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State Research and Development Tax Credits: The Historical Emergence of a Distinctive Economic Policy Instrument

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Abstract

By 2010, all but 12 U.S. states had adopted some form of research and development tax credits. The forces driving the rapid rise and spread of this policy remain unclear. This event history analysis finds adoption to be associated with higher state unemployment levels, supporting the notion of "policy-making from disadvantage." Yet higher patenting activity is also associated with adoption, suggesting that having a strong preexisting research and development (R&D) infrastructure facilitates adoption. In the 1980s, having a Republican governor apparently propelled adoption, but partisan influences disappeared in later years. Having a governorship with constitutionally strong budgetary power and having a centralized governing board for higher education are associated with adoption, and interaction analyses indicate that the combination of a centralized board and a higher number of research universities are especially positive forces in adoption. The socioeconomic, political, and structural influences found in this article suggest several potentially fruitful directions for future analyses.

Keywords

research and development, higher education, state/industry relations, economic development

State governments have directed spending toward science and technology research for decades, but since the 1980s, there has been increasing attention to leveraging university research resources to benefit states' economic development. Instead of the traditional pursuit of heavy industry from other states and nations, these efforts envision stimulating homegrown innovation and entrepreneurship in the sciences and technology (Eisinger, 1988; Plosila, 2004). Under these "new economy" initiatives, states have funded the establishment of discovery-oriented, tax-exempt organizations, provided venture-capital funds, supported business incubators, created university–industry partnerships, invested in new research parks, provided resources for pursuing eminent researchers in various academic fields, and instituted tax credits for corporate research and development (R&D) activity.[1] Of all of these reforms, state programs to support R&D activity may have the most directly visible impacts. Less clear, however, are the specific socioeconomic, political, and structural conditions that drive state-level adoptions of these policies—leaving knowledge gaps for economic developers, policy makers, and researchers and analysts.

States have often been called "laboratories of democracy," because they are freer than the federal government to create and experiment with policies to meet their distinct needs and goals.[2] Yet state-level efforts in R&D may instead reflect national origins, stemming from federal initiatives in the 1980s (Feller, 1992). In 1981, the Reagan administration authorized an R&D tax credit policy to counteract the doldrums that the national economy was in, a move to employ creatively the U.S. tax system to stimulate innovation (Berman, 1991; Cordes, 1989). Under the policy, private firms that exceeded spending thresholds for scientist and engineer wages, manufacturing equipment and processes, and new knowledge creation became eligible for tax rebates (Bozeman & Link, 1984). Subsequently, journalists (e.g., Fink, 2011; Monies, 2006; Passell, 1998) and some analysts (e.g., Bloom, Griffith, & Van Reenen, 2002; Hall & Van Reneen, 1999) have observed that federal R&D tax credits can stimulate additional R&D activity. Evidence is not conclusive, but such policies may incentivize socially optimal levels of innovative efforts.[3]

Many states, faced with "new economy" and international competitive pressures analogous to those facing the federal government, have adopted their own R&D tax credit programs (Miller & Richard, 2010). In 1982, Minnesota became the first state to adopt such a policy. By 2006, 32 states joined the movement by adopting similar policies (Wilson, 2009),

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and more currently appear to be on the way (Bohrer, 2012). Interestingly, not only have more states introduced R&D tax credits over time but also "the average generosity of these credits . . . has grown" (Wilson, 2005, p. 2),[4] and recent years have brought heightened policy commitments in this arena (State Science and Technology Institute, 2013).

Not surprisingly, state-level R&D programs differ widely in their specifics. Wilson (2005) has observed that states have moved toward incremental, nonincremental, and hybrid systems: Incremental policies impose threshold conditions before granting tax credits, whereas nonincremental policies provide credits without such conditions. Unanimously, states have targeted university–industry collaboration (Plosila, 2004), drawing on evidence suggesting that public–private partnerships, often including firms, governments, and universities, can facilitate knowledge exchange and innovation (Acs, Audretsch, & Feldman, 1994; Brett, Gibson, & Smilor, 1991; Feldman & Francis, 2004; Feller, 2004; Geiger, 2004; Luger & Goldstein, 1991; Youtie & Shapira, 2008).

Empirical attention has been given to the efficacy of state R&D tax policy (see Wilson, 2009; Wu, 2008), but strikingly, comparative state-level analyses of policy adoption are sparse. We lack systematic understanding of the factors driving states to adopt this distinctive economic policy instrument. Historical analysis in this arena may not only illuminate those factors and how they vary over time, but also suggest to practitioners and researchers antecedents of ongoing policy reform and innovation. To address this topic, we turn first to the literature on R&D policy formulation, implementation, and assessment. In addition, we draw on literature to discuss the increasing role of higher education in state R&D efforts, an angle not often considered in prior studies of state R&D tax credit policies.

Review of Literature

Since their launch in the 1980s, federal R&D tax credit policies have been heavily scrutinized. Market-driven thinking, political ideology, budget considerations, and special-interest groups influence many national initiatives in technology and R&D (Berman, 1991), but certain aspects of R&D policy are less straightforward. As Bozeman and Link (1984) have noted, tax credits tend to target applied rather than basic research, which could curtail rather than expand knowledge discovery and innovation. Moreover, federal policy's incremental rebate structure tends to favor large firms that have resources and infrastructure rather than the small businesses that play major roles in job growth and homegrown economic development. Also, partisan politics may have a somewhat more divisive role in R&D tax credit policy than in other R&D arenas: Tax credit initiatives are "typically the 'favored child' of conservative politicians and their business constituencies" (Bozeman & Link, 1984, p. 26), prompting Democratic opposition.

Beyond the origin and nature of federal tax credit policies, there have been numerous analyses of their effects. Such policies aim to reduce knowledge-creation costs by providing rebates for R&D expenditures exceeding certain amounts (Cordes, 1989), but from the beginning critics have expressed doubts over claims that such policies truly fuel substantial additional R&D activity. Journalists have noted that the approach incurs short-term losses that can exacerbate the deficit in the pursuit of longer-term returns that may well be ephemeral (e.g., Calmes, 2010; Harwood, 2010), although researchers have expressed concern that the types of data and designs used by analysts may lead to overestimates of the magnitude of effects (Cordes, 1989). For example, Goolsbee (1998) has suggested that designs often fail to account accurately for the relationship between government-subsidized scientist and engineer wages, on one hand, and R&D activity estimates, on the other, arguably leading to overestimating policy impacts by as much as 30% to 50%.

Regardless of these debates, all but 12 states have adopted some form of R&D tax credits since 1981, often paralleling the federal approach (Wilson, 2005). Just as President Reagan championed such policies, state governors have often led R&D tax credit initiatives (Berman, 1991; Eisinger, 1988; Hart, 2008), and Republican control and ideology at the state level appears to play a role (Bozeman & Link, 1984). Might certain internal factors or competition with neighboring states be primary goads to action? Unfortunately, the circumstances under which political leaders might push for state R&D tax credit policies have yet to receive close analytic consideration. In fact, evidence on both the origins and the effects of these state policies is scant. Doubts over the supporting evidence for tax credits and other state ventures into research support have been sufficient to lead some major analysts to outright rejection of this approach. Economist Irwin Feller (1992, p. 288) has noted that state-level outcomes from such efforts are largely uncertain, and he has characterized collaborative economic development initiatives among states, industry, and universities as "unproven undertakings" and "analytically confounding and programmatically undesirable."

Extant research does provide some intriguing hints to the contrary, however. Comparative international findings, for example, suggest a noteworthy aggregate national return on R&D tax credits. In one such study, a $1 increase in tax credits for R&D was associated with a $1 marginal increase in R&D investments (Hall & Van Reneen, 1999). In another, a 10% drop in the cost of R&D was found to stimulate "just over a 1% rise in the level of R&D in the short-run and just under a 10% rise in R&D in the long-run" (Bloom et al., 2002, p. 1). Quantitatively accounting for specific influence processes in these aggregate analyses can be difficult, but the increased integration of public assets, including research university facilities and resources, with private investments may contribute to favorable returns, by reducing the costs and risks of innovation.

Further hints come from Wilson's (2009) analysis of state-level data from 1981 to 2004: The findings suggest that states that increase R&D activity do so at the expense of their neighbors. Similarly, in the high-technology arena, Wu (2008) found that state R&D tax credits prompted sector growth and motivated firms to originate in or move to states with these "pro-technology" tax incentives (p. 147). Taken together, the Wilson and Wu studies offer evidence of policy efficacy.

Those two studies also suggest state-to-state competition may be a driver of R&D tax credit policy diffusion and adoption. Interestingly, other studies have not found such effects. Miller and Richard's (2010) event history analysis of state adoption of R&D tax credits found no evidence of geographical diffusion effects. Instead, three within-state factors appeared most central to adoption: (a) unemployment rates (and thus the need for job creation), (b) an already established manufacturing base and infrastructure, and (c) single-party legislative control. Curiously, beyond party control, Miller and Richard did not explore the influence of other political contexts that some have closely linked to R&D tax credits (see Berman, 1991; Bozeman & Link, 1984).

Universities' roles in economic development, by way of R&D activities have also been overlooked in many prior empirical analyses. Feller (2004) argued that higher education can influence economic development not only by providing human and intellectual capital but also by prompting "virtuous cycles" of regional economic growth (p. 139; see also Geiger & Sá, 2005). Through the academic research enterprise, universities can create, process, and disseminate knowledge (Geiger, 2004). Indeed, they can shift their missions, structures, and procedures to accommodate—and even initiate engagement with—states and industry (Gibbons et al., 1994; Slaughter & Rhoades, 2004; Youtie & Shapira, 2008). As a consequence, these institutions have long been targets of government and corporate investments in R&D activity (Feller, Ailes, & Roessner, 2002), contributors to military and defense breakthroughs (Mumper, Gladieux, King, & Corrigan, 2011), and actors in geographic cluster formation (Feldman & Francis, 2004). "Spillovers" of academic research to industry appear to benefit small and large firms, by increasing corporate patenting activity and innovative output (Acs, Audretsch, & Feldman, 1992; Acs et al., 1994; Jaffe, 1989). Universities' participation in and leadership of research parks, incubators, and other public–private facilities and entities may also help increase regional innovative capacity (Luger & Goldstein, 1991) and sustain the "technopolis" (Gibson & Smilor, 1991) of university, state, and industry collaborations. Overall, these observations and findings suggest how states have utilized—and leveraged through policy—research universities for economic development (see also Feller, 2004; Geiger & Sá, 2005).

The origins and outcomes of R&D tax credit policies are becoming increasingly well documented at the national and international levels, but the findings above notwithstanding, state-level analyses lag somewhat behind. Notably missing thus far is systematic, comprehensive, across-state historical analysis of the origins and effects of R&D tax credit policies in the U.S. states. Here, we focus on the origins: Under which socioeconomic, political, and structural conditions do states move to adopt R&D tax credit policies? This analysis aims to address that question as comprehensively as possible and thus add to the understanding of this significant public policy movement.

Conceptual Framework

Our specific research question focuses on how state-level R&D tax credit policies may originate, gain legitimacy nationally, and then spread among adopters. Because this focus entails the analysis of new policy adoption, we build our conceptual framework using the literatures of innovation, institutional theory, and state policy diffusion.

In organizations and policy research, innovation is most often viewed through the lens of Rogers's (1983, p. xviii) early formulation: An "idea, practice, or object that is perceived as new by an individual or another unit of adoption . . . [and] a new alternative or alternatives, with new means of solving problems." From this perspective, an innovation is not necessarily unique in a universal sense but rather must simply represent a distinctively new approach within a given setting. Thus, innovations can diffuse from setting to setting—Indiana's innovation in 2007, if perceived as successful in overcoming shared challenges, can become, by way of diffusion, Iowa's innovation in 2012. In this way, adopting diffused innovations helps reduce uncertainty. Communication, networks, trust, and compatibility of core beliefs, values, and circumstances among adopters and prospective adopters can each facilitate the spread of information and the diffusion of innovations.

Inevitably, learning occurs over the course of diffusion processes, and new adopters must filter information and tailor decisions to meet their distinct needs (Rogers, 1983). At the same time, however, institutional theory suggests that perceived successes among earlier adopters can offer compelling, legitimate approaches ripe for copying locally. And, as mimetic adopters share evidence of success through professional associations and networks, normative expectations build regarding how others in a field ought to act (DiMaggio & Powell, 1983). Over time, as adopting entities emulate earlier adopters, innovations may become institutionalized and come to reflect rising isomorphism within a field as a whole.

At the state level, the power of state-to-state policy diffusion as a factor in reform cannot be questioned, although the diffusion may take on complex forms and patterns unanticipated in earlier considerations of institutionalization and emulation (Ingle, Cohen-Vogel, & Hughes, 2007; Mooney, 2001; Wilson, 2005, 2009; Wu, 2008). Rivalries with contiguous neighbors blend with the "bounded rationality" and "satisficing" of individual decision makers (March & Simon, 1958; Simon, 1957), and with a variety of internal political, economic, and social determinants to move states toward policy choices resembling one another (Berry & Berry, 1990, 1992, 2007; Boehmke & Witmer, 2004; Mintrom & Vergari, 1998; Walker, 1969).

To elaborate, policy makers often have limited time and attention to give to particular policy issues (Jones & Baumgartner, 2005). Focusing on one arena (e.g., tax policy), they may deprioritize another (e.g., higher education) until their policy priorities reshift (e.g., linking tax and higher education policy arenas). What is more, policy makers may lack information in some cases, while in others they may have an overload of data to sort and interpret. Either way, policy makers' decision making regarding policy adoption may be "bounded" by these constraints, preventing consideration of all possible solutions. They may be forced to "satisfice" (Simon, 1957), sacrificing thorough analysis of issues and problems, available information, and potential solutions and thus forgoing optimal choices in favor of merely satisfactory choices. To make policy decisions amid lacunae they may lean toward following external cues suggesting how best to act. In this way, policy adoptions may reflect and encourage increasing homogeneity within a field. In turn, that homogeneity can signal legitimacy to constituents and competitors.

Grounding our work in this rich base of conceptualizations and literature, we argue that four basic factors drive state policy adoption in the R&D tax credit arena: (a) interstate diffusion of innovative policies, plus the (b) economic, (c) higher education, and (d) political contexts within states. From these four broad propositions, we derive 11 specific hypotheses shaping our empirical work. Those are presented below, each followed by a brief rationale.

Factor 1: Diffusion Hypothesis

An extensive state-to-state diffusion literature suggests that states attend to developments in comparable and neighboring states through emulation or competition. In the case of tax credits, the latter form of diffusion may be especially important.

> **Hypothesis 1:** Adoption of R&D tax credits in neighboring states will be associated with a state's adopting such credits.

Although prior evidence on the relative power of different operationalizations of diffusion is inconclusive, we believe that the very nature of these particular policies' goals—retaining existing industries, recruiting new ones, and generating and maintaining homegrown ventures—will diffuse mainly along geographical boundaries.

Factor 2: Economic Hypotheses

Reviewing prior empirical findings (see Miller & Richard, 2010) and observations regarding state R&D policies (Eisinger, 1988; Plosila, 2004), we observe two competing economic rationales for the use of state R&D tax credits: (a) the need to revitalize declining state economies and (b) the importance of expanding toward "new economy" initiatives. These two arguments reflect somewhat competing perspectives: *policy making from advantage* and *policy making from disadvantage*.

> **Hypothesis 2:** Higher levels of unemployment will be associated with adoption of R&D tax credits.

Since their inception at the federal level, R&D tax credits have been viewed by policy makers as a means for ameliorating challenging economic conditions. Particularly prevalent in discussions of economic health is a state's unemployment rate. In keeping with earlier research (Miller & Richard, 2010), we believe that states with *higher levels* of unemployment will be more likely to adopt R&D tax credits in an effort to address the state-level labor markets.

> **Hypothesis 3:** States with preexisting high patent rates will be more likely to adopt R&D tax credits.

In contrast to our expectation that states will enact R&D tax credits as a means for stimulating a poor economy, we can also envision a logic under which states adopt these policies as a means for enhancing a preexisting economic advantage (e.g., see Miller & Richard, 2010). To test this idea, we employ a measure of a state's patenting activity to examine the idea that relatively successful states will act to perpetuate their economic advantages.

Factor 3: Higher Education Hypotheses

In existing studies of R&D tax credit policy, the role of universities is consistently understated, if not altogether ignored. Drawing from the growing literature on postsecondary-policy adoption, we examine the extent to which the adoption of R&D tax credits may have roots in state science funding to universities, the nature of state governance and coordination of higher education, and the nature of individual universities within states.

> **Hypothesis 4:** States that invest more in university R&D activity will be more likely to act to further incentivize that activity through the use of tax credits.

Although most states do not invest heavily in university-based R&D, those that do may choose to broaden those efforts to further incentivize potential private activity and federal support through tax credits. State investments in university R&D can indicate a state's commitment to stimulating the R&D enterprise through universities and, more indirectly, their commitment to leveraging institutional capacity toward statewide economic development. Geiger (2004) has observed that state science and technology policies are in part directed toward positioning a state's universities for competiveness in both the private and federal arenas. In this sense, states adding tax credits to an array of other R&D-oriented spending may be seeking to stimulate such R&D activity to reach what they perceive as more economically and socially optimal levels for their universities (Ehrenberg, Rizzo, & Jakubson, 2003).

> **Hypothesis 5:** States with larger numbers of universities having high levels of R&D activity will be especially likely to adopt policies that can leverage that activity through targeted policies.

The existence of strong research universities can propel efforts to expand R&D activity in a region or state, as has been shown through the well-known relationships that the Silicon Valley and Route 128 clusters have with certain universities (Feldman & Francis, 2004; Geiger, 2004). While Hypothesis 4 captures a state's commitment to university-based R&D, federal R&D commitments to institutions are more competitively awarded and can thus serve as a proxy for the *quality* of R&D that occurs within a state's universities. What is more, strong research institutions typically employ lobbyists, have presidents who are publicly visible, and often count many state legislators as alumni (Tandberg, 2010), so focusing on institutions high in research allows us to highlight institutions' roles as political actors within their individual states.

> **Hypothesis 6:** States with a consolidated (centralized) governing board overseeing higher education institutions, as opposed to a more decentralized and less empowered form of postsecondary education governance, are more likely to adopt R&D tax credits.

States vary in the level of power they vest in state-level agencies. Some states, including, prominently, North Carolina and Georgia, rely on boards so centralized that they have been termed a "fourth branch of government" (McLendon & Hearn, 2003). These consolidated higher education governing boards create networks of communication and coordination around shared agendas and across varied sectors and may encourage the development of knowledge-based economic development approaches. In contrast, the less centralized structures in some states (e.g., Michigan, Tennessee) serve to mediate between higher education and state government and may be less able to advocate directly for policies, even though those policies may prove directly beneficial to their institutions. State higher education governance arrangements can and often do influence policy decisions (Hearn & Griswold, 1994; McLendon, 2003; McLendon, Deaton, & Hearn, 2007; McLendon, Hearn, & Deaton, 2006), even amid evolving patterns of state and university relationships (Feller, 2008). We posit that more centralized systems may be especially likely to act in the science and technology arena.

> **Hypothesis 7:** States with centralized governance systems and a large number of universities with high R&D activity will be more likely to adopt R&D tax credits.

Because governing bodies each have sway over a different mix of research institutions, we believe that states with centralized systems *and* a particularly high number of R&D-intensive institutions will be particularly apt to enact R&D tax credits. This hypothesis posits an interaction effect of governance and the institutional R&D environment.

Factor 4: Political Hypotheses

While economic and structural conditions unquestionably shape the contexts of policy adoption, it would be naïve to ignore the raw politics of state policy development. Federal R&D tax credits began in the Reagan administration and analogous state policies have long been associated with the Republican Party (Bozeman & Link, 1984). In addition, beyond any partisan relationship, state-level R&D tax credits have often been closely associated with states' executive offices (Berman, 1991). Finally, a state's formal legislative support structure may either help or hinder the adoption of such policies. From these observations, we construct four hypotheses.

> **Hypothesis 8:** States with heavily Republican legislatures will be more likely to adopt R&D tax credits.

As noted earlier, Republican officials have long been considered more likely than Democrats to favor the use of tax-incentive policies for economic development (Bozeman & Link, 1984). Following this premise, we believe that Republican control of the legislative branch will result in a state's propensity to enact R&D tax credits.

> **Hypothesis 9:** States with Republican governors will be more likely to adopt R&D tax credits.

Expanding on the previous hypothesis and on the literature that notes the important role of state governors in pursuing R&D tax credits (Berman, 1991), we pay special attention to the partisan control of the state executive branch. Governors are especially well-positioned to serve as effective policy champions for tax credits.

Hypothesis 10: States endowing governors with stronger budgetary powers will be more likely to adopt R&D tax credits.

While the previous hypothesis focuses on partisanship in the executive branch, governors also differ in the amount of power states vest in them (Beyle, 2003). Thus, governors who are provided significant control over state budgeting will be able to shape policies more closely to their liking—particularly in relation to tax incentives. Entrepreneurial governors can be effective in such contexts (see Hart, 2008).

Hypothesis 11: States with high levels of legislative professionalism will be more likely to adopt R&D tax credits.

Legislatures vary not only in their partisan control but also in their analytic capacity (Squire, 1993). Arguably, R&D tax credits promise a more nuanced and indirect influence on economic development than traditional, straightforward approaches such as "smokestack chasing." Well-funded and well-trained legislative staffs, along with significant legislator commitments to informed policy making, may facilitate adoption of such policies. More informed legislatures—regardless of partisan composition—will be more inclined to institute policies aligned with these goals.

Research Design

To test the hypotheses associated with states' adoptions of state R&D tax credits, we used an estimator from a family of statistical techniques known as event history analysis (EHA). Increasingly, researchers of comparative state policy adoption have turned to this class of models to study phenomena with discrete outcomes occurring across time (e.g., Berry & Berry, 1990; Mooney & Lee, 1995). Beyond the public policy and political science fields, this approach to policy adoption has been used for the study of postsecondary education policies (Doyle, 2006; McLendon et al., 2006) and their intersection with science and technology policies (Levine, Lacy, & Hearn, 2013).

Our sample includes a total of 47 states over a time period of 29 years. Alaska and Hawaii are removed because of their absence of proximate neighbors and our focus on contiguous diffusion. Nebraska was omitted because of the state's distinctive unicameral legislative system, which precludes us from fully testing our hypotheses surrounding partisan politics in the legislative branch.

The data for the dependent variable, the year in which each state first adopted a state R&D tax credit, were found in Wilson (2005) and updated and cross-referenced with websites that track state R&D tax policies. In all cases, these policies were verified through state legislative records.

As suggested earlier in the conceptual framework, the study's independent variables may be grouped into four categories: interstate diffusion, state economic environment, state postsecondary environment, and state political environment. Of course, specific variables do not always neatly fall into mutually exclusive groupings, but we ground our categorizations here in the study's theoretical framework.

The decision to lag many of the variables by 1 year is based on the timing of state legislative sessions. As most legislative sessions are held at the beginning of a calendar year, policy makers would only have access to the prior year's data on a state's economic climate and research enterprise. The data for these variables were collected from a variety of reliable secondary data sources, such as the Bureau of Economic Analysis and the National Science Foundation (NSF). Table 1 provides a description of each of these variables, along with the source of the data. To illustrate changes in these variables over time, Table 2 gives the descriptive statistics for the first and last year of the analysis.[5] Table 3 provides correlations for all independent variables in the models.

In our analysis, time is measured discretely as the calendar year in which a state first adopted an R&D tax credit. Our data set begins in 1982, when Minnesota adopted the first state-level R&D tax credit. We continue until 2010, the final year for which most of our independent variables were available.[6] By this time a total of 36 of our 47 states had adopted an R&D tax credit, representing almost 77% of the sample.

The dependent variable expresses the duration of time in years (t) until a state (i) adopts an R&D tax credit. First, we calculated the survival function, representing the probability that a unit will "survive" (or fail to experience the event) longer than time t (Box-Steffensmeier & Jones, 2004). Next, we calculated the hazard function, which represents the instantaneous rate of change in the probability of experiencing an event at time t, conditional on "survival" up to the specified period of time. Because after adoption, states are no longer at risk of adopting a policy, they are removed and are no longer part of the analysis. Table 4 lists states and the year of adoption, the risk set for each time point, the survivor function, hazard, and cumulative hazard rates.

To aid in an understanding of the phenomenon of interest, Figure 1 is a graphical depiction of the hazard rate over time, smoothed across 2 years. From this figure, one can see a sharp increase, followed by a dip toward the end of the Reagan administration. Then, the 1990s witnessed a steady and continual increase in the hazard of adoption. Following 2003, a year in which three of the remaining 20 states adopted an R&D tax credit, the hazard began to decline.

To test our hypotheses, we use the Cox proportional hazards model. The Cox model provides several advantages over other EHA estimators and traditional logit and probit approaches.[7] First, the Cox model uses the ordered failure times of the event in question, focusing on the relationships between the covariates and the outcome of interest, which

Table 1. Variable Indicator Descriptions and Sources.

Variable indicator	Description	Source
State adoption of a R&D tax credit	Dummy variable (*yes* = 1; *no* = 0) indicating whether a state adopted an R&D tax credit in a given year	Wilson (2005); technologytax.com; Hull & Knarr, LLP; state legislative records
No. of contiguous states previously adopting an R&D tax credit	Number of a state's neighbors with an existing R&D tax credit	Authors' calculations using data from the dependent variable and maps
Unemployment rate (lagged)	A state's annual unemployment rate (lagged)	Bureau of Labor Statistics
Patents per 10,000 population (lagged and logged)	Number of utility patents awarded to a state annually per capita (lagged and logged)	U.S. Patent and Trademark Office
State R&D to universities per capita (lagged and logged)	The annual state-level R&D expenditures to colleges and universities per capita (lagged and logged)	Authors' calculations based on data from NSF WebCASPAR
Number of institutions high in federal R&D funding	The number of institutions greater than one standard deviation above the mean in federal R&D expenditures for that year	Authors' calculations based on data from NSF WebCASPAR
Consolidated governing board (CGB)	Dummy variable (*yes* = 1; *no* = 0) indicating whether the state has a consolidated governing board	McGuinness' (1997) *States Structures Handbook* and Education Commission of the States
Republican legislative strength	Average percentage of major party legislators who are Republicans, across the two chambers of the legislature	Klarner data retrieved from http://www.indstate.edu/polisci/klarnerpolitics.htm
Republican governor	Dummy variable (*yes* = 1; *no* = 0) indicating whether the state has a Republican governor	Klarner data retrieved from http://www.indstate.edu/polisci/klarnerpolitics.htm
Governor's budgetary powers	Five-point scale measuring the formal budgetary authority of the governor	Beyle data retrieved from http://www.unc.edu/~beyle/gubnewpwr.html
Legislative professionalism	Measure of a state's legislative professionalism (higher scores indicate great capacity)	Squire (1993)

Table 2. Descriptive Statistics for the Sample.

	1982		2010	
	Mean	*SD*	Mean	*SD*
No. of contiguous states previously adopting an R&D tax credit	0.06	0.25	2.83	1.07
Unemployment (lagged)	7.32	1.81	8.57	1.92
Patents per capita (lagged and logged)	0.20	0.64	0.60	0.77
State R&D to universities per capita (lagged and logged)	1.71	0.84	2.29	0.84
No. of institutions high in R&D (lagged)	1.87	2.08	2.91	2.83
Consolidated governing board	0.36	0.49	0.36	0.49
Interaction of no. of institutions high in R&D and CGB	0.36	0.82	0.55	1.04
Republican legislative strength	40.12	20.69	45.94	14.93
Republican governor	0.45	0.50	0.47	0.50
Interaction of R gov and ln(*t*)	0.00	0.00	1.58	1.70
Governor's budgetary powers	4.66	1.03	3.68	4.40
Legislative professionalism	0.21	0.11	0.18	0.12

Note. CGB = consolidated governing board.

enables us to avoid the need to make statements regarding the functional form of duration (Box-Steffensmeier & Jones, 2004). Unlike scientists and engineers who use similar estimators, researchers of comparative state politics typically have one realization of data (i.e., history), thus making it theoretically challenging to prescribe a distributional statement to particular policies.

The following equation expresses the Cox Proportional Hazards model that we use for our analysis:

$$h_i(t) = h_0 \exp(\beta' x).$$

In this equation, $h_i(t)$ is the hazard of adopting an R&D tax credit policy for state i in year t, and $\beta' x$ is the matrix of

Table 3. Correlation Table for Independent Variables.

	No. of contiguous states w/ an R&D tax credit	Unemployment	Patents per capita	State R&D to univ.	No. of inst high in R&D	Consolidated governing board	Republican legislative strength	Republican governor	Governor's budgetary powers	Legislative professionalism
No. of contiguous states w/ an R&D tax credit	1.00									
Unemployment	−0.32	1.00								
Patents per capita	0.35	−0.27	1.00							
State R&D to univ. per capita	0.20	−0.20	−0.05	1.00						
No. of inst high in R&D	0.13	0.06	0.36	−0.03	1.00					
Consolidated governing board	−0.15	−0.07	−0.27	0.13	−0.34	1.00				
Republican legislative strength	0.18	−0.32	0.24	0.14	−0.08	0.20	1.00			
Republican governor	0.07	−0.11	0.10	0.02	0.07	0.04	0.16	1.00		
Governor's budgetary powers	−0.19	0.16	−0.19	−0.08	−0.09	−0.01	−0.14	−0.11	1.00	
Legislative professionalism	0.09	0.18	0.38	−0.17	0.70	−0.27	−0.11	0.01	0.04	1.00

Note. N = 1,363. Because of the longitudinal nature of our study, the sample for this table consists of 1,363 state-years (47 states over 29 years).

Table 4. States Adopting an R&D Tax Credit, With Kaplan–Meier Survivor Function and Hazard Rate.

Year	States adopting a R&D tax credit	No. of adoptions	Risk set	Survivor function	Hazard	Nelson–Aalen cumulative hazard
1982	MN	1	47	0.979	0.001	0.021
1983		0	46	0.979	0.000	0.021
1984		0	46	0.979	0.000	0.021
1985	IN, IA	2	46	0.936	0.003	0.065
1986	WI, WV	2	44	0.894	0.003	0.110
1987	CA	1	42	0.872	0.002	0.134
1988	KS, ND	2	41	0.830	0.004	0.183
1989	OR	1	39	0.809	0.002	0.208
1990	IL	1	38	0.787	0.002	0.235
1991	MA	1	37	0.766	0.002	0.262
1992		0	36	0.766	0.000	0.262
1993	CT	1	36	0.745	0.003	0.290
1994	RI, MO, NJ, AZ	4	35	0.660	0.012	0.404
1995		0	31	0.660	0.000	0.404
1996	ME, NC	2	31	0.617	0.007	0.468
1997	PA	1	29	0.596	0.004	0.503
1998	GA	1	28	0.575	0.004	0.539
1999	MT, UT	2	27	0.532	0.010	0.613
2000	MD, DE	2	25	0.489	0.012	0.693
2001	SC, TX, ID	3	23	0.426	0.020	0.823
2002		0	20	0.426	0.000	0.823
2003	VT, AR, LA	3	20	0.362	0.028	0.973
2004	OH	1	17	0.340	0.011	1.032
2005	NY, NM	2	16	0.298	0.028	1.157
2006		0	14	0.298	0.000	1.157
2007	NH, MI	2	14	0.255	0.047	1.300
2008		0	12	0.255	0.000	1.300
2009		0	12	0.255	0.000	1.300
2010	OK	1	12	0.234	0.167	1.383

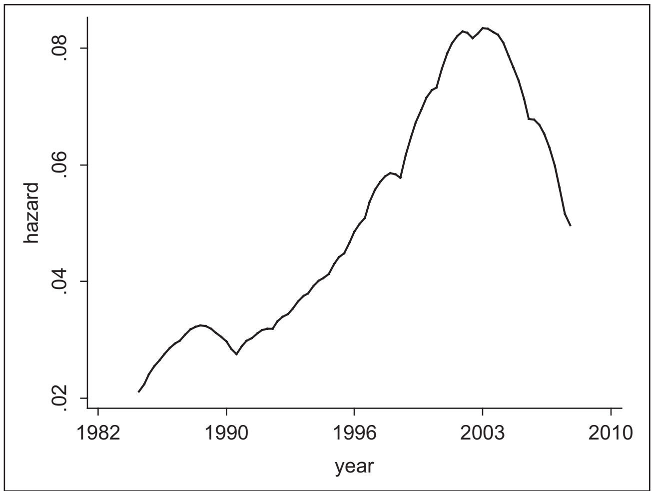

Figure 1. Smoothed hazard estimate for R&D tax credits (smoothed 2 years).

regression parameters and covariates (Box-Steffensmeier & Jones, 2004; Hosmer & Lemeshow, 1999). Maximum partial likelihood estimation is used to calculate the parameter estimates using information about these ordered failure times to predict the likelihood of observing the data that we have in fact observed. These estimates characterize how the hazard distribution changes as a function of the covariates, without making any assumptions about the underlying nature or shape of the baseline hazard rate. A challenge in EHA modeling is how to account mathematically for the presence of events occurring simultaneously as a result of the measure of time. To address such "tied events" we use a method developed by statistician Bradley Efron.[8] The Efron method was appealing to our model for both its handling of tied events and its ability to also allow for clustering standard errors around states, a correction we believed needed to be done a priori.

After specifying the initial model, we ran diagnostics to test the proportional hazards assumption, an assumption that if violated can muddle inference (Box-Steffensmeier & Zorn, 2001). This assumption requires that the ratio of the hazard rates is constant over time. Said plainly, it assumes that the effect of any covariate does not substantially change throughout the time period of the study. To test this assumption, Schoenfeld

Table 5. Results From Cox Proportional Hazards Model for State Adoption of an R&D Tax Credit (Standard Errors in Parentheses).

	Model 1	Model 2	Model 3	Model 4
No. of contiguous states previously adopting an R&D tax credit	0.02 (0.19)	−0.07 (0.19)	−0.01 (0.21)	−0.02 (0.23)
Unemployment (lagged)		0.20 (0.12)	0.24* (0.12)	0.23* (0.11)
Patents per capita (lagged and logged)		0.74** (0.24)	0.96** (0.26)	1.02** (0.33)
State R&D to universities per capita (lagged and logged)			0.29 (0.31)	0.37 (0.28)
No. of institutions high in R&D (lagged)			0.05 (0.07)	0.10 (0.08)
Consolidated governing board			0.76 (0.53)	1.12† (0.61)
Interaction of no. of institutions high in R&D and CGB			0.19 (0.17)	0.10 (0.21)
Republican legislative strength				−0.01 (0.01)
Republican governor				3.64* (1.49)
Interaction of Republican governor and ln(*t*)				−1.30* (0.57)
Governor's budgetary powers				0.49* (0.22)
Legislative professionalism				−0.65 (1.59)
N	864	864	864	864

Note. CGB = consolidated governing board.
†$p < .1$. *$p < .05$. **$p < .01$.

residuals were calculated to determine whether the effect of any of the covariates changed disproportionately over time (Grambsch & Therneau, 1994). These diagnostics suggested that the variable for "Republican governor" violated the proportional hazards assumption. One technique for satisfying this assumption—and the correction we believe to be most theoretically appropriate for studies of a historical nature—is to interact the offending variable with some form of time, and repeat the diagnostics. Because we do not have a theoretical basis for selecting a particular shape of the interaction's temporal component, we used the natural log of time in which *1982 = 1, 1983 = 2*, and so forth. Because this interaction is complicated and involves a couple of transformations, we caution readers from interpreting the effect of these variables based on covariates and standard errors, directing them to the ensuing graphical representation that shows the "combined effect."

We also include a hypothesized interaction between a state's higher education governance board and the number of institutions high in research and development. We believe this interaction is of theoretical interest because, as we hypothesize, a state with centralized control of higher education governance *and* many institutions with extremely high R&D activity likely has different policy interests from a similarly centralized state with few or no real research institutions (i.e., a state in which major institutions emphasize other functions). For both this and the other interaction discussed above, we encourage readers to focus not on the individual effects and standard errors presented in Table 5 but rather on the "combined effects" presented in the figures following the table.[9]

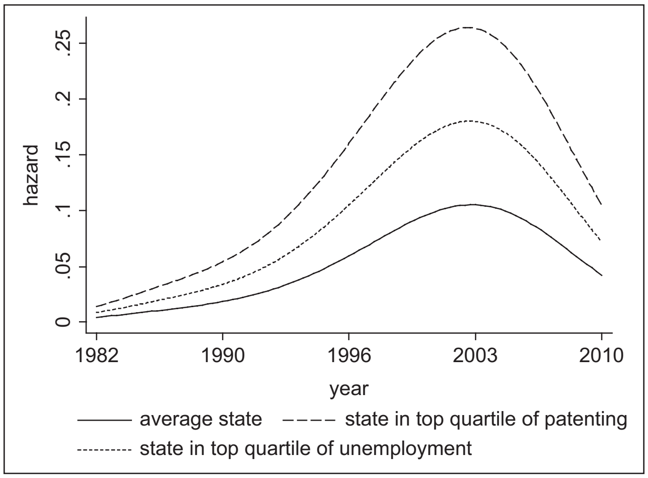

Figure 2. Smoothed hazard function by "economic" characteristics.

Findings

Table 5 presents the results of the Cox proportional hazards models for states' adoption of R&D tax credit policies. The models reflect successively the four categories of our hypotheses: (a) diffusion, (b) economic environment, (c) higher education environment, and (d) political environment.

We found no effect of state-to-state diffusion, and thus no support for Hypothesis 1. We did find, however, support for both Hypotheses 2 and 3. That is, high levels of unemployment and high levels of patenting both appear to have increased a state's likelihood of adopting an R&D tax credit. Figure 2 shows the effect of a state's being in the top quartile in unemployment and in the top quartile in patenting, contrasted with a theoretically average state.[10]

This support for two somewhat competing hypotheses is striking. Recall that we hypothesized that states may create policies from *disadvantage*, thereby using them to address economic duress, but we also find it plausible that states may enact economic development policies from *advantage*, as

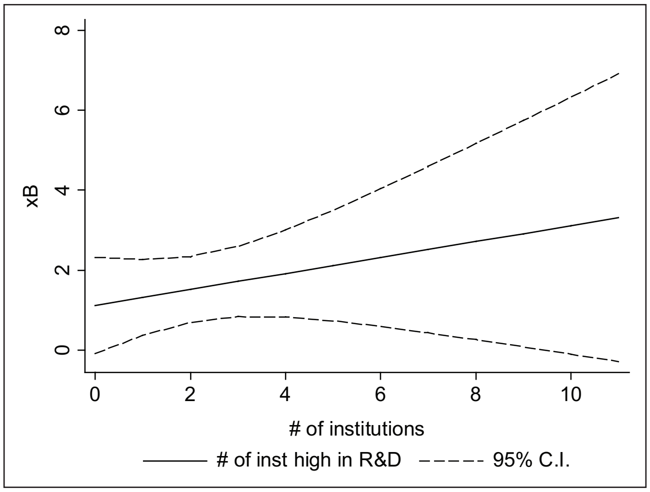

Figure 3. Interaction of CGB and R&D institution count.
Note. CGB = consolidated governing board.

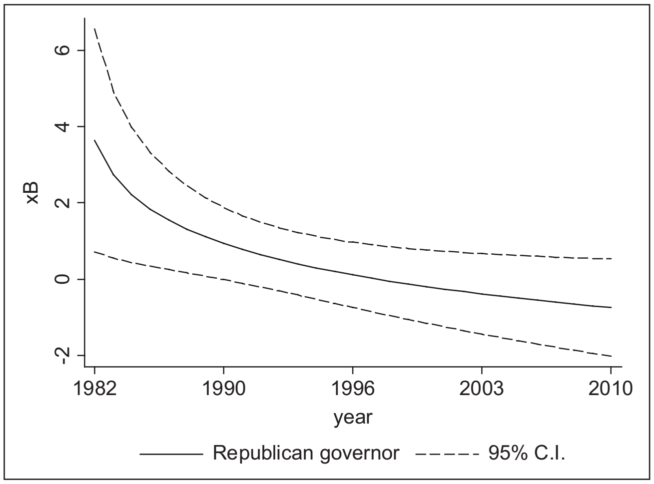

Figure 4. Interaction of Republican governor and time.

tools to support an existing, robust research base. That our results point to both may underscore the complexity of these policies: States may choose to adopt R&D tax credits for seemingly opposing rationales.

We also proposed that a state's higher education structure and research capacity could influence the adoption of R&D tax credits. Contrary to Hypothesis 4, we found no evidence that a state's investments in R&D activity would prompt adoption, and found no immediate evidence of support for Hypothesis 5 regarding the effects of having large numbers of R&D-intensive institutions.

Regarding the latter finding, however, there is more to say. We found some evidence that states with consolidated governing boards (i.e., states with the most centralized governance structures) showed stronger tendencies to adopt an R&D tax credit (Hypothesis 6). This effect is subtle, however, and linked to the number of R&D-intensive institutions (Hypothesis 5). In short, Table 5 alone does not tell the full story.

We argue that greatly empowered state higher education agencies may operate like cartels and may look mainly to protect the interests of their institutions (see McLendon et al., 2006; Zumeta, 1996). Thus, it is useful to account for the nature of these institutions themselves. Accordingly, Figure 3 presents the combined effect of having a centralized agency and the number of institutions high in federal R&D expenditures. When conditioned on the number of institutions, we see that centralized states with zero or one strong research institution have an effect on adoption that is indistinguishable from zero. We begin to see a positive effect in centralized states with two institutions, however, and that effect increases along with the institutional count.[11] This dynamic finding supports Hypothesis 7 and suggests that, under certain conditions, higher education governance structures and universities may combine forces as political actors in this policy arena.

Turning to issues of politics and power, we find no support for Hypothesis 8; this hypothesis suggested that Republican-dominated legislatures would be especially likely to pursue adoption. We did, however, find support for influences of both a governor having Republican political affiliation (Hypothesis 9) and a governor's state-afforded budgetary powers (Hypothesis 10). Regarding the former, our initial estimate was found to violate an essential assumption of our statistical model. We addressed this violation by letting this variable's influence change over time. Figure 4 shows this changing effect of Republican governors across time, presenting the combined effect of the variable and the interaction term presented in Table 5. In the early years, we find that having a Republican governor had a positive and statistically significant influence on states' adoptions of R&D tax credits. As the 1980s progressed, however, this effect diminished, and from 1989 onwards it became indistinguishable from zero. This temporal conditioning effect is notable in that it coincides with the years of the Reagan administration, which championed these credits as a policy tool at the federal level.

In contrast to this devolving partisan effect of governors, states that vested greater degrees of budgetary power in the executive branch had a positive influence throughout the time period of our study. Figure 5 compares a state where the governor is in the top quartile of budgetary powers with a theoretically average state. Relative to other approaches to economic development, R&D tax credits may be especially attractive to governors because of their alignment with federal efforts and their not requiring direct capital outlays. Budgetarily empowered governors are provided freedom to pursue such options, and that freedom may be especially appealing.

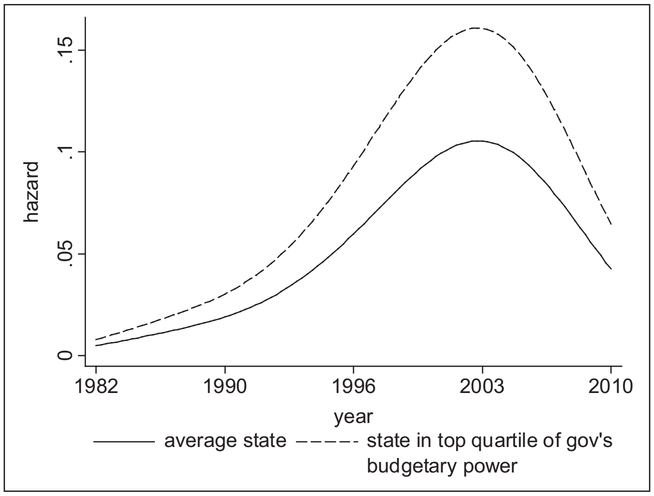

Figure 5. Smoothed hazard function by governor's budgetary power.

Interestingly, we found no support for Hypothesis 11 regarding the effects of high levels of legislative professionalism. The hypothesis suggested that tax-credit policies would likely be developed in states with professionalized legislatures because of the indirect and complex nature of such policies. That reasoning, however, may be based in an outdated vision of the policy context. In an era of more abundant information moving quickly across geographic and political boundaries (Simon, 1997), and in an era in which alternative policy models can be made available instantaneously in electronic format, the immediately available professional resources of state legislatures themselves may be becoming muted.

Implications

Strikingly, this analysis provides support for the notion that state R&D policy making can emerge from both relative state disadvantage and relative state advantage. Notably, the hypothesis of "policymaking from disadvantage" was supported by unemployment's positive relationship to tax-credit adoption. On the other hand, the hypothesis of "policymaking from advantage" was supported by the finding that adoption was especially likely in states with centralized, research-intensive university sectors and with preexisting higher levels of patent activity. Taken together, these results suggest that R&D tax credits are viewed as both *stimulants of activity in low-resource environments and as potential reinvigorators of already developed economic, educational, and research environments.*

In many respects, these mixed findings echo and supplement the earlier individual state case studies of R&D tax credits. The findings also parallel earlier event-history work on states' development of "eminent scholars" policies (Hearn, McLendon, & Lacy, 2013). Increasingly, it appears that both rationales are at play in states' adoptions of economic development policies leveraging universities. For R&D tax credits in particular, we note that early adopters of these credits were states well known for preexisting economic development, strong research universities, and technological innovation, including California, Minnesota, Massachusetts, and Illinois. Conversely, it was not until North Carolina became the 18th adopter in 1996 that a state in the South or Southwest had joined the trend, followed by Georgia in 1998 and Texas in 2001. In each case, these pioneering Sun Belt states had more developed economies and university systems (on various scales) than others in their region.

Unlike much earlier research on policy adoption in which interstate competition was found to exist, our analysis provides no evidence of contiguous or regional state-by-state diffusion. Instead, it appears that R&D tax credits may have been driven by *similar economic, educational, and structural conditions rather than by similar geographic conditions.* That is, diffusion may be influenced by competitive peers rather than by geographic neighbors. In this sense, Massachusetts may have been driven to adopt reform in 1991 not by New York or Connecticut or New Jersey (which each followed it in later years) but rather by California, a primary competitor in the computing and bioscience arenas that adopted an R&D tax credit program in 1987.[12]

A third noteworthy theme emerging from the results involves the special limited nature of partisan influences. Contrary to our initial hypotheses, we found no evidence that Republican legislatures were any more likely than Democratic ones to adopt tax credit policies, but we did find evidence of a time-delimited partisan effect. Namely, Republican governors were associated with policy adoption in the years following the adoption by the predominantly Republican-controlled federal government of national-level tax credits. Over time, this association of Republican governors with R&D tax-credit adoption faded, perhaps because states with Republican tendencies may have all adopted the policies as they became more ubiquitous in the 1990s. It is possible that over time, this kind of initiative became less a signature feature of Republican politics and, as diffusion theories suggest, more an institutionalized, expected feature of state economic development portfolios across the ideological spectrum.

While we found little evidence of partisan influences in this study, the analysis does suggest that governors with greater budgetary powers have been more likely to adopt R&D tax credits. Prior research and accounts in the popular press highlight the key role of governors in R&D policy development, and nothing found here discounts that role. At the same time, our analysis does suggest a nuance in state policy dynamics. The root support of governors' entrepreneurial R&D policy actions may be more structural than partisan.

The analysis provides several potential directions for future research. State echoing of federal economic and educational policy initiatives is an intriguing possibility, especially considering the partisan patterns suggested here. And without question, for every example of imitative behavior (e.g., the widespread launching of research parks after earlier successes), there are counterexamples of active state resistance or counteraction, as in the cases of California and other states adopting permissive stem-cell research funding policies in the face of federal withdrawal from such policies (Levine, 2005).

At the state level, it would be instructive to examine variation in R&D tax credit policies. As Wilson (2005) has noted, states adopting those policies can choose from a range of incremental and nonincremental incentive systems. For example, a nonincremental policy might provide tax credits without organizations having to meet a base spending floor, while an incremental policy would set certain spending conditions before credit provision. In our sample and time frame, some states went in one or the other direction, while others (including Massachusetts, Connecticut, and Maryland) chose both types. What might drive these distinctive state choices? A typology categorizing the variations of R&D policy (e.g., by incremental, nonincremental, and entrepreneurial intent) would facilitate longer-term analysis of overall patterns and trends in state responses in relation to federal initiatives and initiatives in other competing states.

The absence in our findings of any detected state-to-state policy diffusion commands further work. Why might earlier suppositions about the existence of diffusion effects in this policy domain be upheld by neither our study nor Miller and Richard's (2010) earlier event history analysis? As discussed earlier, event history analyses in other, related economic, educational, and science policy arenas have indeed found such effects. Emerging qualitative work on research utilization in policy making processes and decisions (Ness, 2010) holds potential to illuminate more richly not only the types of information influencing policy adoptions but also the roles of national sources, of linking and intermediary organizations, and of social networks of research-evidence providers such as think tanks, ideologically-oriented agencies, and foundations. Potential insights from this line of research may enrich our rather puzzling findings. In particular, further conceptual and empirical work may build on our emerging supposition that states may rely more on national than on regional reference points as they develop their R&D policies.

Of particular interest to us is the possibility that more intensive case-study analysis could support the proposition that universities play especially active roles in the establishment and evolution of these policies. In much of the existing literature, higher education leaders and institutions have been portrayed as somewhat constrained by formal state governance arrangements, and often as mainly reacting to state R&D initiatives. In case-study analyses for the larger project under which the present analysis was funded, it has become clear that in at least one state, research university officials sought enhanced funding not solely to improve their prestige nationally and internationally but also to better leverage themselves for active participation in governments' science and technology policies and in corporate research and development agendas. Many of these interactions have taken place well outside formal university governance structures. Thus, examining how higher education leaders seek and initiate partnerships with public and corporate officials could illuminate the relational and lobbying dynamics that propel R&D initiatives.[13]

Finally, we think it important to consider further how R&D tax credit policies are, and might be, integrated not only with other state-level economic development initiatives but also, more broadly, with other state efforts. Notably, to what extent are a given state's R&D tax credits blended with overarching state agendas in science and research policy? The analysis presented here examines R&D policy as stand-alone policy innovation, and that approach may, in fact, reflect the nature of such tax credits' origins and sustenance in most states. After all, these state policies were initially adopted in the space and momentum created by federal tax credit initiatives and may not be typically considered in a broader context. The policies' nature as "tax expenditures," as opposed to outright state investments, may sustain their distinctive political and legislative contexts. Yet earlier case study evidence suggests that, in at least some states, the credits were adopted as elements in larger portfolios of policies in the research arena. To the extent that is true, further analysis is warranted. R&D tax credits may supplement, or be central elements in some states' efforts in economic development, while serving purely ancillary roles in others—a distinction warranting attention.

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Notes

1. See Sá, Geiger, and Hallacher (2008) and State Science and Technology Institute (2006).
2. The phrase's origin is attributed to Supreme Court Justice Louis Brandeis.
3. Later in the article, we more specifically discuss this critical literature.
4. For example, in recent years Wisconsin initiated Governor Jim Doyle's "Innovate Wisconsin" plan to boost R&D activity by both attracting firms and creating homegrown enterprises (Dresang, 2008), and neighboring Minnesota worked toward aggressively expanding its pioneering R&D tax credit policy (Arundhati, 2011; Newmaker, 2011a, 2011b). Such developments reflect the increasing commitment to tax credits across states observed by Wilson (2005).
5. Consolidated Governing Board has the same values for 1982 and 2010 but this is coincidental: States did change their structures over the timespan covered in our data.
6. Adoptions taking place outside of this timespan of this study include Virginia and Florida in 2011 and Colorado in 2012.
7. For an excellent discussion of these advantages in a public policy and political science context, see Jones and Branton (2005).
8. For a detailed discussion of this approach, see Efron (1977).
9. We provide graphical depictions of all variables in the model for which the findings supported our initial thinking.
10. In this figure, all other variables in the model are held at their mean.
11. The 95% confidence intervals contain zero when the number of institutions high in R&D is greater than 9. In all practicality, the uncertainty surrounding this prediction has as much to do with the fact that no states with this number of research-intensive institutions (only CA, NY, and TX in 1994) have a consolidated governing board.
12. The lack of contiguous or regional state-by-state diffusion for R&D tax-credit-policy adoption is somewhat inconsistent with earlier conceptualizations (Wilson, 2005, 2009; Wu, 2008) and popular press reports (Dresang, 2008), yet does parallel findings from prior historical analysis of the topic (Miller & Richard, 2010).
13. The work of Geiger and Sá (2005), Harvey (2005), and Slaughter and Rhoades (2004) provides provocative perspectives on these processes.

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