Paper to be presented at the DRUID Academy 2012

on

January 19-21
at
University of Cambridge /The Moeller Centre

Banking Deregulations and Corporate Innovation

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Abstract

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Jelcodes:G30,O31

Credit Supply and Corporate Innovation

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Abstract

We present causal evidence that financial development plays a key role in technological progress. We focus on corporate innovation, measured by the patenting activity of firms, and exploit the staggered passage of banking deregulation in the US states during the 1970s and 1980s as a source of variation in the availability and quality of credit. We find that deregulations of the banking sector had a significant beneficial effect on the number and quality of firm innovations. This effect is mainly present among firms that are more financially constrained, and it does not become evident until some years after the deregulations. Moreover, the effect is partly driven by a greater ability of deregulated banks to diversify credit risk.

JEL: G34

Keywords: innovation, patents, financial development, banking deregulations

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For insightful comments and suggestions we thank Morten Bennedsen, Bruno Cassiman, Andrea Fosfuri, Jens Iversen, Paloma Lopez-Garcia, Ben Sand, Battista Severgnini, Jesper Rangvid and Thomas Rønde, as well as participants at the Zvi Griliches Research Workshop in Economics of Innovation and participants at the INSEAD brownbag seminar. Contact address: mda.eco@cbs.dk

1. Introduction

Schumpeter argued that developed and well-functioning financial systems are essential for promoting innovation and long-term economic growth. As discussed by Jarayatne and Strahan (1996), this relationship arises via two possible mechanisms. First, a pure volume effect results when financial intermediaries channel savings to investment (Bencivenga and Smith 1991). Second, financial systems can increase the productivity of that investment (Greenwood and Jovanovic 1990; King and Levine 1993a) by allocating funds to the most qualified firms. Our contribution is to establish a causal effect of financial development on the innovation activities of firms.

Recent evidence suggests that innovation is positively correlated with stock issues (Brown et al. 2009), access to bank credit (Benfratello et al. 2008) and banking relationships' depth (Herrera and Minetti 2007). However, the empirical study of finance's effects on innovation is plagued by the endogeneity of financial development. Arguably, general economic conditions, industry characteristics and other unobserved factors may influence both innovation activities and credit availability. In addition, firms with higher value-added projects may have better access to financing.

To overcome these concerns, we rely on the passage of intrastate and interstate banking deregulations in the US during the 1970s and 1980s. While intrastate deregulations eased bank branching within a given state, interstate deregulations allowed banks to enter different states. Banking deregulations induced exogenous variations in the availability and quality of external finance for at least three reasons. First, banking deregulations, in particular those across states, facilitated banks' geographic diversification (Goetz et al. 2011), thus encouraging lending to riskier projects. Second, deregulations strengthened competition and the market for corporate control, which is thought "to have improved allocative efficiency by allowing capital to flow more freely toward project yielding highest returns" (Kerr and Nanda 2009). Third, deregulations improved bank efficiency and the quality of banks' loan portfolios (Jayratne and Strahan 1996; 1998), and also encouraged lenders to adopt improved screening technologies which allowed interest rates to reflect the underlying risk more accurately (Dick and Lehnert 2010).

Our main result indicate that interstate deregulations caused a relevant increase in firm innovation, as measured by patent-based metrics. We first use unconditional evidence to document a gradual increase in a state's total number of patents granted following the passage of interstate deregulations. This finding, which is confirmed at the firm level, suggests that increased patenting activity stemmed from across-state, rather than within-state, expansion of credit access. We also find an increase in the "relevance" of the innovations introduced, as measured by the number of citations in future patent applications, and in their originality and generality, suggesting that firms subject to a wider access to external finance changed the technological nature of their innovation projects. These effects remain significant after controlling for firm fixed effects and other confounding factors. In particular, controlling for R&D stock we observe that firms make more productive use of their existing innovation inputs after deregulations – though again these positive effects became larger a few years after deregulation is enacted.

Next, we focus on the channels behind our main findings. An increase in innovation can be explained by the greater willingness of banks to take risk once they have become more diversified geographically. Out-of-state banks may be thus willing to lend at more favorable terms – all the more so if credit risk in the deregulating state is less correlated with their existing exposure. We find that most of the increase in patenting and its productivity occurred in states whose economies exhibited least comovement with the overall US economy. We also assess whether deregulations affected innovation because firms faced less binding financial constraints and thus invested more on high-return projects requiring less collateral. We focus the analysis on the intensity of innovation inputs, measured by ratio of R&D expenses to the total investment, and adopt a number of proxies for firms' financial constraints prior to deregulation. Our findings indicate that financially-constrained firms, i.e. firms that are young, that do not have a bond rating enabling access to the public debt market, and that operate in industries highly dependent on external finance, shift their investment policy towards R&D expenses following deregulations.

By analyzing corporate innovations, we provide novel evidence to the existing literature on the effects of banking deregulations, which so far has been primarily focused on entrepreneurship and Schumpeterian destruction (Bertrand et al. 2007; Black and Strahan 2002; Cetorelli and Strahan 2006; Kerr and Nanda 2009, 2010). We also contribute to a broad research on the relationship between financial development and economic growth (King and Levine 1993b; Jayaratne and Strahan 1996; Demirguc-Kunt and Maksimovic 1998). While some determinants of this relationship, such as firm entry and entrepreneurial activity, have been widely analyzed (Black and Strahan 2002; Guiso et al. 2004; Cetorelli and Strahan 2006; Kerr and Nanda 2009), there is less direct empirical evidence on the role of technological progress (Benfratello et al. 2008). We extend this recent literature by establishing a causal effect of financial development on corporate patenting. Finally, our study is close to a recent research on how variations in access to external finance affect corporate investment (Campello et al. 2010; Duchin et al. 2010). Our contribution to this research is to reinforce the notion that external financing has strong effects on the investment policy of firms, and to provide evidence that these effects are reflected in firms' patenting behavior. Section 2 describes the policy changes that transpired in the US banking industry. Section 3 presents the data. Section 4 outlines our empirical methodology. Section 5 presents and discusses our findings. Section 6 concludes.

2. Deregulations in the US banking industry

The geographic expansion of banking activities in the US has been historically restricted by laws such as the FcFadden Act of 1927 and the Douglas Amendment to the Bank Holding

Company Act of 1956. During the 1970s and 1980s, US states passed a number of deregulations of branching and interstate banking activities which effectively terminated the restrictions on banking expansion across and within states.

Our identification strategy exploits the staggered passage of these banking deregulations. Table 1 illustrates the timeline of deregulations by state and year. As shown, US states first reduced restrictions on branching within states, and then barriers to banking across states. The first intrastate deregulations were passed in the early 1970s, while the first state passing an interstate deregulation was Maine in 1978, followed by Alaska and New York in 1982. The wave of deregulations continued until the approval in the mid-1990s of the interstate banking provisions of the Riegle-Neal Interstate Banking and Branching Efficiency Act.[1]

Deregulations were associated with many major improvements that set the stage for the emergence of "expansion-minded banks" (Black and Strahan, 2002). Specifically, deregulations enhanced the openness and competitiveness of the banking sector, improved banks' loan portfolios and reduced loan rates (Jayratne and Strahan 1998), introduced more specialization of bank activities, innovation in the securitization markets (Zarutskie 2011), and sophisticated technologies to screen and monitor riskier borrowers (Dick and Lehnert 2010). While innovative firms have been shown to prefer equity vis-a-vis bank debt (Atanassov et al. 2007), such major improvements in both the quality and the availability of credit induced by the deregulations are thought to have produced benefits for a broad array of economic activities, including the financing of firm innovation.

The two types of deregulation had distinct implications for the US banking sector. Intrastate branching deregulations reduced entry barriers into new markets within the passing states and made it easier for banks to gain control over other bank's assets. In particular, branching deregulations allowed banks to expand either by mergers and

[1] It was passed in 1994, went into effect on 30 September 1995 and became effective on 1 June 1997 (Carow and Heron 1998).

acquisitions or by opening new branches. The effect was to reduce the banks' ability to raise prices above their marginal cost in local markets and, in some cases, even to break local monopolies (Kerr and Nanda 2009). Instead, interstate deregulations allowed banks to enter different states. Prior to interstate deregulations, only bank holding companies located within a state could buy banks chartered in that state; however, after deregulations bank holding companies operating in other states were allowed to do so. Kerr and Nanda (2009) provide evidence that indeed interstate deregulations let to an expansion of large banks across state borders. Because out-of-state banks were endowed with more capital and sophisticated technologies to monitor borrowers, interstate deregulations encouraged lending to risky borrowers (Dick and Lehnert 2010). In addition, the reduction of restriction to banking across states improved the scope for banks' geographic diversification (Goetz et al. 2011), thus allowing them to finance more freely risky projects yielding higher returns without increasing the overall risk.

3. Data and summary statistics

We measure innovation by using patent applications, which represent a widely-used approach to quantify a firm's innovative performance (Griliches 1990). We start our analysis using data from the US Patent and Trademark Office (USPTO) on the total number of patents granted in each US state for the period 1976-1995.[2] This period covers all years when interstate branching rules were deregulated (which started in 1978) as well as a large part of intrastate branching rules were deregulated (which started in 1971). We do not extend our sample after 1995 to avoid confounding the effects with the Reagle-Neal Act, which was passed in 1994 and went into effect at the end of 1995. Following the literature

[2] The state is determined by the residence of the first-named inventor. The starting year is selected to make the analysis consistent with the firm-level analysis (patent citations data and assignee matches to Compustat are available from 1976).

on US banking deregulations, we exclude observations in Delaware and South Dakota because these states were subject to special tax incentives.

Figure 1 reports the average and median logarithm of the total number of patents granted at the state-level before and after the banking deregulations. As shown, the number of patents gradually increased following interstate deregulations. By contrast, patents do not increase following the passage of intrastate deregulations.

To formally test the effect of deregulations on innovation, we collect data at the firm level. In particular, we use the Compustat dataset, which contains a rich set of financial characteristics for US publicly traded firms. We exclude firms with negative or zero values for book value of assets and sales, and firms headquartered outside the US[3] We consider SIC codes up to 4000 (mostly manufacturing firms). Thus, we exclude industries such as financial services or utilities, which typically operate under specific regulations, or as the software industry, which is primarily dependent upon non-debt sources of financing such as venture capital or equity.[4] In fact, as documented in Scherer (1983) and more recently in Balasubramanian and Sivadasan (2011), the bulk of patenting activity occurs within the manufacturing sector, which for this reason has been the focus of many existing studies (e.g. Hall and Ziedonis, 2001; Hall et al. 2005).

We then match Compustat firms with the patent dataset assembled at the National Bureau of Economic Research (NBER), which contains information on the patents awarded by the USPTO and all citations to these patents (Hall et al. 2001; Bessen 2009). Since the existing research has demonstrated that patents differ greatly in “value” and that simple patent counts do not capture the relative importance of the underlying inventions (see e.g.

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[3] A concern arises from the fact that Compustat only reports the last state of operations, and we may be unable to observe changes of headquarter from a state to another that are potentially endogenous to the deregulation passages. However, using data on headquarter relocations from the Compact Disclosure database, Pirinsky and Wang (2006) document that most of the changes are driven by mergers and acquisitions. After excluding these and other major restructuring events, they found just 118 relocations for the period 1992-1997.
[4] In unreported analyses we replicated our findings with the inclusion of wholesale (SIC 5000-5199) and retail trade (SIC 5200-5999).

Harhoff et al., 1999), our main measure of innovation weighs each patent by the number of future citations received from subsequent patents. Forward citations reflect the economic and technological “importance” as perceived by the inventors themselves (Jaffe et al. 2000) and knowledgeable peers in the technology field (Albert et al. 1991). Since forward citations suffer from truncation problems, we adopt patent counts weighted by truncation-adjusted citation counts from the NBER data (see e.g. Hall et al. 2001; Hall et al. 2005).[5]

We construct several firm characteristics such as logarithm of sales, capital-to-labor ratio, R&D stock[6] (computed following the conventional 15% depreciation rate used in the related literature; see e.g. Hall et al. 2005), return on assets (ROA), firm age, cash holdings and tangibility (the construction of each variable is described in Appendix). In addition, we construct the Herfindahl-Hirschman Index (HHI) to control for the impact of industry concentration on innovation. The HHI is based on the distribution of revenues of the firms in a particular three-digit SIC industry. A higher HHI implies a higher concentration. We correct for potential misclassifications due to the presence of a single firm in a given industry by dropping 2.5% of the firm-year observations at the right tail of the HHI distribution (Giroud and Mueller 2010).

Table 2 reports the summary statistics for the sample we use, after dropping observations with missing values in the key variables. As documented in previous works on the Compustat-NBER patent dataset, citation statistics are very skewed; in our sample, the average number of cite-weighted patents is approximately 132 but the median number is 0.

[5] The problem arises from the fact that “citations to a given patent typically keep coming over long periods of time, but we only observe them until the last date of the available data” (Hall et al. 2005). Besides the use of truncation-adjusted citation counts, the problem is mitigated by the inclusion of year fixed effect. In fact, our results are robust to the adoption of unadjusted citation counts.

[6] The R&D stock is computed following the conventional 15% depreciation rate used in the related literature (see e.g. Hall et al. 2005). Also, we use linear interpolations to replace missing values of R&D; however, our results are robust to leaving those observations missing or treating them as zeros.

4. Methodology

We use a difference-in-differences model to explore the causal relationship between firm innovation and banking deregulations. The important advantage of using a difference-in-differences model is that we can control for omitted variables and absorb nation-wide shocks or common trends that might affect the outcome of interest.

We start by using two binary variables, *intrastate deregulations*$_{jt}$ and *interstate deregulations*$_{jt}$, which are equal to one if, respectively, the firm *i* is located in a state *j* which has passed an intrastate or interstate deregulation at time *t*, and zero otherwise. These variables capture the effect of the two banking deregulations on firm patents, comparing outcomes before and after a given deregulation year, *vis-à-vis* deregulations passed later. We also adopt alternative specifications that allow for estimating the dynamic effects of deregulations.

Our first approach consists in using the logarithm of patent counts as dependent variable and estimating OLS regressions. However, one concern with this approach is that it does not appropriately deal with firms that have zero patents. To avoid losing these observations we employ count data models, which are widely used in the econometric analysis of patents. Following Hausman et al. (1984), we hypothesize that the expected number of patents of a firm *i* applied for in year *t* is an exponential function of both treatments[7] T_{jt}, and firm- and industry-specific characteristics. More specifically, we estimate conditional-mean Poisson models:

$$E\left[Y_{ijt} \middle| T_{jt}, X_{it-1}\right] = \exp\left(\alpha + \beta T_{jt} + \delta X_{ijt-1} + \eta_i + \tau_t\right)$$

We estimate fixed-effect Poisson models by Quasi-Maximum-Likelihood, which will provide consistent estimates as long as the conditional mean is correctly specified even if

[7] Our results do not change if we estimate models in which the interstate and intrastate treatments are included separately.

the true underlying distribution is not Poisson (Wooldridge 1999). Since our deregulation treatments are defined at the state level, we cluster standard errors at the state of location.

Following the literature on the production function of patents (see Galasso and Simcoe 2011; Aghion et al. 2009), our baseline specification includes a vector X_{ijt-1} of one-year lagged firm controls, such as firm sales and capital-labor ratio, in addition to firm specific idiosyncratic effects denoted by η_i. Depending on the specification, we also control for R&D stock. As stressed by Aghion et al. (2009), not controlling for the R&D stock implies that the coefficient of the variable of interest on the right-hand side will reflect both the increase in R&D investment and the R&D productivity. By contrast, when the R&D stock is included as a control, the effect of the variables of interest can be interpreted as an effect on the innovative productivity. In additional analyses, we include other controls related to firm age and tangibility, to control for existing dependence and access to bank credit, return on assets (ROA), to control for cash flow positions, cash holdings and equity, to control for differences in capital structure, and HHI, to absorb the effect of concentration in the industry where a firm operates.

Given that the U.S. patenting activity increased substantially starting from the mid 1980s (see e.g. Hall 2004), it is important to control for aggregate trends. First, we include a full set of year dummies, denoted by τ_t. Second, we control for industry trends by constructing yearly four-digit SIC industry averages of the dependent variable after excluding the firm in question. Third, we assess the robustness of our findings to the inclusion of geographic trends, computed as yearly averages of each headquarter's state after excluding the firm in question.

5. Empirical results

This section contains our empirical results. First, we present baseline OLS and Poisson estimates of a model that compares innovation, measured using a variety of patent-based metrics, before and after the deregulations. Second, we analyze the dynamic effects of deregulations. Third, in the aim to shed light on the channels that drive our results, we investigate the role of diversification of banks' financial activities and look into the role of firm's financial constraints.

5.1 Baseline regressions

We start with the preliminary results based on the OLS regressions, using the logarithm of patents as the dependent variable. We report the results in Table 3. In Column (1), we show that the interstate deregulations have a positive and 5% significant coefficient, whereas the coefficient of intrastate deregulations is not statistically different from zero. While in Column (1) we only control for industry and year fixed effects, in Column (2) we add the logarithm of sales and capital-to-labor ratio. Controlling for firm characteristics reduces the magnitude of the interstate coefficient, which is however more precisely estimated and becomes significant at 1%. In Column (3), we further control for R&D stock. As expected, the stock of R&D is positive and highly significant; however, the interstate coefficient remains significant at 1%. In Column (4), we further include a host of controls that are typically associated with innovation, such as logarithm of firm age, HHI, ROA, tangibility and cash holdings. These variables proxy for the availability of internal resources, access to external finance, and product market competition. Our results confirm that interstate deregulations cause an increase in innovation. In Columns (5) - (8), we further assess the robustness of our findings by adopting a more restrictive specification that instead of industry fixed effects includes firm fixed effects, as well as industry linear trends. As expected, restricting the identification to within-firm variations leads to a smaller interstate deregulations' coefficient, but its statistical significance is confirmed at 1% level. The economic magnitude of the effect is relevant as well: the most restrictive specification (Column 8), indicate a 12.8% increase in patents.

We proceed by estimating count data models that deal with the zero patents.[8] In Table 4, we confirm our OLS finding by re-estimating the firm fixed-effects specifications using Poisson models (Columns 1- 4).[9] We further address the quality of the patents. In Columns (5) - (8), we use cite-weighted and truncation adjusted patents as alternative dependent variable that allows us to measure both the number but also the relevance of each innovation. The coefficient of interstate deregulations reported in Column (5) is significant at 10%; however, controlling for R&D stock and the other firm characteristics increases the precision of our estimates (Columns 6 - 8).

5.2 Confounding events and robustness checks

We test the validity of our findings in several ways. First, we address the concern that other policies potentially affecting innovation were adopted around the same period of the banking deregulations. In the late 1980s, 30 US states passed a set of business combination (BC) laws that reduced the threat of hostile takeovers, thus weakening the market for corporate control as a governance device (Giroud and Mueller 2010; Bertrand and Mullainathan 2003). These laws might have affected our analysis if corporate governance affects the managerial incentives to innovate[10], and that effect is not captured by our specification since BC laws affected firms at their state of incorporation. To mitigate this concern, in our specification we include a variable equal to one if firms were incorporated in the states that passed a BC law, from the year of the passage onwards, and zero

[8] A solution could be to use other transformations of the dependent variable; however, these transformations are arbitrary and often not robust to alternative methods. For example, in unreported analyses we have replicated Table 3, Panel A, adopting the logarithm of (1+number of patents) as dependent variable. Our results are in line with those reported in Table 3, Panel A.

[9] In unreported analyses, we also replicated the specification with industry fixed effects (as in Table 3, Panel A, Columns 1-4) with count data models. Using Poisson or Negative Binomial models, our results confirm the positive and significant effect of interstate deregulations.

[10] The effect of corporate governance on innovation is, in fact, ambiguous. Some empirical studies indicate that worse corporate governance reduces the incentives to innovate (Atanassov 2009). Chemmanur and Tian (2011) argue that some degree of managerial entrenchment isolates CEOs from short-term pressures, thus inducing them to focus on long-term value creation and innovate more. Sapra et al. (2011) show that the effect of corporate governance on innovation follows a U-shaped relationship.

otherwise (Table 5, Column 1). In Column (2), we also interact BC laws and interstate deregulations to control for heterogeneous deregulation effects on innovation depending on incorporations in states with or BC laws. Our estimates indicate that the positive effect of banking deregulations on firm innovation is not confounded by changes in corporate governance induced by the BC laws.[11]

Next, we present a number of robustness checks. In Column (2), we exclude observations corresponding to the year of interstate deregulations. In Column (3), we show that our results are robust to the inclusion of linear state trends centering the identification on discontinuities surrounding the interstate deregulations (Kerr and Nanda 2009). In Colum (4), we estimate present alternative estimates from a negative binomial model. We perform additional checks (unreported) that further validate the robustness of our results. First, to better isolate the effect of interstate deregulations, we exclude those states that passed intrastate deregulations within a year of interstate deregulations. Second, we restrict the analysis to firms that remain in the sample for at least 5 (10 or 15) years to purge the analysis from entry and exit. Third, we use contemporaneous rather than lagged firm-level controls. Fourth, we exclude firms headquartered in California and Massachusetts, since these states have a particularly high innovation activity. Fifth, we extend our sample up to 1997, i.e. the year when the implementation of the Riegle-Neal act finally enacted a nation-wide deregulation of the banking sector.

5.3 Technological fields and risk

So far our results have indicated that firms subject to a wider access to high-quality credit patent more and make more relevant innovations, as measured by the overall number of future citations received. In this section, we further study the firms' patenting activity by combining citations with information on patents' technological fields.

[11] The smaller number of observations is due to the fact that some firms have a missing state of incorporation.

Technological fields are defined by the USPTO and consist of about 400 main (3-digit) patent classes. We use the generality and originality indexes, which were developed by Trajtenberg et al. (1997) and computed by Hall et al. (2001), as proxies for the fundamental nature of the research being patented. The generality index is equal to $1 - \sum_{j}^{n_j} s_{ij}^2$, where s_{ij}^2 denotes the percentage of citations received by a patent *i* that belong to the patent technology class *j* out of n_i patent classes. The index will take high values (*high generality*) if a patent receives citations from suqsequent patents that belong to many different technological fields. The originality index is constructed in a similar way, but its computation relies on the citations made rather than citations received; hence, it will take a high value if a patent cites other patents that belong to many different fields (*high originality*).

We use these two indexes as separate dependent variables and use a specification similar to the one used in Table 4. Our results, reported in Table 6, indicate that interstate deregulations had a positive and significant effect on the generality of patents: firms subject to the interstate treatment exhibited a higher propensity to patent inventions within a broader technological field (Columns 1 - 3). The same result is found for the originality of patents (Columns 4 - 6).

Showing that following deregulations firms patented innovations in broader technological classes, our results suggest that a wider access to external finance led to a more ambitious innovation policy, which in turn may entail potential failures. We provide evidence that the patenting activity indeed became riskier, i.e. there was a rise in both successful and unsuccessful patents. Although we have already established that, on average, the number of cite-weighted patents increased, we study whether there was a simultaneous increase in patents that received many citations as well as few citations in the future. We estimate quantile regressions at different percentiles of the distribution of the logarithm of patents or cite-weighted patents. In line with our notion of increased risk, our results, reported in Table 7, confirm that indeed the effect is present at low deciles (e.g. 30% and 40%) as also at high deciles (e.g. 80%).

5.4 Dynamic effects

Because patenting an innovation is the outcome of a process that may typically require several years, a specification that compares outcomes before and after deregulations may not be well suited to capture the potential dynamics underlying the impact of banking deregulations on innovation. Unconditional averages reported Figure 1 already suggest that interstate deregulations increase innovation but in a gradual manner starting from the reform year.

We test for dynamic effects by drawing on the specifications introduced in Kerr and Nanda (2009). First, we allow the effect of deregulations on innovation to grow over time by adopting linear treatment effects that replace our pre-post dummies with variables equal to zero up to the deregulation year and then equal to the number of years since a deregulation was passed, capping the treatment effect at 8 years. Results, reported in Table 8, confirm that interstate deregulations have a positive growing impact on firm patents; its statistical significance underlines the importance to allow for growing treatment effects.

Second, we construct a dynamic difference-in-differences specification based on a set of dummies that measure the time distance from each deregulation, using as reference group the period three years or earlier before the deregulations. Results, reported in Table 9, show that the coefficient prior to the interstate deregulation is small and statistically insignificant, thus confirming that our results are not merely driven by diverging trends prior to the deregulations. By contrast, the post-deregulation coefficients are all positive and significant at conventional levels; they also become larger as we move forward from the reform year, with the largest effect corresponding to six and seven years after the interstate deregulations.[12]

5.5 Diversification channel

One of the channels that can explain the higher patenting activity of firms after the entrance of new banks is that out-of-state banks were able to finance riskier investments as they were less exposed to the background risks of the state's economy. At the same time, credit in this state provides out-of-state banks an opportunity to diversify their loan portfolio, for instance, due to different industry composition of the state. We provide preliminary evidence for this argument by separating the states according to how their economic indicators comove with the rest of the US economy.

We extract a coincident index that summarizes state-level economic indicators from the Federal Reserve Bank of Philadelphia. The coincident index combines data on nonfarm payroll employment, average hours worked in manufacturing, the unemployment rate, and wage and salary disbursements deflated by the consumer price index (US city average). The trend for each state’s index is set to the trend of its gross domestic product (GDP), so long-term growth in the state’s index matches long-term growth in its GDP (Crone and Clayton-Matthews 2005). We estimate the correlation of state's economy to the rest of the US from the monthly values of the coincident indices of the states as well as the coincident index of the US over 1979-1984, before interstate deregulation started to come into effect. We then interact this correlation variable with the interstate treatment. In Table 10, we show that the increase in patenting as well as the productivity of patents primarily rose in the states with the recent history of least covariation with the rest of the US

[12] These findings are also confirmed using the originality and generality indexes as dependent variables.

5.6 Investment policy and financial constraints

If an easier access to credit was one channel through which banking deregulations affected innovation, we expect the effect to be prevalent among firms for which raising external finance before the deregulations was relatively more costly. Also, if a wider access to external finance makes physical collateral less relevant for future investment, firms may change their investment policy in favor of R&D expenses relative to fixed assets.[13] To test these notions, we use the ratio of R&D expenses to total investment as dependent variable and adopt a number of proxies for financial constraints.[14] Our model is estimated using OLS regressions with firm fixed effects, year dummies and industry trends. In addition, we control for lagged logarithm of sales, capital-to-labor ratio, profitability and cash holdings to absorb the effect of firm characteristics and internal financial resources.

Old and well-established firms can access the public debt market or raise equity and thus they should not be particularly influenced by changes in bank credit. By contrast, young firms, which are more financially constrained due to limited collateral and asymmetric information problems, are expected to respond more to an easier access to external finance. To test this notion, we construct the interaction between interstate deregulations and a dummy equal to one for firms that were young at the time of the interstate deregulation. We define as young those firms that are present for less than 10 years in Compustat (Rajan and Zingales 1998; Cetorelli and Strahan 2006).[15] As shown in Table 11, Columns (3) and (4), the interaction of interstate deregulations and young firms is positive, significant and economically large. This finding suggests that interstate deregulations fostered innovation by relaxing firms' financial constraints.

[13] See Rajan and Zingales (2001) for a discussion of a similar argument.
[14] Because our goal here is to test for the importance of financial constraints we prefer to use a variable related to R&D expenditures, which are the monetary input of the innovation process, rather the number of patents itself. However, the findings in this section can be extended to patent counts.
[15] Our results are robust to the adoption of alternative thresholds, such as 5 or 15 years.

To further explore this aspect, we sort firms according to whether in 1985 they were assigned a long term bond rating by Standard & Poors.[16] A bond rating permits firms to access public debt markets and is thus related to lower credit constraints (Kashyap et al 1994; Almeida et al. 2004; Faulkender and Petersen 2006; Denis and Sibilkov 2010). We construct an indicator equal to one if a firm reports a bond rating and a positive debt, and equal to zero if a firm is not assigned to a rating or if it has no debt. Columns (5) and (6) show the results using the interaction between this dummy and the interstate deregulations treatment. As expected, the effect of interstate deregulations is primarily present among firms that are constrained in accessing other sources of finance.

Next, we test the importance of industry-level dependence from external finance. We posit that the effect of deregulations is greater for industries that have a precedence of raising external finance compared to industries that rely more on internal sources of finance. To test this hypothesis, similar to Rajan and Zingales (1998) we first classify firms based on whether the industry in which they operated was above or below the across-industry median in 1984 in terms of the external financial capital that they raised.[17] Second, we interact the dummy indicating a high dependence from external finance with the interstate deregulations treatment. As shown in Columns (7) and (8), the effect of deregulations is primarily present when the dependence from external finance is high.

In conclusion, our results indicate substantial variations of deregulations' effect on innovation expenses depending on a firm's financial constraints: the beneficial effect of interstate deregulations on innovation expenses was primarily present among younger firms, firm with a worse access to alternative financing sources, and firms operating in industries where external finance was more important.[18]

[16] 1985 is the first year when the coverage of S&P ratings in Compustat started.
[17] We adopt 1984 as starting year due to data availability (Leary and Roberts 2005).
[18] Notice that the results of this section do not change if we also include interactions between firm and industry characteristics and intrastate deregulations; the interactions with interstate deregulations remain

6. Conclusion

While the relationship between economic prosperity and financial development has been widely debated, establishing the direction of causality remains a challenging task. We focus on corporate innovation as a driving force of technological progress and growth, and exploit the passage of banking deregulations in the US during the 1970s and 1980s to establish exogenous variations in financial development. Deregulations, in particular those that removed restrictions to banking across states, increased the availability and quality of credit, induced the adoption of screening and monitoring technologies, and allowed banks to geographically diversify their loan portfolios, thus favoring lending to a larger pool of companies and riskier projects. Our results indicate that financial development has a causal positive effect on innovation. Banking deregulations had a beneficial role in spurring firm innovation, as measured by patent-based metrics; furthermore, we find that the effect was not imminent, as innovations typically take time to show up, and was mainly present among financially-constrained firms, which reacted to the deregulations by changing their investment policy in favor of R&D expenses.

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significant and with similar coefficient, whereas neither intrastate deregulations nor the interactions are statistically significant.

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Figure 1.
Innovation and banking deregulations

This graph illustrates the average and median logarithm of patents around the passage of interstate and intrastate deregulations

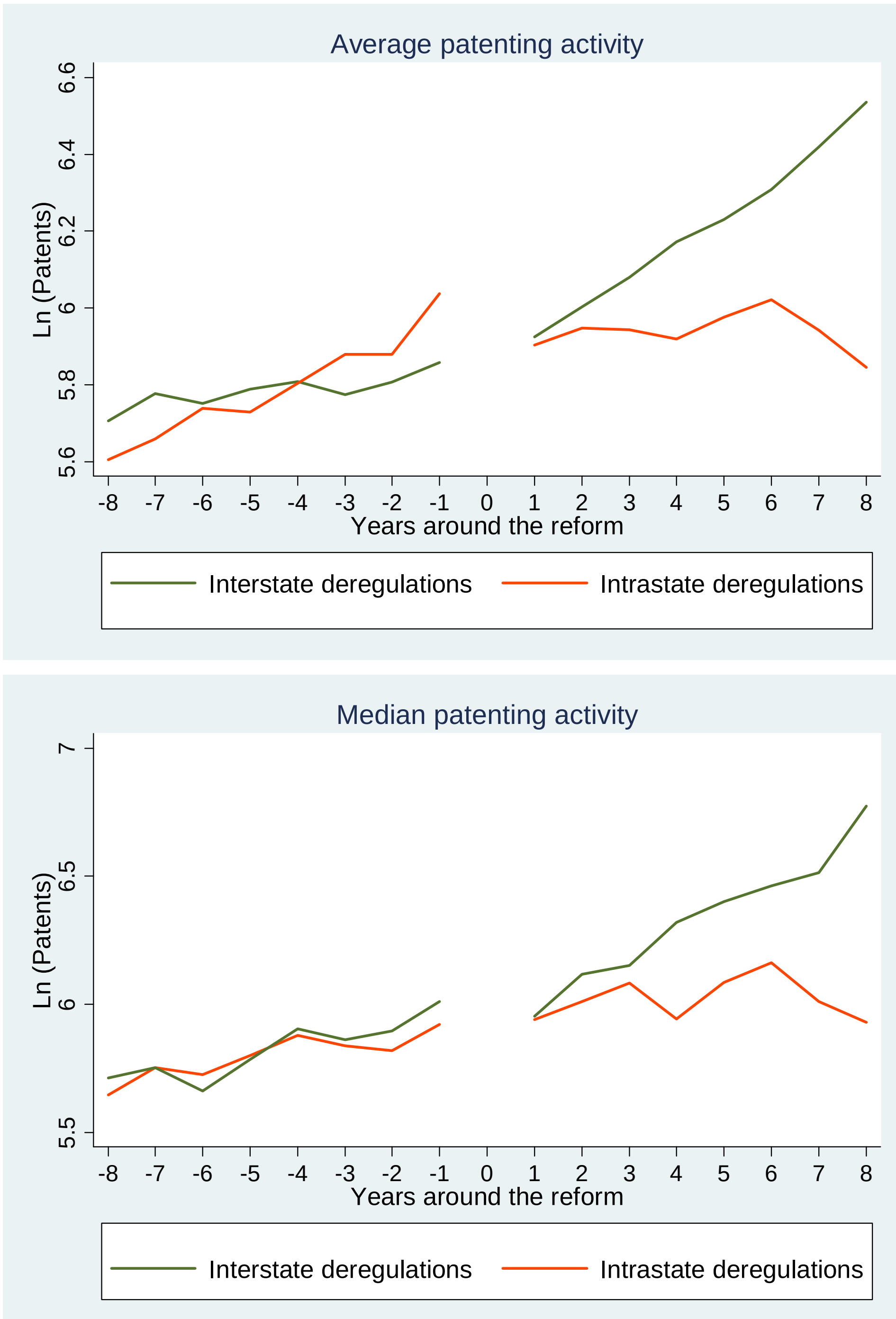

Table 1.
US states by intrastate and interstate deregulations

This table illustrates the timing of intrastate and interstate deregulations in the US states. Deregulations passed in 1975 or earlier are listed as “Before 1976”.

Year	Intrastate deregulations	Interstate deregulations
Before 1976	Maine, Alaska, Rhode Island, North Carolina, Virginia, District of Columbia, Nevada, Maryland, Idaho, Arizona, South Carolina, Delaware, California, Vermont, South Dakota	-
1976	New York	-
1977	New Jersey	-
1978	-	Maine
1979	Ohio	-
1980	Connecticut	-
1981	Utah, Alabama	-
1982	Pennsylvania	New York, Alaska
1983	Georgia	Connecticut, Massachusetts
1984	Massachusetts	Rhode Island, Utah, Kentucky
1985	Tennessee, Oregon, Washington, Nebraska	North Carolina, Ohio, Virginia, District of Columbia, Nevada, Maryland, Idaho, Georgia, Tennessee, Florida
1986	Mississippi, Hawaii	Arizona, New Jersey, South Carolina, Pennsylvania, Oregon, Michigan, Illinois, Indiana, Missouri, Minnesota
1987	Michigan, New Hampshire, West Virginia, North Dakota, Kansas	California, Alabama, Washington, New Hampshire, Texas, Oklahoma, Louisiana, Wyoming, Wisconsin
1988	Florida, Illinois, Texas, Oklahoma, Louisiana, Wyoming	Delaware, Vermont, South Dakota, Mississippi, West Virginia, Colorado
1989	Indiana	New Mexico, Arkansas
1990	Kentucky, Missouri, Wisconsin, Montana	Nebraska
1991	Colorado, New Mexico	North Dakota, Iowa
1992	-	Kansas
1993	Minnesota	Montana
1994	Arkansas	-
After 1994	Iowa	Hawaii

Table 2.
Summary statistics

This table represents summary statistics. Patent counts represent a firm's number of patents. Cite-weighted patents represent a firm's patents weighted by the number of future citations and truncation-adjusted. Ln (R&D) is the logarithm of R&D expenditures. R&D/Investment is the ratio of R&D expenditures to total investment, computed as the sum of Capex and R^D expenses. Ln (Sales) is the logarithm of a firm's sales. Ln (K/L) is the logarithm of capital to labor ratio. Ln (Age) is the logarithm of 1 plus the number of years a firm has been in Compustat. ROA is return on assets, measured as the ratio of earnings before interest and depreciation (EBITDA) divided by the book value of assets. See Table A1 for a full description of each variable.

	Number of observations	Mean	Standard deviation	Median
Innovation measures				
Patents	23016	9.898	39.343	0
Cite-weighted patents	23016	151.901	759.797	0
Ln (R&D)	21951	1.567	1.483	1.110
R&D/Investment	21739	0.421	0.269	0.395
Other firm characteristics				
Ln (Sales)	22949	4.260	2.413	4.179
Ln (K/L)	22736	2.837	1.011	2.800
Ln (Age)	23016	2.519	0.781	2.565
ROA	22756	0.089	0.201	0.134

Table 3.
Patents and banking deregulations: OLS estimates

This table reports OLS regression results using the pre-post specification and Ln (Patents) as dependent variable. Columns (4) and (8) include an additional set of firm and industry lagged controls. Specifically, they include: Ln (Age), HHI, ROA, tangibility, cash holdings. Coefficients, unreported to save space, are available upon request. The construction of control variables is described in Appendix A1. Standard errors clustered by State are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable: Ln (Patents)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Interstate deregulations	0.2059**	0.1777***	0.1972***	0.2031***	0.1499***	0.1371***	0.1316***	0.1289***
	(0.0879)	(0.0447)	(0.0417)	(0.0447)	(0.0392)	(0.0340)	(0.0338)	(0.0334)
Intrastate deregulations	-0.1437	-0.0780	-0.0762*	-0.0900**	-0.1225	-0.0765	-0.0623	-0.0698
	(0.0989)	(0.0511)	(0.0441)	(0.0442)	(0.0820)	(0.0531)	(0.0439)	(0.0468)
Ln (Sales)		0.4577***	0.1000***	0.1841***		0.3388***	0.2481***	0.2934***
		(0.0241)	(0.0155)	(0.0182)		(0.0376)	(0.0547)	(0.0621)
Ln (K/L)		0.1389***	0.0448*	-0.0740**		0.0620	0.0376	0.0091
		(0.0359)	(0.0244)	(0.0301)		(0.0439)	(0.0434)	(0.0491)
Ln (R&D stock)			0.5217***	0.5143***			0.1950***	0.2048***
			(0.0333)	(0.0317)			(0.0436)	(0.0555)
Industry FE	Yes	Yes	Yes	Yes	No	No	No	No
Firm FE	No	No	No	No	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	No	No	No	No	Yes	Yes	Yes	Yes
Additional controls	No	No	No	Yes	No	No	No	Yes
Number of obs.	11284	11284	11284	11284	11284	11284	11284	11284

Table 4.
Patents and banking deregulations: Poisson estimates

This table reports Poisson regression results using the pre-post specification. We use as dependent variables patent counts (Columns 1-4) or cite-weighted and truncation-adjusted patents (Columns 5-8). Columns (4) and (8) include an additional set of firm and industry lagged controls. Specifically, they include: Ln (Age), HHI, ROA, tangibility, cash holdings. Coefficients, unreported to save space, are available upon request. The construction of control variables is described in Appendix A1. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable:	Patents				Cite-weighted patents			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Interstate deregulations	0.1561***	0.1513***	0.1502***	0.1494***	0.1143*	0.0927**	0.0894**	0.0915***
	(0.0533)	(0.0356)	(0.0350)	(0.0327)	(0.0664)	(0.0374)	(0.0359)	(0.0352)
Intrastate deregulations	-0.1798	-0.1463**	-0.1329**	-0.1292**	-0.0608	-0.0048	0.0139	0.0071
	(0.1216)	(0.0607)	(0.0611)	(0.0541)	(0.1517)	(0.0712)	(0.0715)	(0.0623)
Ln (Sales)		0.6950***	0.5699***	0.6198***		0.6709***	0.5166***	0.5606***
		(0.0625)	(0.0644)	(0.0722)		(0.0583)	(0.0589)	(0.0762)
Ln (K/L)		0.2481***	0.2364***	0.1802**		0.2418***	0.2283***	0.1868***
		(0.0585)	(0.0658)	(0.0715)		(0.0596)	(0.0656)	(0.0690)
Ln (R&D stock)			0.2038***	0.1775**			0.2474***	0.2708***
			(0.0604)	(0.0702)			(0.0582)	(0.0613)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls	No	No	No	Yes	No	No	No	Yes
Number of obs.	18125	18125	18125	18125	17990	17990	17990	17990

Table 5.
Robustness checks

This table reports Poisson regression results using the pre-post specification. We use as dependent variable future cite-weighted and truncation-adjusted patent counts. We include the full set of controls considered in Table 3B, Column (6), and described in Appendix A1. In Column (1), we include a dummy equal to one if the firm is incorporated in a state that passed a BC law from the year of the passage on, and zero before the passage of BC laws or for firms incorporated in states that did not pass a BC law. In Column (2), we further include the interaction between BC laws and interstate deregulations. In Column (3), we exclude observations corresponding to the year of passage of interstate deregulations. In Column (4), we control for state linear trends. In Column (5), we present estimates from a negative binomial model. Each column includes an additional set of firm- and industry-level lagged controls. Specifically, they include: Ln (Age), HHI, ROA, tangibility, cash holdings. Variables included are described in Appendix A1. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable: Cite-weighted patents					
	(1)	(2)	(3)	(4)	(5)
Interstate deregulations	0.0902**	0.0895**	0.0946*	0.0899***	0.1032*
	(0.0366)	(0.0385)	(0.0551)	(0.0334)	(0. 0624)
BC	-0.0349	-0.0588			
	(0.0581)	(0.0806)			
Interstate deregulations × BC		0.0248			
		(0.1027)			
Intrastate deregulations	-0.0015	-0.0016	0.0048	0.0115	-0.1657***
	(0.0670)	(0.0669)	(0.0655)	(0.0550)	(0.0584)
Ln (Sales)	0.5799***	0.5800***	0.5512***	0.5593***	0. 1996***
	(0.0742)	(0.0743)	(0.0800)	(0.0795)	(0. 0301)
Ln (K/L)	0.1861***	0.1859***	0.2063***	0.1859***	-0.1646*
	(0.0636)	(0.0639)	(0.0726)	(0.0672)	(0.0846)
Ln (R&D stock)	0.2648***	0.2648***	0.2764***	0.2741***	0. 3583***
	(0.0622)	(0.0622)	(0.0607)	(0.0611)	(0. 0351)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes	Yes	Yes
Number of obs.	15997	15997	16997	18009	18009

Table 6.
Patenting and technological fields

This table reports Poisson results using the pre-post specification. We use as dependent variable the originality index (Columns 1-3) and the Generality index (Columns 4-6). The construction of control variables is described in Appendix A1. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable:	Originality Index			Generality Index		
	(1)	(2)	(3)	(4)	(5)	(6)
Interstate deregulations	0.1415**	0.1343***	0.1325***	0.1268**	0.1452***	0.1448***
	(0.0630)	(0.0435)	(0.0430)	(0.0517)	(0.0450)	(0.0439)
Intrastate deregulations	-0.1979*	-0.1631***	-0.1507**	-0.1163	-0.0744	-0.0609
	(0.1199)	(0.0591)	(0.0591)	(0.1279)	(0.0670)	(0.0662)
Ln (Sales)		0.6816***	0.5760***		0.7448***	0.6213***
		(0.0618)	(0.0616)		(0.0592)	(0.0557)
Ln (K/L)		0.2466***	0.2384***		0.2415***	0.2304***
		(0.0653)	(0.0720)		(0.0586)	(0.0621)
Ln (R&D stock)			0.1722***			0.1994***
			(0.0593)			(0.0622)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs.	17412	17412	17412	16788	16788	16788

Table 7.
Quantile regressions

This table reports quantile regression results using the pre-post specification and Ln (Patents) (in Columns 1 and 2) or Ln (Cite-weighted patents) (in Columns 3 and 4) as dependent variables. Interstate and intrastate treatments are jointly estimated but reported in separate columns. All regressions include the full set of controls as used in e.g. Table 3, Column (8). Coefficients, unreported to save space, are available upon request. The construction of control variables is described in Appendix A1. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable:	Ln (Patents)		Ln (Cite-weighted patents)	
	(1)	(2)	(3)	(4)
Percentile	Intrastate deregulations	Interstate deregulations	Intrastate deregulations	Interstate deregulations
10	0.0377	0.0110	0.0604	-0.0966
	(0.0280)	(0.0409)	(0.0917)	(0.1304)
20	0.0520	0.0362	-0.0221	0.0148
	(0.0454)	(0.0657)	(0.0680)	(0.0965)
30	0.0113	0.0711	-0.0028	0.0931
	(0.0347)	(0.0498)	(0.0545)	(0.0780)
40	0.0445	0.1000*	0.0453	0.1588*
	(0.0418)	(0.0602)	(0.0644)	(0.0927)
50	0.0339	0.1606***	0.0439	0.1832**
	(0.0358)	(0.0517)	(0.0517)	(0.0745)
60	0.0248	0.1845***	0.0717	0.1752**
	(0.0426)	(0.0616)	(0.0481)	(0.0697)
70	0.0362	0.1584***	0.0804*	0.1411**
	(0.0381)	(0.0551)	(0.0465)	(0.0677)
80	-0.0058	0.1253**	0.0934*	0.1417*
	(0.0396)	(0.0574)	(0.0510)	(0.0752)
90	0.0029	0.1435**	0.0702	0.0822
	(0.0429)	(0.0630)	(0.0513)	(0.0749)

Table 8.
Linear treatment effects

This table reports Poisson regression results using the linear treatment effect specification. We use as dependent variable future cite-weighted and truncation-adjusted patent counts. Years since interstate and intrastate deregulations are variables equal to the number of years after the deregulation passages, with a long-term effect at eight years, and equal to zero before the deregulations. Column (4) includes an additional set of firm and industry lagged controls. Specifically, they include: Ln (Age), HHI, ROA, tangibility, cash holdings. Coefficients, unreported to save space, are available upon request. The construction of control variables is described in Appendix A1. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable: Cite-weighted patents				
	(1)	(2)	(3)	(4)
Years since Interstate deregulations	0.0528***	0.0532***	0.0555***	0.0590***
	(0.0192)	(0.0179)	(0.0161)	(0.0152)
Years since Intrastate deregulations	-0.0088	-0.0161	-0.0220	-0.0229
	(0.0164)	(0.0170)	(0.0185)	(0.0179)
Ln (Sales)		0.6774***	0.5195***	0.5670***
		(0.0537)	(0.0615)	(0.0763)
Ln (K/L)		0.2141***	0.1964***	0.1609***
		(0.0549)	(0.0591)	(0.0582)
Ln (R&D stock)			0.2545***	0.2791***
			(0.0582)	(0.0628)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes
Additional controls	No	No	No	Yes
Number of obs.	17990	17990	17990	17990

Table 9.
Dynamic effects

This table reports Poisson results using a dynamic specification. We use as dependent variable future cite-weighted and truncation-adjusted patent counts. The response to interstate and intrastate deregulations is modeled by a series of leads and lags for each reform, consolidated into two-year increments extending from one year before to eight years or more after the deregulations. Coefficients for leads are relative to the period two years before deregulations. Column (4) includes the additional set of firm and industry lagged controls used in Table 4. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable: Cite-weighted patents	(1)	(2)	(3)	(4)
Response to interstate deregulations				
Years 1-2 before reform	0.1483	0.0641	0.0512	0.0600
	(0.0998)	(0.0554)	(0.0555)	(0.0518)
Reform year and one after	0.2616*	0.1672**	0.1535**	0.1639**
	(0.1359)	(0.0781)	(0.0777)	(0.0714)
Years 2-3 after reform	0.3291*	0.2006*	0.1867	0.2230*
	(0.1880)	(0.1143)	(0.1139)	(0.1161)
Years 4-5 after reform	0.4423**	0.2787**	0.2732**	0.3147**
	(0.2144)	(0.1380)	(0.1341)	(0.1352)
Years 6-7 after reform	0.5967**	0.4236**	0.4135**	0.4608***
	(0.2546)	(0.1663)	(0.1644)	(0.1712)
Years 8+ after reform	0.4525*	0.3139*	0.3132*	0.3577*
	(0.2635)	(0.1751)	(0.1734)	(0.1839)
Response to intrastate deregulations				
Years 1-2 before reform	-0.1173	-0.0740	-0.0658	-0.0752
	(0.1014)	(0.0503)	(0.0511)	(0.0473)
Reform year and one after	-0.1343	-0.0555	-0.0398	-0.0507
	(0.1488)	(0.0835)	(0.0838)	(0.0769)
Years 2-3 after reform	-0.2169	-0.1000	-0.0744	-0.0914
	(0.2047)	(0.1141)	(0.1128)	(0.1017)
Years 4-5 after reform	-0.3067	-0.1511	-0.1234	-0.1465
	(0.2501)	(0.1420)	(0.1409)	(0.1313)
Years 6-7 after reform	-0.3292	-0.1636	-0.1366	-0.1659
	(0.2895)	(0.1619)	(0.1608)	(0.1517)
Years 8+ after reform	-0.4873*	-0.2700	-0.2472	-0.2755
	(0.2732)	(0.1851)	(0.1812)	(0.1760)
Ln (Sales)		0.6605***	0.5094***	0.5561***
		(0.0614)	(0.0601)	(0.0766)
Ln (K/L)		0.2316***	0.2186***	0.1719***
		(0.0602)	(0.0657)	(0.0646)
Ln (R&D stock)			0.2435***	0.2712***
			(0.0578)	(0.0616)
Firm, year FE and industry trends	Yes	Yes	Yes	Yes
Additional controls	No	No	No	Yes
Number of obs.	17990	17990	17990	17990

Table 10.
Diversification channel

This table reports Poisson regression results using the pre-post specification. We use as dependent variables patent counts (Columns 1-2) or cite-weighted and truncation-adjusted patents (Columns 3-4). The construction of control variables is described in Appendix A1. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable:	Patents		Cite-weighted patents	
	(1)	(2)	(3)	(4)
Interstate deregulations	0.4776***	0.3905***	0.5490***	0.4152***
	(0.1393)	(0.0982)	(0.1873)	(0.1005)
Intrastate deregulations	-0.1679	-0.1246*	-0.1142	-0.0373
	(0.1191)	(0.0674)	(0.1192)	(0.0667)
Interstate deregulations × State comovement	-0.4424**	-0.3389**	-0.5936**	-0.4471***
	(0.1932)	(0.1527)	(0.2714)	(0.1357)
Ln (Sales)		0.7159***		0.6764***
		(0.065)		(0.0621)
Ln (K/L)		0.2057**		0.2009***
		(0.0803)		(0.0703)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes
Additional controls	No	No	No	No
Number of obs.	18837	18837	18665	18665

Table 11.
Innovation expenses and financial constraints

This table reports OLS regression results using the pre-post specification. We use as dependent variables the ratio of R&D expenses to total investment, computed as the sum of Capex and R&D expenditures. In Column 2, we interact the interstate deregulation with a dummy equal to one if the firm was present for 10 years or less in the Compustat dataset at the time of the reform passage. In Column 3, we use the interaction with a dummy equal to one if the firm report an S&P bond rating in 1985. In Column 4, we use an interaction with a dummy equal to one if the industry in which the firm operates was above the median level of security issuances at the year of the reform passage. Standard errors clustered by state of operation are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Dependent variable: R&D investment intensity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Interstate deregulations	0.0009	0.0035	-0.0157	-0.0128	-0.0215*	-0.0167	-0.0310***	-0.0291***
	(0.0076)	(0.0079)	(0.0102)	(0.0105)	(0.0115)	(0.0113)	(0.0097)	(0.0099)
Intrastate deregulations	0.0061	0.0045	0.0088	0.0068	0.0067	0.0044	0.0099	0.0072
	(0.0104)	(0.0105)	(0.0100)	(0.0105)	(0.0101)	(0.0104)	(0.0089)	(0.0093)
Interstate deregulations × Young firms			0.0543***	0.0533***				
			(0.0117)	(0.0124)				
Interstate deregulations × Credit constrained firms					0.0318***	0.0277***		
					(0.0092)	(0.0084)		
Interstate deregulations × High external dependence							0.0570***	0.0581***
							(0.0100)	(0.0103)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Number of obs.	21073	21073	13627	13627	13511	13511	13715	13715

Appendix.
List of variables

Name	Description	Source
Innovation variables		
Ln (R&D Stock)	Logarithm of (1+cumulative R&D expenditures), computed assuming a 15% annual depreciation rate	Compustat
R&D/Investment	Ratio of R&D expenses to total investment, computed as the sum of CAPEX and R&D expenses	Compustat
Ln (Patents)	Logarithm of a firm's number of patents for the period 1976-1995	NBER
Patents	Count of a firm's number of patents for the period 1976-1995	NBER
Cite-weighted patents	Count a firm's number of patents for the period 1976-1995 weighed by future citations received and adjusted for truncation (as described in Hall et al. 2001; Hall et al. 2005)	NBER
Firm, industry and state characteristics		
Ln (Age)	Logarithm of (1+age), where age is the number of years that the firm has been in Compustat	Compustat
Ln (Sales)	Logarithm of a firm's sales	Compustat
Market-to-Book	Ratio of market value of assets to the book value of assets. Values are limited between 0 and 10.	Compustat
Ln (K/L)	Logarithm of capital to labor ratio	Compustat
Tangibility	1- (intangible assets to total assets)	Compustat
ROA	EBITDA to total assets, dropping 1% of observations at each tail of the distribution to mitigate the effect of outliers	Compustat
Cash holdings	Cash and marketable securities to total assets	Compustat
CAPEX	Capital expenditures to total assets, winsorized at 0 and 1	Compustat
Industry HHI	Herfindahl-Hirschman Index, computed as the sum of squared market shares of all firms, based on sales, in a given three-digit SIC industry in each year. We drop 2.5% of observation at the right tail of the distribution to mitigate potential misclassifications (Giroud and Mueller 2010)	Compustat
State comovement	Correlation of state's coincident index to the US coincident index estimated from the monthly values of the indices over 1979-1984. The coincident index combines data on nonfarm payroll employment, average hours worked in manufacturing, the unemployment rate, and wage and salary disbursements deflated by the consumer price index (US city average).	Federal Reserve Bank of Philadelphia
Industry and state trends		
Industry-year	Average of the dependent variable across all firms in the same four-digit SIC industry of the firm, where averages are computed excluding the firm in question	Compustat
State-year	Average of the dependent variable across all firms in the same state of location of the firm, where averages are computed excluding the firm in question	Compustat
Banking deregulations variables		
Interstate/Intrastate deregulations	Dummy variable equal to one from the deregulation year onwards, and zero for the period prior to deregulations. Deregulations passed in 1975 or earlier are coded as 1976	