Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

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2016-029

Please cite this paper as:
Chang, Andrew C. (2016). "Banking Consolidation and Small Firm Financing for Research and Development," Finance and Economics Discussion Series 2016-029. Washington: Board of Governors of the Federal Reserve System, http://dx.doi.org/10.17016/FEDS.2016.029.

Banking Consolidation and Small Firm Financing for Research and Development

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April 8, 2016

Abstract

This paper examines the effect of increased market concentration of the banking industry caused by the Riegle-Neal Interstate Banking and Branching Efficiency Act (IBBEA) on the availability of finance for small firms engaged in research and development (R&D). I measure the financing decisions of these small firms using a balanced panel of Small Business Innovation Research (SBIR) applications. Using difference-in-differences, I find IBBEA decreased the supply of finance for small R&D firms. This effect is larger for late adopters of IBBEA, which tended to be states with stronger small banking sectors pre-IBBEA.

JEL Classification Codes: G21, G28, G39, O30

Keywords: Banking Deregulation; IBBEA; Interstate Bank Branching Deregulation; Market Concentration; Riegle-Neal; Research and Development; R&D; Small Business Innovation Research; SBIR

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This research was supported by separate grants from the Department of Economics and the Graduate Division at the University of California - Irvine. However, the opinions expressed in this paper are mine and do not necessarily reflect those of the university or the Board of Governors of the Federal Reserve System. I thank anonymous referees, Stephanie Aaronson, Volodymyr Bilotkach, Marianne P. Bitler, Nick Bloom, William A. Branch, Jiawei Chen, Linda R. Cohen, Amihai Glazer, Ivan Jeliazkov, David Jenkins, Jakub Kastl, David Neumark, Gary Richardson, George C. Saioc, Matthew Shum, and Don Walls for helpful comments. I also thank Clara C. Asmail, Nicholas Cormier, Kay Etzler, and Leslie A. Jensen for help with SBIR data; Daniel J. Wilson for graciously providing state-level data on the user cost of R&D; and Tyler J. Hanson for valuable research assistance. Any errors are mine.

1 Introduction

This paper examines how the deregulation and subsequent consolidation of the U.S. banking industry affected financing for small firms engaged in research and development (R&D). Because technological development drives economic growth (Solow, 1957), and because small firms are a significant driver of innovation (Acs and Audretsch, 1987), understanding the link between small firm finance and their R&D expenditures is an important issue.

I analyze the effect of the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 (IBBEA) on the propensity for small firms to apply for external R&D funding through the U.S. government's Small Business Innovation Research (SBIR) program, an award program for R&D projects at both private and public small firms.[1] Prior to IBBEA, there were geographic restrictions on interstate bank branching, which dated back to the beginning of the U.S. banking system. Implemented on a state-by-state basis, IBBEA removed geographic restrictions on interstate bank branching and consolidated the banking industry. Figure 1, which plots the Herfindahl Index of the U.S. banking sector from fiscal year (FY) 1987 to FY 2000, shows an increase in market concentration after IBBEA passed.

With a negative binomial model and difference-in-differences, I estimate the effect of IBBEA on SBIR applications with a balanced panel of state-year SBIR application counts. I find IBBEA increased SBIR applications between 10 to 50 percent. This effect is present for all states, but I find larger effects for states that adopted IBBEA later. Later adopters of IBBEA had stronger small banking sectors, more potential targets for interstate bank mergers, and the potential to have a larger change in banking structure due to the deregulation caused by IBBEA (Kroszner and Strahan, 1999).

The key identification assumption for relating changes in SBIR applications to implications about small R&D firm finance is that SBIR awards and bank finance are substitutes. Under this assumption, if IBBEA made it more difficult for firms to secure funding for R&D projects, then

[1] For a review of U.S. banking deregulation, including IBBEA, see Johnson and Rice (2008). For a summary of SBIR, see Lerner (1999).

firms should have sought an alternative source of funding in SBIR awards and we should observe an increase in SBIR applications due to IBBEA.

Evidence on the financing decisions of small R&D firms supports the idea that these firms view SBIR finance and all other sources of finance as substitutes. Combining SBIR grants with funding from other sources imposes costs on the firm and restricts the firm's use of its inventions. The imposed costs include SBIR application time and annual reporting requirements.[2] In addition, as a condition of funding research with an SBIR grant, the firm must disclose all invention(s) that come from the grant to the government and provide the government a license to use the disclosed invention(s). If the firm patents or licenses technology funded by SBIR, then the firm must submit an annual utilization report on the technology to the government. The government may also force the firm to grant licenses to other firms when the government deems licensing to be in the public interest (National Institutes of Health, 1995). For SBIR award winning firms, Wallsten (2000) estimates an elasticity of substitution between SBIR award dollars and all other sources of funding as negative 0.82, indicating nearly dollar-for-dollar substitution between SBIR awards and other sources of finance for R&D.

Assuming bank finance and SBIR are substitutes, my estimated 10 to 50 percent increase in SBIR applications implies that IBBEA diminished bank finance for small R&D firms. Because I measure changes in finance with SBIR applications, as the balance sheet data on small R&D firms are unavailable, I cannot say exactly how much the supply of finance changed because of banking consolidation. However, with some assumptions, a rough calculation suggests that IBBEA decreased the supply of finance for small R&D firms in FY 1999 between 138 - 508 million dollars.[3] In FY 1999 the budget for SBIR was $1.25 billion. The total value of SBIR finance to the IBBEA-induced applicants should be 82 percent of the value of lost bank fiance, using the elasticity of substitution from Wallsten (2000) of negative 0.82 between SBIR and bank finance, as well as making the following assumptions: (1) firms did not consider the

[2] Informal conversations with SBIR administrators suggest that the initial application for SBIR takes approximately 200 hours to complete.

[3] Dollar figures in this paragraph are in 2005 dollars, inflated with the Bureau of Economic Analysis' (BEA's) implicit price deflator (BEA, 2011).

fact that their award chances changed because of banking consolidation and (2) firms that were induced into applying for SBIR subsequent to IBBEA had an equal expected value of an SBIR application as a firm that would have applied without IBBEA. Because the estimates indicate that SBIR applications increased 10 to 50 percent, the lower bound on the change in finance should be $(1-\frac{1}{1+0.1})*1.25\ billion = 0.82*bankfinance\ lowerbound$, or $\frac{1}{0.82}*(1-\frac{1}{1+0.1})*1.25\ billion = 138\ million = bankfinance\ lowerbound$. A similar calculation for the upper bound is $\frac{1}{0.82}*(1-\frac{1}{1+0.5})*1.25\ billion = 508\ million = bankfinance\ upperbound$.

My panel of state-year SBIR application counts is a data set that offers three advantages for this study. First, because the data set comes from administrative records, it is free of the self-reporting bias present in survey data.[4] Second, the data set is a balanced panel of SBIR application counts that is free of the survivorship bias usually present in bank or firm-level data. Third, the panel of SBIR application counts represents both public and private companies as opposed to just public companies (for example, companies in Compustat). This last advantage allows an analysis of small private companies, which are important to the conduct of R&D and for which little data are available. Previous research on banking deregulation looks at the effect of deregulation on the average small firm or the effect on lending for small firms at the state level, finding mixed results on how deregulation affected the supply of credit (Jayaratne and Wolken, 1999; Vera and Onji, 2010). To my knowledge, this paper is the first that examines the effects of IBBEA specifically on small, private R&D firms.

2 Institutional Details of IBBEA and SBIR

This section reviews IBBEA and SBIR. I discuss how IBBEA led to the consolidation of the banking industry. For SBIR, I describe how the program is structured and present summary statistics of small R&D firms that are eligible for SBIR.

[4]See, for example, Berger and Udell (1995) and Peek and Rosengren (1996) for evidence of errors in survey data.

2.1 IBBEA

Passed on September 29, 1994, IBBEA set a default opt-in trigger date of June 1, 1997. However, states could opt into IBBEA early or opt out of IBBEA entirely by the default opt-in date. Approximately one-third of states waited until the trigger date to opt into IBBEA's provisions, and several states had active debates on opting out of IBBEA (Kane, 1996; Johnson and Rice, 2008). Texas and Montana initially opted out, although both states later opted in. Table 1 shows the initial opt-in dates for each state. Subject to certain conditions, IBBEA allowed several new types of banking activity: (1) interstate bank acquisitions, (2) interstate agency operations, (3) interstate branching, and (4) de novo branching (Johnson and Rice, 2008).

IBBEA changed the structure of the banking industry. Prior to IBBEA, in 1994 there were only 62 out-of-state bank branches — less than 1 percent of the total number of branches. With the removal of the restrictions on interstate branching, by 1999 there were more than 10,000 out-of-state bank branches — approximately 20 percent of the total number of bank branches (Johnson and Rice, 2008).

In addition to allowing interstate bank branches, IBBEA increased interstate bank mergers, which contributed to the consolidation of the banking industry documented in Figure 1. Figure 2 plots interstate bank mergers during the 1990s and shows a significant increase in interstate mergers subsequent to IBBEA.

IBBEA fueled research on the relationship between banking consolidation, deregulation, and finance.[5] This research may have been encouraged by suspicions that IBBEA was detrimental for small firm finance, which was also a chief concern in Congress when IBBEA was debated (U.S. Congress, 1993).

[5] Examples include Berger, Saunders, Scalise, and Udell (1998); Cole and Walraven (1998); Peek and Rosengren (1998); Strahan and Weston (1998); Jayaratne and Wolken (1999); Craig and Hardee (2007); Rice and Strahan (2010); Vera and Onji (2010); and Cornaggia, Mao, Tian, and Wolfe (2015).

2.2 SBIR

Congress created the SBIR program in 1982 in part to combat market failures associated with R&D.[6] Public Laws 97-219, 99-443, and 102-564 require each federal agency with an extramural research program greater than $100 million to set aside a fixed percentage of the agency's extramural research budget for SBIR. Certain characteristics of the SBIR program are mandatory (for example, the set-aside percentage), and the Small Business Administration (SBA) oversees the general SBIR program. However, each agency administers its own SBIR program separately, which gives the individual agencies some flexibility to meet SBIR's congressional mandates.[7]

Qualified businesses that can receive an SBIR award are located in the U.S., are for-profit, are at least 51 percent owned by U.S. citizens or permanent residents, and employ a maximum of 500 employees. Financial data on firms that applied for SBIR are not available. However, the 1993 National Survey of Small Business Finances (NSSBF) contains financial and other demographic data on small firms that employed R&D workers, which are the types of firms that would have applied for SBIR grants (Board of Governors of the Federal Reserve System, 1993).[8] Most of the survey describes characteristics of firms in 1993, although some questions reference either 1992 or 1994.

Table 2 displays characteristics of firms that employed R&D workers from the 1993 NSSBF. Column (1) describes all firms that employed R&D workers in 1992. Column (2) restricts the sample to only firms with R&D workers in 1992 that also applied for venture capital from 1992 to 1994. The table inflates all dollar figures to 2005 dollars with the BEA's implicit price deflator.

Column (1) shows that in 1992, the average small R&D firm had 12 workers, almost a quarter million dollars in payroll, and more than $1.6 million in sales. Importantly for this paper, 38.9

[6] For market failures, in addition to the liquidity constraint problem arising from uncertainty and asymmetric information (Arrow, 1962; Hall and Lerner, 2009), R&D also suffers from an appropriation issue (Griliches, 1992).

[7] As of FY 1999, the participating agencies were the Departments of Agriculture, Commerce, Defense, Education, Energy, Health and Human Services, and Transportation; the Environmental Protection Agency; the National Aeronautics and Space Administration; and the National Science Foundation.

[8] The NSSBF defines a small firm as one with fewer than 500 employees, which is the same definition that SBIR uses. The NSSBF has data available for 1987, 1993, 1998, and 2003. However, the 1998 edition did not collect information on R&D employees, and the 1987 and 2003 editions are outside of this paper's sample period.

percent of these firms applied for a loan from 1993 to 1994 and, on average, were approved for more than half a million dollars. These data show that loans are an important source of finance for these firms. Firms that also applied for venture capital were larger, on average, than those that did not. In addition, firms that applied for venture capital also secured loans as a source of finance.

Agencies divide their SBIR awards into either two or three phases. A Phase I award is for a firm to explore the technical and commercial feasibility of the R&D project. If the results of the Phase I project are promising, the firm may be invited to apply for a Phase II award to further develop and commercialize the idea. Firms cannot undertake a Phase II project without first completing Phase I. Some agencies also have a Phase III program, which involves partnering the firm with a collaborator; this phase does not provide additional government SBIR money.

For the empirical analysis, I use the total state by FY SBIR Phase I applications for the agencies with the largest SBIR budgets: the Departments of Defense, Energy, and Heath and Human Services; the National Aviation and Space Administration (NASA); and the National Science Foundation (NSF). These five agencies compose more than 96 percent of the SBIR budget in each FY (National Science Board, 2008). I use Phase I applications as the dependent variable because these give the strongest indicator of the effort small R&D firms expend to seek external finance.[9] Phase II and Phase III applications represent a mixture of firm effort and agency politics, as they are conditional on good progress in earlier SBIR phase(s) and can require an invitation by the SBIR agency to even apply.

3 Model and Data

3.1 Model

Two features of IBBEA's deregulation are important for this study. First, the removal of banking restrictions consolidated the banking industry and potentially affected the cost of credit (Cole and Walraven, 1998; Peek and Rosengren, 1998; Strahan and Weston, 1998; Jayaratne and Wolken,

[9]Unfortunately, I do not observe the total dollar amount applied for, only the application count.

1999; Craig and Hardee, 2007; Rice and Strahan, 2010; Vera and Onji, 2010). Second, because there is between-state variation in deregulation dates, I can identify the effect of IBBEA on small R&D firm finance in a treatment-control setup.

Because the dependent variable, SBIR applications, is a count variable, I estimate a negative binomial model (Cameron and Trivedi, 1998, 2005). The negative binomial model is

$$f(y_{i,t}|\lambda_{i,t}) = \frac{exp(-\lambda_{i,t})\lambda_{i,t}^{y_{i,t}}}{y_{i,t}!},\ \lambda_{i,t} = \mu_{i,t}\nu \tag{1}$$

where

$$\mu_{i,t} = exp(X'_{i,t}\beta) \tag{2}$$

$$\nu \overset{iid}{\sim} g(\nu|\alpha) \tag{3}$$

$$E(y_{i,t}|\mu,\alpha) = \mu_{i,t} \tag{4}$$

$$Var(y_{i,t}|\mu_{i,t},\alpha) = \mu_{i,t} + \alpha\mu_{i,t}^2 \tag{5}$$

In equations (1) to (5), i is a state, t is the FY, $exp(\bullet)$ is the exponential function, $E(\bullet)$ is the expectations operator, $Var(\bullet)$ is the variance, X is a matrix of covariates, and α, β and δ are parameters to be estimated.

In addition to the fact that the negative binomial model only predicts non-negative outcomes, the negative binomial model's estimated marginal effects account for heterogeneous state sizes. Differentiating the conditional mean in equation (4) with respect to a single covariate x_j, the expected marginal effect for y with respect to x_j is

$$\frac{dE(y|\,X)}{dx_j} = \beta_j \times exp(X'\beta) \tag{6}$$

which depends on the parameter for covariate x_j, β_j, the entire matrix of covariates X, and their associated parameters β through the term $exp(X'\beta)$.[10]

3.2 Policy Variable

A standard policy variable is an indicator for post-deregulation that assumes a uniform effect of deregulation over time. I instead construct the policy variable to allow for time-varying effects of deregulation.

I divide states into three cohorts, one for each FY from the passage of IBBEA to the IBBEA trigger date: (1) deregulators by FY 1995, (2) deregulators in FY 1996, and (3) deregulators in FY 1997. For each cohort, I model the policy implementation as a series of time dummies beginning in the year immediately after the cohort passes IBBEA.[11] For example, for the earliest deregulation cohort (by FY 1995), there are four time dummies: FY 1996, FY 1997, FY 1998, and FY 1999. For the FY 1996 deregulators, there are three dummies: FY 1997, FY 1998, and FY 1999. The same pattern holds for the last cohort. This type of policy variable allows heterogeneous effects of IBBEA by deregulation cohort as well as through time.

Formally, let D_t be a year dummy for FY t and $D_{i,\tau}$ be a dummy for state i if it deregulated in FY τ. The conditional mean for state i in FY t with the policy variable is:

$$\mu_{i,t} = exp(\sum_{t=1996}^{1999} \zeta_t D_t D_{i,1995} + \sum_{t=1997}^{1999} \eta_t D_t D_{i,1996} + \sum_{t=1998}^{1999} \theta_t D_t D_{i,1997} + X'_{i,t}\beta) \quad (7)$$

In equation (7), ζ_t represents the effect of IBBEA on SBIR applications in FY t for the group of states that deregulated by FY 1995, η_t represents the effect of IBBEA on SBIR applications in FY t for the group of states that deregulated in FY 1996, and θ_t represents the effect of IBBEA on SBIR applications in FY t for the group of states that deregulated in FY 1997.

I model the policy variable using equation (7) instead of the standard policy indicator variable to be completely flexible for allowing time-varying effects of IBBEA by deregulation cohort.

[10] Tests for overdispersion consistently reject $H_0: \alpha = 0$. vs. $H_A: \alpha \neq 0$.

[11] Section 5 considers alternate timings of the policy variable that produce similar results.

There are at least three reasons to expect that IBBEA had different effects both over time and by deregulation cohort. One reason is that when states deregulated, it affected the banking industry in states that had already deregulated. For example, when states deregulated in 1995, banks could conduct interstate mergers but only between banks in the deregulated states. When the next wave of states deregulated in 1996, the banks in these states could merge with other banks in the newly deregulated states and also with banks in states that were already deregulated. Similarly, states that were already deregulated had a new influx of banks with which they could merge. Therefore, each new wave of deregulation affected the banking industry in both the newly deregulated states and the states that had already deregulated, which implies that IBBEA had time-varying effects and makes the standard indicator policy variable unsatisfactory.

A second reason to expect different effects of IBBEA by deregulation cohort is that later adopters of IBBEA had stronger small banking sectors than early adopters (Kroszner and Strahan, 1999). Therefore, for later adopters there was a potential for a greater amount of change post-IBBEA.

A third reason is a timing and learning story. Suppose that when the first wave of deregulation passed in 1995, banks were unfamiliar with the procedures needed to instigate the now-legal mergers. Therefore, some banks in the states that deregulated in 1995 may have delayed merging. However, by 1997, banks may have been familiar with these procedural hurdles and could execute mergers more quickly than when IBBEA was first passed. In this scenario, we can expect the effect of deregulation on market concentration to vary over time. I model IBBEA's time-varying effect as the flexible form in equation (7) to be completely agnostic on the mechanism behind changes in banking concentration.[12]

[12] An even more flexible policy variable would be able to take into account the degree of deregulation, as states had some latitude to restrict interstate branching (Johnson and Rice, 2008). However, there is not a clear way to parametrize the dimensions to which states were allowed to deregulate. As a robustness check, I create an alternate policy variable that takes into account the restrictions on interstate branching based on the indicator from Rice and Strahan (2010) with the same time-series form as equation (7). This alternate policy variable indicates that SBIR applications increased between 7 to 15 percent by FY 1999, calculated for the mean deregulator, but the estimates are less precise (significant at the 10 percent level to insignificant), which suggests that the dimensions by which states were allowed to restrict interstate branching might not be important factors in determining the effect of banking consolidation on SBIR applications.

3.3 Dependent Variable and Controls

The dependent variable is state-FY SBIR Phase I applications that come from a balanced panel from FY 1990 to FY 1999. SBIR programs at participating federal agencies are independently operated and funded. I aggregate SBIR applications from the five largest SBIR agencies to create the panel: the Departments of Defense, Energy, and Health and Human Services - National Institutes of Health; NASA; and the NSF. The SBIR programs for these five agencies compose more than 96 percent of the budget for SBIR in each FY (National Science Board, 2008). For NASA, the data are available on NASA's website (National Aviation and Space Administration, 2010). For the remaining agencies, I query the relevant SBIR officials to obtain the data sets.[13] Except for the applications from Hawaii in FY 1993 and North Dakota in FY 1994 to the Department of Defense, the data set contains data for all five agencies in each state and FY. The results are robust to excluding Hawaii and North Dakota.

The key identification assumption relating changes in SBIR applications caused by IBBEA to IBBEA's effect on small R&D firm finance is that SBIR applications and bank finance are substitutes (Wallsten, 2000). Therefore, if we observe an increase in SBIR applications, then the implication is that IBBEA decreased the supply of bank finance. In this situation, firms switched from bank finance to trying to receive an SBIR award, which increased SBIR applications. The opposite holds for a decrease in SBIR applications.

To identify the effect of IBBEA on SBIR application rates, I use a variety of additional covariates that control for other factors that can influence a state's SBIR applications. I use state fixed effects to remove time-invariant characteristics of states that could affect SBIR applications. I also include state-specific time trends and time dummies to control for the trend of SBIR applications prior to IBBEA.

I remove the effects of the business cycle on SBIR applications using gross state product from the BEA (BEA, 2011). R&D expenditures are correlated with the business cycle, which implies

[13] Specifically, I use the Freedom of Information Act (Department of Defense, 2010; Department of Energy, 2010; National Science Foundation, 2010a; National Institutes of Health, 2010).

that the financing patterns for R&D, including SBIR applications, should also be correlated with the business cycle regardless of the state of banking deregulation (Barlevy, 2007; Chang, 2013).

Changes in the number of SBIR applicants may be affected by changing demand for the funds for SBIR, as opposed to the supply-side effects this paper investigates. For example, if the number of small electronics firms in a state increases, then the number of SBIR applications to agencies that fund R&D projects in electronics should also increase. Because firms that receive SBIR awards are primarily from the North American Industry Classification System (NAICS) industry R&D in the Physical Sciences (NAICS 541710), to control for the universe of potential applicants I add the number of employees and the total establishment count of firms in R&D in the Physical Sciences into the regressions.[14,15] Total employee counts by state, six-digit NAICS industry, and FY come from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) (BLS, 2011). I also estimate specifications with total employment and establishment counts in the top-10 six-digit NAICS codes that give similar results.[16]

The propensity for a firm to seek funding may also be a function of other state-specific factors. For example, if a state adopts policies that are more friendly to innovative activities, then it could alter the SBIR application rate for that state. Alternatively, through the fertile technology hypothesis, if a large amount of innovation occurs in a particular state, then it can create additional

[14]To determine the industry composition of SBIR-award-winning firms, I use data on SBIR award winners from the SBA's TECH-Net database (SBA, 2010). The database records details on SBIR awards: characteristics of winning firms, the abstracts of the SBIR proposals, amount of the award, etc. I take a random sample of 1000 SBIR awards from FY 1990 to FY 2000, divided evenly over each of the five largest SBIR agencies by budget, and use TECH-Net's information to assign each award-winning firm to either one or two NAICS codes. I match the sampled firms from TECH-Net to publicly available databases that contain information on firms and their product lines (Dun and Bradstreet, 2010; Federal Government Bid Intelligence Company, 2011; Gale Group, 2010) as well as crosscheck the information from these databases against available public reports, company websites, published articles, and patent applications to accurately assign the SBIR awardees to NAICS codes.

[15]For this control to be valid, the industry distribution of the SBIR-award-winning firms needs to be similar to the industry distribution of all SBIR applicants. Although there are no data available to analyze this relationship directly, the most common industry classification for all SBIR applicants is likely R&D in the Physical Sciences (NAICS 541710). SBIR agencies typically solicit proposals for technologies to fulfill a specific agency research requirement, and there is no reason to suspect applicants from outside R&D-intensive industries would apply for SBIR awards.

[16]The other top NAICS codes are: 325414 (biological product, excluding diagnostic, manufacturing), 334413 (semiconductor and related device manufacturing), 334511 (search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing), 339112 (surgical and medical instrument manufacturing), 541330 (engineering services), 541380 (testing laboratories), 541511 (custom computer programming services), 541512 (computer system design services), and 541690 (other scientific and technical consulting services).

opportunities for innovative activities, which would alter the SBIR application rate through a channel other than IBBEA (Kortum and Lerner, 1998). I add three controls to the model to proxy for the innovative climate in a state.

First, I add total state academic R&D expenditures. Academic R&D expenditures should be correlated with the degree of innovative atmosphere in a state, particularly where basic research is concerned. Data on academic R&D expenditures come from the NSF's WebCASPAR database National Science Foundation (2010b). Second, I use Wilson (2009)'s estimate of the state-level cost of R&D capital, which is a function of a state's corporate tax and R&D tax policies. A change in the cost of R&D should induce firms to change their R&D project portfolio and therefore affect their demand for R&D financing.[17] Third, I use utility patent applications, conditional on eventual patent approval.[18] Although noisy, patent counts offer one measurement of the amount of inventive activity in a state. Data on utility patents come from the National Bureau of Economic Research (NBER) patent database, documented in Hall, Jaffe, and Trajtenberg (2001) and available from NBER (2011).

Firms may also decide to apply for SBIR as a function of agency-specific investment in the state. For example, suppose the Department of Defense increases its R&D funding in Alabama. Firms in Alabama would then begin to acquire knowledge of and familiarity with the Department of Defense's technological and R&D demands. This familiarity could induce firms in the state to apply for SBIR awards, as they would have garnered additional information on the department or have revised estimates of the expected value of an SBIR award. To control for agency-specific investment, I add total R&D obligations for U.S. performers by the five SBIR agencies into the model. Data on R&D obligations come from the NSF's WebCASPAR database (**?**).

[17] Other examples of research into R&D tax incentives include Chang (2014) and Guceri and Liu (2015).

[18] To determine which types of patents to include in this measure, I sample the largest SBIR agency's (Department of Defense) award winners from the SBA Tech-Net Database. I present results where the patent count control variable includes total patent applications for the following two-digit Hall, Jaffe, and Trajtenberg (2001) technology categories: gas (13), communications (21), computer hardware and software (22), computer peripherals (23), information storage (24), electrical devices (41), electrical lighting (42), measuring and testing (43), nuclear and x-rays (44), power systems (45), semiconductor devices (46), miscellaneous electronics (49), materials processing and handling (51), metalworking (52), motors (53), optics (54), transportation (55), miscellaneous mechanical (59), and heating (66). I also check the results using all patent applications, and the results are nearly identical.

Table 3 displays summary statistics of the dependent variable and controls.[19]

4 Results

Table 4 presents the estimated average marginal effects from the baseline model.[20] Column (1) presents a parsimonious specification with only aggregate time dummies, state time trends, and state fixed effects. The marginal effects reported indicate the average change in SBIR applications by cohort for each FY subsequent to deregulation relative to the pre-IBBEA period. Column (2) presents the same specification as column (1) in percent changes. For example, in the first row of results, for the states that deregulated by FY 1995, column (1) estimates deregulation to have an average effect of increasing SBIR applications by 35.8 per state in the FY immediately after deregulation. From the same row in column (2), this average marginal effect translates to a 6.71 percent increase over the pre-IBBEA period. Adding additional state controls in column (3) yields similar effects for all IBBEA cohorts. Column (4) displays the results of column (3) in percent terms.[21]

From Table 4, for almost all treatment periods, the model indicates that IBBEA increased SBIR applications. Under the assumption of constant substitutability between bank finance and SBIR awards, this increase in applications implies IBBEA decreased the supply of bank finance for small R&D firms. In addition, for all cohorts this decrease in finance is exacerbated over time. For the FY 1995 cohort, immediately after deregulation (FY 1996) there is a small effect (6.71 percent) of IBBEA on SBIR applications. However, the estimates for four years after deregulation (FY 1999) indicate a 25.2 percent increase in SBIR applications. A similar upward trend in applications holds for the FY 1996 and FY 1997 cohorts, implying a downward trend in the

[19] I also experiment with specifications that include the state-level unemployment rate and the state-level unemployment rate interacted with the fed funds rate, which is a covariate that could capture heterogeneous effects of monetary policy on SBIR applications. These specifications give similar results, and I omit them for brevity.

[20] For state i's regressor j, $x_{i,j}$, the average marginal effect is $\frac{1}{N}\sum_{i=1}^{N}\frac{dy_i}{dx_{i,j}}$, where N is the total number of states.

[21] Removing the time effects generates estimates close to zero for all cohort years. The time dummies and state time trends account for the pre-IBBEA trend in SBIR applications.

supply of finance.[22] For the FY 1995 and FY 1996 cohorts, the effect of IBBEA on SBIR applications is statistically significant at the 5 percent level in 1999; for the FY 1997 cohort the effect is significant in 1998. Late adopters of IBBEA had stronger small banking sectors, more possible targets for interstate bank mergers, and the potential to have a larger change in banking structure subsequent to deregulation (Kroszner and Strahan, 1999). One possible explanation for the upward trend in SBIR applications is the successive waves of consolidation caused by IBBEA, which caused steadily increasing market concentration.

Of the control variables in Table 4, patent counts and agency R&D obligations are individually significant, and the joint F-test of all control variables indicates the controls are jointly significant. In unreported specifications that include additional lags of the control variables or differences of the controls, the effect of IBBEA on SBIR applications is similar to the baseline.[23]

The tendency for SBIR applications to rise from FY 1997 to FY 1999 corresponds with the large increase in market concentration of the commercial banking sector, suggesting the increased concentration of the banking industry decreased small firm finance for R&D. The estimation is consistent with the hypothesis that the relationship lending channel of small banks is more important than the geographic diversification potential of large banks for small R&D firm financing.[24]

5 Robustness Checks

In this section, I present additional robustness checks on the main results from section 4.

[22]Weighting states by gross state product still shows an upward trend in applications for all cohorts. The weighted estimates are similar to the unweighted estimates for the FY 1995 and FY 1996 cohorts. For the FY 1997 cohort, the weighted estimates are about half of the unweighted estimates. For all cohorts, the coefficients for IBBEA are statistically significant at standard levels.

[23]To check for stationarity of covariates, I run the Harris and Tzavalis (1999) small-T adjusted panel unit root test. The test indicates that academic R&D, the user cost of R&D, patent count, gross state product, and the establishment count are non-stationary. To address the potential effect of non-stationary covariates on my results, I conduct two exercises: (1) I reestimate the model with only the stationary covariates from the baseline specification, and (2) I first-difference the non-stationary covariates and reestimate the model with these differenced covariates (the Harris and Tzavalis (1999) test indicates that all of the first-differenced covariates are stationary). In both of these specifications, the estimates of the effect of IBBEA on SBIR applications are similar to the baseline, with IBBEA increasing SBIR applications by 22 to 36 percent, depending on the deregulation cohort.

[24]Evidence on the causes and consequences of relationship lending is mixed. See, for example, Elsas (2005), Presbitero and Zazzaro (2011), and Mudd (2013).

5.1 Policy Variable Timing

The first robustness check I consider is the timing of the policy variable. The policy variable in section 4 models IBBEA as taking effect the year after deregulation. However, banks could potentially respond to deregulation either faster or slower than with a one year lag. Therefore, I adjust the timing of the policy variable to start either in the year IBBEA was passed or two years after, as opposed to one year after.

Table 5 shows the results for changing the timing of the policy variable. Columns (1) and (2) show the results of modeling IBBEA as having an effect the year it was passed. Columns (3) and (4) model IBBEA's effect as two years after it was passed. Columns (1) and (3) report the average marginal effect in levels, and columns (2) and (4) report the effects of columns (1) and (3) in percents.[25]

The treatment patterns when shifting the timing of the policy variable in Table 5 are similar to the baseline model in Table 4. From columns (1) and (2) of Table 5, modeling the treatment as having an effect the year IBBEA was passed still suggests that IBBEA increased SBIR applications and therefore decreased the supply of finance for small R&D firms. As with the baseline model, there is an upward trend in SBIR applications. From column (2) of Table 5, for the FY 1995 deregulation cohort there is a mere 2.95 percent increase in SBIR applications in FY 1995, but this number grows monotonically to 41.5 percent by FY 1999. The same upward patterns of SBIR applications hold for the other two deregulation cohorts.

Changing the treatment to have an effect two years after deregulation (columns 3 and 4) attenuates the estimated increases in SBIR applications, but the point estimates are generally still positive and increase with time as in the previous specifications. In FY 1999, relative to the baseline (Table 4, column 4), the estimated increase in SBIR applications due to IBBEA disappears for the FY 1995 cohort, changes from a 30.5 percent increase to a 17.4 percent increase for the FY 1996 cohort, and changes from a 37.7 percent increase to a 23.1 percent increase for the FY 1997

[25] Table 5 does not report the control variables to save space, but the signs and magnitudes of the control variables are similar to the baseline in Table 4. The F-test for significance of all controls is significant for at least the 5 percent level.

cohort.

5.2 Specific States

An additional concern is whether certain states drive the results in Table 4. Specifically, I consider North Dakota (ND), Montana (MT), and Texas (TX) by individually excluding each of these states from the estimation. Table 6 shows the results. Column (1) presents the baseline results (Table 4, column 4) for comparison.

The Bank of North Dakota anchors North Dakota's banking system as the only state-owned bank in the United States. State law tasks the bank with "promot[ing] agriculture, commerce, and industry in North Dakota" (Bank of North Dakota, 2011). Because of the presence of a state-owned bank, the effect of IBBEA on North Dakota could have been different from the average effect across states. Therefore, I re-estimate Table 4 without North Dakota, which yields similar results as shown in Table 6, column (2).

Next, I turn my attention to the control group, which varies over time. For example, in FY 1995, identification of the effect of IBBEA uses states that deregulated later than FY 1995 as a control group. In FY 1996, the model identifies the effect of IBBEA on deregulators in FY 1995 and FY 1996 using the control group of all states that deregulated later than FY 1996. Finally, identifying the effect of IBBEA in FY 1997 to FY 1999 for deregulators from FY 1995 to FY 1997 uses the two states that opted out of IBBEA, Montana and Texas, as a control group. Identification of the parameters in all regressions requires the control group to be unaffected by region-specific shocks. Because Montana and Texas are in the control group for the entire time period, and the model identifies the effect of IBBEA from FY 1997 to FY 1999 using these two states as a control group, I check to see whether a state-specific shock to either Montana or Texas drives the results.

To do so, I individually exclude Montana and Texas from the estimation. If, for example, Montana experienced a shock to SBIR applications but Texas did not, then the estimates using just Montana as a control group should be different than when using just Texas as a control group and both estimates should be different than when using both states as a control group, as in Table 4.

Similarly, I can rule out a state-specific shock driving the results when the estimates using either Montana or Texas or both Montana and Texas are all similar.

When sequentially excluding the control states, the results are similar to using both control states. IBBEA continues to increase SBIR applications and decrease the supply of finance for small R&D firms. Using just Texas as a control state in column (4) generates larger estimates of this effect than either using both Montana and Texas or just Montana, but all of the qualitative results from the baseline model continue to hold.

6 Conclusion

The deregulation of interstate bank branching and relaxed restrictions on interstate bank mergers by IBBEA increased market concentration in the U.S. banking industry. This paper uses a balanced panel to investigate how the increase in market concentration by IBBEA affected the supply of finance for small R&D firms. The applicants to SBIR are small R&D firms, both private and public.

Economic theory gives an ambiguous prediction of the effect of banking consolidation on small firm financing. Large banks benefit from geographic diversification. Because large banks are involved in multiple, geographically distinct product markets, they are able to distribute risk over different regions and shield themselves against adverse regional capital or business shocks (Peek and Rosengren, 1996). The diversification potential of large banks gives them an advantage over small banks when offering financing terms for small R&D firms.

However, when trying to obtain a source of finance, the firm will generally have superior information about the value of the firm relative to a prospective financier. This information disparity is particularly true of small R&D firms, which have little collateral or other hard information to signal their worth to financiers. Small banks, by forming long-term relationships with and collecting soft information on clients (for example, a firm owner's work ethic), can reduce informational asymmetries and therefore offer superior financing terms to large banks, which rely on transaction lending (for example, credit histories) to make investment decisions (Petersen and Rajan, 1994; Stein, 2002).

I find that IBBEA decreased the supply of finance for small R&D firms. This result implies that the relationship lending channel of small banks, in which small banks develop long-term relationships with potential clients to overcome information asymmetries associated with finance, might be more important than the geographic diversity advantage of large banks for small R&D firm finance (Petersen and Rajan, 1994; Peek and Rosengren, 1996).

Government support for R&D is justified by the presence of market failures for R&D. These market failures stem from at least two characteristics of R&D: (1) the social return to R&D is higher than the private return to R&D, as innovators are unable to capture profits from the positive spillovers associated with their inventions (Griliches, 1992; Samuelson, 1954), and (2) asymmetric information between firms and potential financiers complicates the financing of R&D and gives rise to market failures due to moral hazard and adverse selection problems (Arrow, 1962). This paper suggests banking consolidation worsened these market failures.

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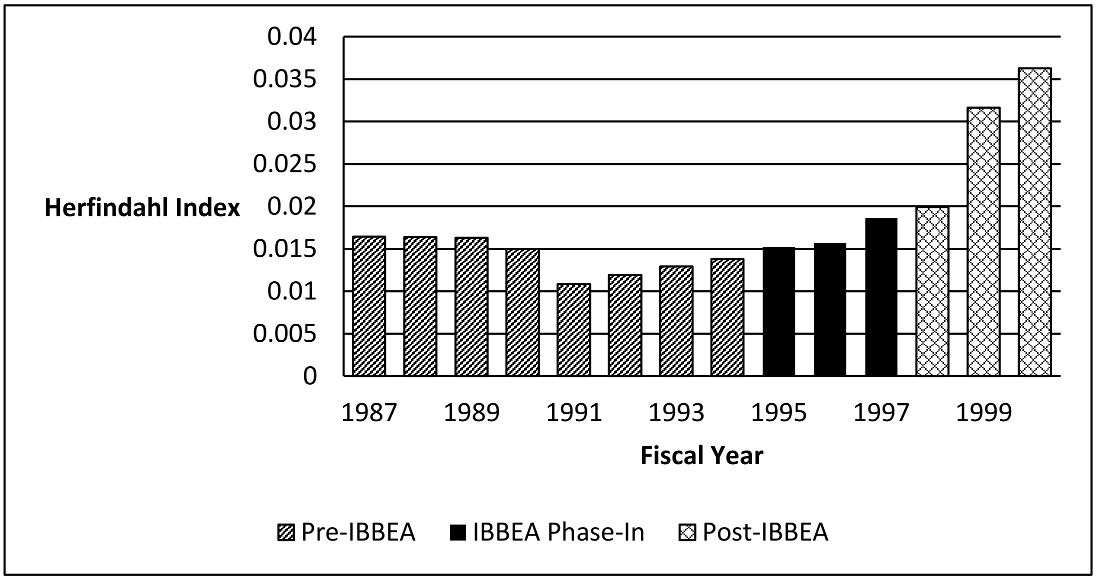
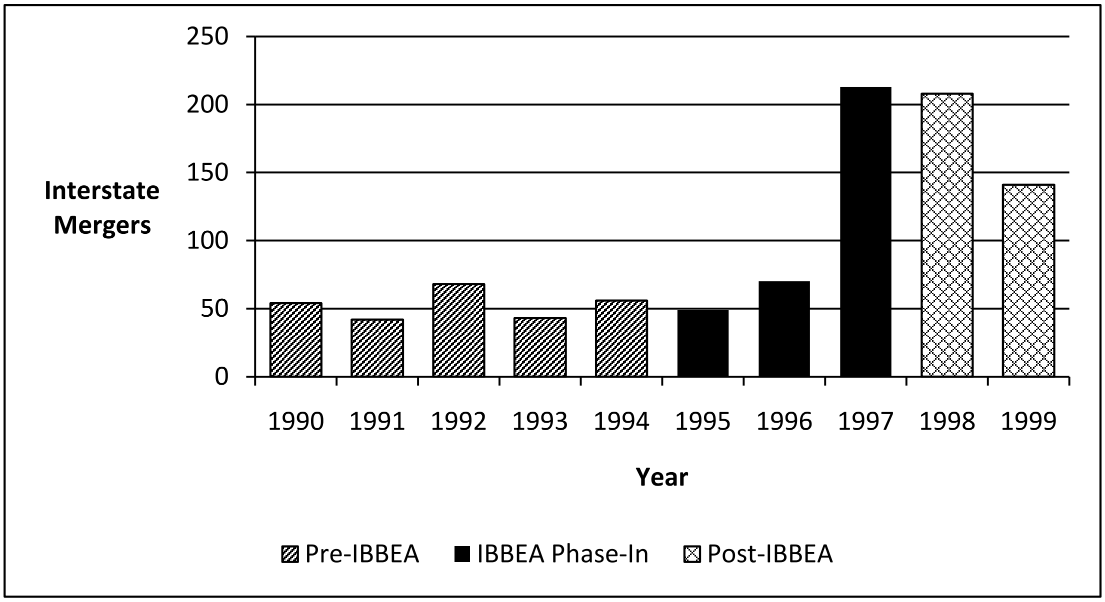
Figure 1: Herfindahl Index For U.S. Bank Holding Companies By Total Assets: FY 1987–2000



This figure measures market concentration using data from the first quarter of each FY. Source: Call Reports, (Kashyap and Stein, 1995, 2000; Den Haan, Sumner, and Yamashiro, 2002; Federal Reserve Bank of Chicago, 2011).

Figure 2: Interstate Bank Mergers: 1990–1999



Source: Vera and Onji (2010).

Table 1: Initial IBBEA Opt-In Dates

State	Date	State (Continued)	Date (Continued)
Alabama	5/31/1997	Montana	10/1/2001
Alaska	1/1/1994	Nebraska	5/31/1997
Arizona	9/1/1996	Nevada	9/29/1995
Arkansas	6/1/1997	New Hampshire	6/1/1997
California	9/28/1995	New Jersey	4/17/1996
Colorado	6/1/1997	New Mexico	6/1/1996
Connecticut	6/27/1995	New York	6/1/1997
Delaware	9/29/1995	North Carolina	7/1/1995
District of Columbia	6/13/1996	North Dakota	5/31/1997
Florida	6/1/1997	Ohio	5/21/1997
Georgia	6/1/1997	Oklahoma	5/31/1997
Hawaii	6/1/1997	Oregon	2/27/1995
Idaho	9/29/1995	Pennsylvania	7/6/1995
Illinois	6/1/1997	Rhode Island	6/20/1995
Indiana	6/1/1997	South Carolina	7/1/1996
Iowa	4/4/1996	South Dakota	3/9/1996
Kansas	9/29/1995	Tennessee	6/1/1997
Kentucky	6/1/1997	Texas	9/1/1999
Louisiana	6/1/1997	Utah	6/1/1995
Maine	1/1/1997	Vermont	5/30/1996
Maryland	9/29/1995	Virginia	9/29/1995
Massachusetts	8/2/1996	Washington	6/6/1996
Michigan	11/29/1995	West Virginia	5/31/1997
Minnesota	6/1/1997	Wisconsin	5/1/1996
Mississippi	6/1/1997	Wyoming	5/31/1997
Missouri	9/29/1995		

Source: Johnson and Rice (2008).

Table 2: Means and Standard Deviations for Characteristics of Small R&D Firms

	Small R&D Firms (1)	Small R&D Firms that Applied for Venture Capital (2)
Total employment in 1992	12.10	24.23
	(33.29)	(40.61)
Wage expenses in 1992	233,839	805,622
	(1,381,430)	(1,814,489)
Sales in 1992	1,635,006	2,675,071
	(6,673,610)	(6,419,629)
Percentage applied for loan from 1993 to 1994	38.9	67.1
Size of most recent approved loan in 1993–1994	504,388	4,040,527
	(3,060,744)	(6,447,936)

Means with standard deviations in parentheses. Total employment indicates FTE employment. Loan size calculated for firms that were granted loans and includes all loans applied for from 1993 to 1994. Dollar amounts inflated to 2005 dollars using the BEA's implicit price deflator (BEA, 2011). Sample size is 1191 for R&D firms and 31 for R&D firms that also applied for venture capital. Source: 1993 National Survey of Small Business Finances (Board of Governors of the Federal Reserve System, 1993).

Table 3: Descriptive Statistics of Controls and SBIR Count

Academic R&D expenditures	492.7
(Tens of millions)	(599.7)
User cost of R&D	1.21
	(0.06)
Patent count	0.74
(Thousands)	(1.60)
Agency R&D obligations	303.2
(Tens of Millions)	(976.4)
R&D employees	7.61
(Thousands)	(12.0)
Gross state product	168.9
(Billions)	(2.01)
R&D establishment count	216.5
	(346.4)
SBIR application count	354.6
	(650.1)

Means with standard deviations in parentheses. R&D employees and R&D establishment count are NAICS industry 541710 from the QCEW. The user cost is the implicit rental rate of R&D capital from Wilson (2009). Dollar figures in 2005 dollars deflated with the BEA's implicit price deflator. Sources: Wilson (2009), **?**, BEA (2011), and NBER (2011).

Table 4: Baseline Regressions

Deregulation Cohort	Years Since Deregulation	Units: Raw Count (1)	Percent (2)	Raw Count (3)	Percent (4)
FY 1995	1 year	35.8	6.71	36.6	6.68
		(32.2)	(6.04)	(33.6)	(6.30)
	2 years	6.92	1.29	8.56	1.60
		(45.5)	(8.51)	(47.9)	(8.98)
	3 years	98.2	18.3	102.1	19.1
		(76.1)	(14.2)	(76.4)	(14.3)
	4 years	135.2	25.2	142.3	26.6
		(65.2)**	(12.2)**	(63.5)**	(11.9)**
FY 1996	1 year	-1.25	-0.32	0.60	0.15
		(22.3)	(5.74)	(21.5)	(5.53)
	2 years	70.3	18.1	78.2	20.1
		(50.0)	(12.8)	(48.1)*	(12.3)*
	3 years	106.2	27.3	118.6	30.5
		(42.1)**	(10.8)**	(40.4)***	(10.4)***
FY 1997	1 year	52.6	25.3	55.4	26.6
		(23.1)**	(11.1)**	(22.1)***	(10.5)***
	2 years	75.1	36.0	78.6	37.7
		(22.1)***	(10.6)***	(20.8)***	(10.0)***
Academic R&D expenditures				0.03	0.01
				(0.10)	(0.02)
User cost of R&D				66.7	18.7
				(166.1)	(46.7)
Patent count				-20.9	-5.88
				(10.7)**	(3.03)**
Agency R&D obligations				-0.004	-0.001
				(0.003)*	(0.0008)*
R&D employees				-0.12	-0.03
				(1.80)	(0.50)
Gross state product				0.63	0.17
				(0.43)	(0.12)
R&D establishment count				-0.10	-0.02
				(0.13)	(0.04)
F-test for all controls (p-value)				0.02**	
State FE		Yes	Yes	Yes	Yes
Time effects		Yes	Yes	Yes	Yes

Average marginal effects reported. Columns (1) and (3) report the effect in levels ($\frac{dy}{dx}$), and columns (2) and (4) report the effects of columns (1) and (3) as semielasticities converted to percents ($\frac{dy/y}{dx} \times 100\%$). Gross state product is in real 2005 billions, all other dollar figures are in real tens of 2005 millions, patent count and employee count are in thousands. Number of observations is 510. Standard errors clustered by state in parentheses. *, **, ***: significant at the 10%, 5%, 1% level, respectively.

Table 5: Alternate Timing of Policy Variable

		Units			
Deregulation Cohort	Years Since Deregulation	Raw Count (1)	Percent (2)	Raw Count (3)	Percent (4)
FY 1995	0 years	15.7	2.95		
		(42.3)	(7.93)		
	1 year	57.9	10.8		
		(50.5)	(9.47)		
	2 years	105.1	19.6	-15.3	-2.87
		(76.4)	(14.3)	(31.0)	(5.81)
	3 years	175.4	32.8	-47.5	-8.89
		(116.6)	(21.8)	(45.5)	(8.85)
	4 years	221.9	41.5	39.0	7.29
		(107.0)**	(20.1)**	(45.5)	(8.85)
FY 1996	0 years	20.7	5.33		
		(23.1)	(5.96)		
	1 year	69.5	17.9		
		(44.8)	(11.5)		
	2 years	128.7	33.1	-12.1	-3.11
		(75.1)*	(19.3)*	(20.3)	(6.07)
	3 years	173.7	44.6	67.6	17.4
		(67.7)***	(17.4)***	(23.6)***	(6.07)***
FY 1997	0 years	34.7	16.6		
		(17.7)**	(8.53)**		
	1 year	77.1	36.9		
		(33.0)**	(15.8)**		
	2 years	101.8	48.8	48.3	23.1
		(30.9)***	(14.8)***	(11.2)***	(5.41)***

Average marginal effects reported. Columns (1) and (3) report the effect in levels ($\frac{dy}{dx}$). Columns (2) and (4) report the effects of columns (1) and (3) as semielasticities converted to percents ($\frac{dy/y}{dx} \times 100\%$). Number of observations is 510. All regressions include control variables from Table 4, aggregate time dummies, state time trends, and state time-invariant effects. Standard errors clustered by state in parentheses. *, **, ***: significant at the 10%, 5%, 1% level, respectively.

Table 6: Specific State Robustness

Deregulation Cohort	Years Since Deregulation	(1)	(2)	(3)	(4)
FY 1995	1 year	6.68	7.88	6.75	6.75
		(6.30)	(6.17)	(6.34)	(6.33)
	2 years	1.60	2.98	0.56	1.25
		(8.98)	(8.79)	(9.05)	(9.12)
	3 years	19.1	20.3	16.2	34.6
		(14.3)	(14.3)	(15.5)	(13.5)***
	4 years	26.6	28.1	26.2	39.3
		(11.9)**	(11.9)***	(12.9)**	(18.1)**
FY 1996	1 year	0.15	0.90	-0.78	0.06
		(5.53)	(5.58)	(5.47)	(5.66)
	2 years	20.1	20.5	17.3	36.5
		(12.3)*	(12.4)*	(13.8)	(11.4)***
	3 years	30.5	30.9	30.2	43.6
		(10.4)***	(10.4)***	(11.9)***	(18.0)**
FY 1997	1 year	26.6	27.1	24.1	42.9
		(10.5)***	(10.6)***	(12.3)**	(9.74)***
	2 years	37.7	38.1	38.0	50.9
		(10.0)***	(10.1)***	(11.7)***	(17.8)***
Academic R&D expenditures		0.01	0.01	0.01	0.01
		(0.02)	(0.02)	(0.02)	(0.03)
User cost of R&D		18.7	20.7	19.0	15.5
		(46.7)	(45.7)	(47.7)	(46.7)
Patent count		-5.88	-5.63	-6.09	-5.71
		(3.03)**	(3.01)*	(3.06)**	(3.49)*
Agency R&D obligations		-0.001	-0.001	-0.001	-0.001
		(0.0008)*	(0.0008)*	(0.0008)	(0.0008)*
R&D employees		-0.03	-0.06	-0.002	0.06
		(0.50)	(0.50)	(0.50)	(0.56)
Gross state product		0.17	0.19	0.16	0.15
		(0.12)	(0.12)	(0.12)	(0.14)
R&D establishment count		-0.02	-0.03	-0.03	-0.02
		(0.04)	(0.03)	(0.03)	(0.04)
F-test for all controls		0.02**	0.02**	0.03**	0.02**
(p-value)					
No. obs.		510	500	500	500
Excluded state			ND	MT	TX

Average marginal effects reported as semielasticities converted to percents ($\frac{dy/y}{dx} \times 100\%$). All regressions include aggregate time dummies, state time trends, and state time-invariant effects. Gross state product is in real 2005 billions, all other dollar figures are in real tens of 2005 millions, patent count and employee count are in thousands. For excluded states, "ND" = North Dakota, "MT" = Montana, and "TX" = Texas. Standard errors clustered by state in parentheses. *, **, ***: significant at the 10%, 5%, 1% level, respectively.