistical significance at the 1%, 5% and 10% (two-tail) test levels, respectively.

We use annual loans granted in each state as a proxy for the bank financing. The coefficient is 14% and statistically significant in our basic specification with time and firm fixed effects. It is very close to the coefficient in front of the Blue Sky dummy pointing that stock markets are as important as bank finance. The coefficient for bank loans become larger than the coefficient for Blue Sky dummy if we focus only on the firms have patents more than 10 (Table 4- Column 3). This result is in line with the idea that equity financing is more crucial for small firms.

As a final exercise, we replace the Blue Sky dummy with event year dummies. The coefficient are reported in Figure 5 with respect to 1912, the year before the enactment of statute in treatment states. Figure 5 shows that there is no significant difference between the firms located in treatment and control states. This finding relieves the possible concerns

Figure 5: Parallel Trends Assumption



The graph shows the coefficients and 95% their confidence intervals for the specification with event year dummy variables.

that statutes passed in response to increasing pre-trend in innovation.

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6 Conclusion

We investigate the relationship between investor protection and innovation using the introduction of Blue Sky Laws in the US when there was no federal regulation. First, we provide evidence from archival records that private firms used stock markets to finance R&D expenditures in the early 20^{th} century. Then, we show that investor protection laws and the early institutions eased the access of private firms to stock markets and these firms significantly increased their patenting activity.

Our results are in line with the previous literature showing that (i) investor protection and contracting institutions foster financial development and growth, and (ii) stock markets play a critical role in financing of R&D. These results stress the importance of legal reforms in emerging economies with limited capital markets to ensure long-term economic growth.

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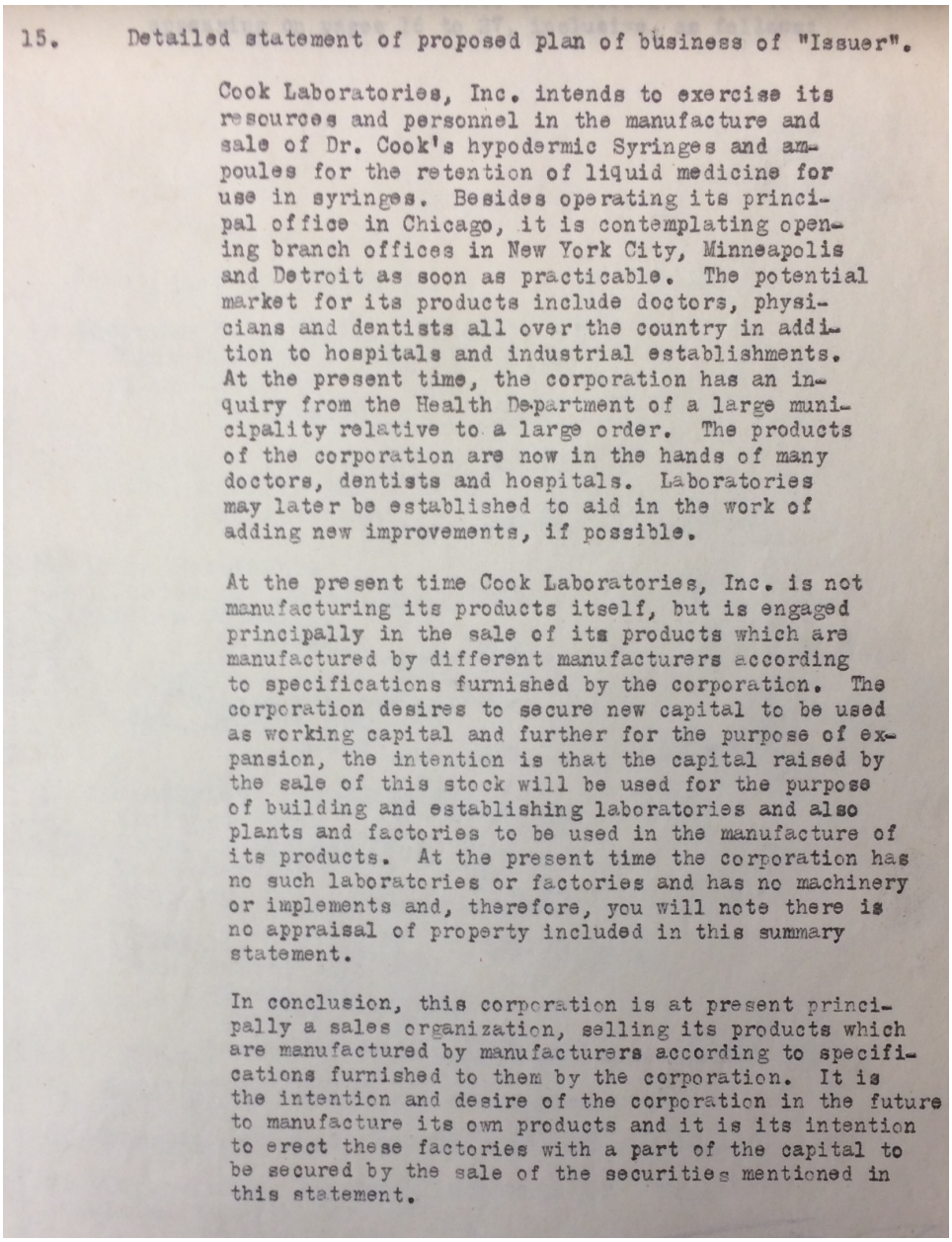
7 Appendix A: Financing Innovation

Figure 6: Business Plan of Cook Laboratories



15. Detailed statement of proposed plan of business of "Issuer".

Cook Laboratories, Inc. intends to exercise its resources and personnel in the manufacture and sale of Dr. Cook's hypodermic Syringes and ampoules for the retention of liquid medicine for use in syringes. Besides operating its principal office in Chicago, it is contemplating opening branch offices in New York City, Minneapolis and Detroit as soon as practicable. The potential market for its products include doctors, physicians and dentists all over the country in addition to hospitals and industrial establishments. At the present time, the corporation has an inquiry from the Health Department of a large municipality relative to a large order. The products of the corporation are now in the hands of many doctors, dentists and hospitals. Laboratories may later be established to aid in the work of adding new improvements, if possible.

At the present time Cook Laboratories, Inc. is not manufacturing its products itself, but is engaged principally in the sale of its products which are manufactured by different manufacturers according to specifications furnished by the corporation. The corporation desires to secure new capital to be used as working capital and further for the purpose of expansion, the intention is that the capital raised by the sale of this stock will be used for the purpose of building and establishing laboratories and also plants and factories to be used in the manufacture of its products. At the present time the corporation has no such laboratories or factories and has no machinery or implements and, therefore, you will note there is no appraisal of property included in this summary statement.

In conclusion, this corporation is at present principally a sales organization, selling its products which are manufactured by manufacturers according to specifications furnished to them by the corporation. It is the intention and desire of the corporation in the future to manufacture its own products and it is its intention to erect these factories with a part of the capital to be secured by the sale of the securities mentioned in this statement.