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Multilevel innovation policy mix: A closer look at state policies that augment the federal SBIR program

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ABSTRACT

This paper examines nested, multilevel innovation policies paying particular attention to U.S. federal and state small business innovation research programs. With 45 states offering a range of SBIR Outreach and SBIR Match programs specifically designed to enhance the federal SBIR program, such programs provide a useful lens for examining the nature of the multilevel innovation policy mix. The contributions of this article are twofold. First, the article provides theoretical motivation for multilevel innovation policy responses placing emphasis on positive policy responses in which state policies enhance federal policies. Second, the article provides an empirical analysis examining the multilevel factors associated with a state government response that augments the federal SBIR program. The results from this analysis indicate these state policy actions are associated with a confluence of multilevel factors driven not only from top to down federal actions, but also from bottom to up, internal state political and economic factors as well as from lateral pressures from peer states.

1. The innovation policy mix in multilevel systems

Innovation policy is comprised of multiple layers of public programs and investment made by different jurisdictions with overlapping objectives, diverse mandates and different resource constraints. Taken together, different levels of policies comprise a policy mix that involves significant complementary interactions and interdependencies that requires joint analysis (Flanagan et al., 2011). National innovation policies are designed to spur international economic competitiveness and thereby increase aggregate societal welfare (Kuhlmann, 2001: p.954). Whereas subnational governments, recognizing that the locus on innovative activity occurs at a more concentrated geographic scale, enact policies to build or reinforce existing local innovative capacities and capture greater returns within their jurisdiction. Taken together the rationales, domains and instruments among different administrative units define a multilevel innovation policy mix (Magro & Wilson, 2013: p.1654). The policy mix is not static but represents the agenda-setting outcome of a policymaking process that involves learning and dissemination (Flanagan et al., 2011). The resulting multilevel policy mix is the product of differing motives, interacting incentives and diffusion. At a time when market fundamentalism guides policy debates, the full impact of multiple layers of the innovation policy mix needs to be understood so that better policy options may be articulated and implemented (Block and Keller, 2009; Schrank and Whitford, 2009).

Federalist systems provide a context to understand the dynamic interaction between different levels of government. Policy actions may be conceptualized as a response to other policies: they are adopted in a pre-existing context and institutional framework that have been shaped by successive policy changes (Uyarra, 2010). Most examinations of the multilevel policy mix focus on the European context (e.g., Uyarra and Flanagan, 2010); however, the U.S. offers an example not only for theoretical development but also for empirical examination. In the context of innovation policy, scholars have overwhelmingly focused attention on federal programs (Keller and Block, 2013; Lerner, 1999; Link and Scott, 2012; Toole and Czarnitzki, 2007; Wallsten, 2000; and others). Yet states are actively engaged with innovation policies (e.g., Berglund and Coburn, 1995; Feldman et al., 2014; Plosila, 2004). This sets the stage for greater theoretical development of the dynamic temporal relationships that define the multilevel policy mix.

This article provides a theoretical framework to consider multilevel innovation policy responses within a federalist system. We consider innovation policy responses within a dynamic context

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highlighting that initiation can originate either from the national or subnational levels to then yield a positive or null policy response. We then develop four archetypes – policy enhancement, policy experimentation, acquiescence and local exceptionalism. To be complete, there is the potential for policy counter-responses where different levels of government aim to play a substitutive role.[2] For the empirical analysis, we focus on the U.S. context and pay particular attention to policy enhancement, a prominent policy response as U.S. states respond to the greater resources at the federal level.

The U.S. Federal Small Business Innovation Research (SBIR) program[3] provides our empirical example of policy enhancement. Established in 1982, the Small Business Administration (SBA) oversees an interagency consortium of 11 federal agencies[4] that provide competitive extramural R&D funds to small businesses for proof-of-concept, demonstration and commercialization. Since 1984, all but five U.S. states[5] have introduced programs formally designed to enhance the federal SBIR program. The intentional design of these programs offers an ideal case for examining the most common archetype of multilevel policy responses – specifically, state policies designed to enhance an existing federal policy. From a detailed analysis of state responses to the federal SBIR program, two different types of policy enhancement emerge. The first type offers information and consulting services that complement the federal program, while the second type provides more aggressive financial incentives that augment and extend the existing federal policy. Our analysis reveals that forty-two states have enacted SBIR Outreach programs that complement the federal SBIR program, and 17 states have enacted more aggressive SBIR Match programs to augment funding.[6]

This article provides an empirical analysis to understand the multilevel conditions that motivate state policy responses that become part of the SBIR policy mix. Specifically, we consider a range of top–down, bottom–up and lateral antecedent factors that influence the adoption of the SBIR State Match Phase I (SMP-I) program. This is the most broadly diffuse SBIR Match program and among the more aggressive state policy responses to the federal program.

The article is organized as follows: Section 2 presents a theoretical framework for multilevel innovation policy responses within a federalist system and develops the concept of policy enhancement – state government innovation policy responses that either complement or augment federal policy. Section 3 illustrates the concept of policy enhancement with a discussion of two broad types of U.S. state SBIR programs that have been implemented in response to the federal SBIR program. Section 4 presents the methods and research design to estimate multilevel factors associated with implementing and maintaining an SMP-I program. Section 5 discusses the empirical results, and Section 6 offers concluding comments and directions for future research.

2. Multilevel innovation policy mix

Drawing from economic policy debates, Flanagan et al. (2011) place attention on the policy mix, highlighting the activity between different governance levels. Importantly, this offers a clearer framework not only for understanding the public sector's complex and myriad roles but also for discerning how public policy goals are realized (Flanagan et al., 2011: p.702). Multiple levels of governments have vested interests in innovation policy to strengthen the competitiveness of the economy (or selected sectors of an economy) and to increase societal welfare (Kuhlmann, 2001: p.954).[7] Considerable attention has focused on the evolution of objectives and the variety of instruments used in national innovation policy (Dosi and Nelson, 2010; Mytelka and Smith, 2002). However, the spatial concentration of the benefits of innovative activity offers strong incentives for subnational innovation policies (Jenkins et al., 2008). Importantly, policies interact at the regional level; and outcomes are commonly experienced in local jurisdictions (Uyarra and Flanagan, 2010). Nevertheless, less is known about motivations for the adoption of innovation policies between different jurisdictions or governance levels that comprise a policy mix.

Policy implemented at one level of government may induce a response from other levels of government. While the literature has considered national systems of innovation (Fagerberg et al., 2006) and regional or subnational systems of innovation (Asheim et al., 2011), Uyarra and Flanagan (2010: p.683) find a tendency to overestimate the homogeneity among different levels and argue the need to compare roles. Most of the time, the national level is the highest level of jurisdiction with the greatest command of resources and ability to direct broad agendas.[8] Subnational levels comprise smaller geographic jurisdictions and are in touch with local conditions, yet they have fewer resources. The shared imperative of bolstering economic activity among these innovation-based policies ties these multiple systems together into a policy mix. As Brickman (1979) notes this policy coordination is varied, ranging from national, top–down or vertical to bottom–up or horizontal. Where they vary are in terms of their capacity and approach; nevertheless, they share a common directive. Depending on the circumstances and context, actions from one level may solicit positive or null responses from other levels. Taken together these interactions form the policy mix.

We conceptualize this phenomenon broadly by considering policy actions in subsequent stages within a federalist framework: initiated by a jurisdiction at one level and followed by a response from another jurisdiction at either a different level or at the same level of government. Within a multilevel governance structure, initiation can originate either from national or subnational levels to then yield a positive or null policy response. A simple 2×2 matrix presents four archetypes: policy enhancement, policy experimentation, acquiescence and local exceptionalism (see Fig. 1). Policy enhancement occurs when innovation policy is initiated at the national level and yields a positive policy response; policy experimentation occurs when the policy is initiated at the subnational level and yields a positive policy response; acquiescence occurs when the policy is initiated at the national level yet yields a null policy response; and local

[2] We focus on the four archetypes – policy enhancement, policy experimentation, acquiescence and local exceptionalism in this article. Future research could explore counter-responses, such as current state efforts to dismantle federal policies.

[3] Although the SBIR and STTR (small business technology transfer) share similarities, this article focuses on the former, which does not include the additional requirements of university collaboration.

[4] The 11 federal agencies that participate in the SBIR program include: Department of Agriculture, Department of Commerce (National Oceanic and Atmospheric Administration and National Institutes of Standards and Technology), Department of Defense, Department of Education, Department of Energy, Department of Health and Human Services, Department of Homeland Security, Department of Transportation, Environmental Protection Agency, National Aeronautics and Space Administration, and National Science Foundation.

[5] These include Colorado, Nevada, New Mexico, Rhode Island, and Texas.

[6] This classification is the result of a careful study of the range of state programs designed to complement the federal SBIR program. Our data collection methods are recorded in the Appendix to encourage replication, and information on SBIR Outreach and SBIR Match programs are detailed for transparency. Despite the growing importance of state innovation policy and R&D funding, there is surprisingly little reliable, centralized documentation of these policies. Tables 2 and 3 present the list of state policy responses; detailed information on these programs is available upon request from the authors.

[7] Paraskevopoulou (2012: 1058) provide an overview and review of the intellectual development of the concept of innovation policy.

[8] This is most prominent in the U.S. context; however, the distribution of power is more varied in the E.U. context .

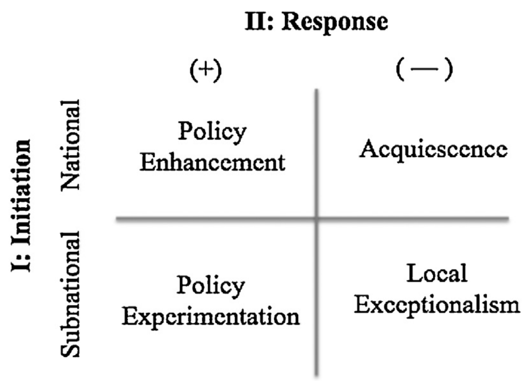

Fig. 1. Multilevel innovation policy responses – 2 × 2 matrix.
Note: Authors' own illustration.

exceptionalism occurs when the policy is initiated at the subnational level yet yields a null policy response. Each of these is discussed in turn, beginning with the latter two archetypes – acquiescence and local exceptionalism – followed by policy experimentation and policy enhancement. We place emphasis on policy enhancement, which considers potential complementarity in multilevel innovation systems.

In principle, in some cases innovation policy is more efficiently offered at the federal level for the U.S. or the Union level for the E.U. For example, intellectual property (IP) protection is clearly reserved for the federal government by the U.S. constitution. Subnational jurisdictions have little incentive to set their own standards for IP or incur the expense of setting up a patent examiner system. Indeed, the movement has been toward uniformity with patent treaties and the establishment of the European Patent Office and the World Intellectual Property Organization. In addition, E.U. innovation policy initiatives are officially restricted to benefiting the European economy as a whole, an objective that, on theoretical grounds, is most efficiently pursued at the Union level (Kuhlmann, 2001: p.963).[9] Subnational policy units, such as states, have little incentive to respond and implement policies with aspatial objectives and that would benefit from economies of scale, potentially increase transaction costs and subsequently decrease innovation.

In other cases, policies designed at the subnational level and responsive to local context are examples of local exceptionalism. These include programs with tailored objectives. Expanding from Tiebout's (1956) discussion of feet voting, state policymakers have the discretion to allocate public goods such that they more closely reflect the preferences of their constituent population. While this is an efficient approach to address concerns with the local context, these narrow programs yield null responses given that they are at cross-purposes with other jurisdictions. Gray et al.'s (2011) and Lowery et al.'s (2010) examinations of state-level initiatives provide an illustrative example where subnational policies fail to elicit a response from the federal level.

The third archetype – policy experimentation – involves multilevel innovation policies that percolate from the bottom up and are designed to respond to more local conditions. This is the classic laboratories of democracy argument as first articulated by U.S. Supreme Court Justice Louis Brandeis in New State Ice Company v. Liebmann (1932) to describe how a "state may, if its citizens choose, serve as a laboratory; and try novel social and economic experiments without risk to the rest of the country." Essentially, the U.S.'s federalist structure naturally encourages experimentation in policymaking. This has been explored in a number of studies including Volden's (2006) assessment of the Children's Health Insurance Program, which argues that subnational policymaking generates the adoption of more effective policies. Of course, state policies that are perceived as successful or as offering some advantage will diffuse widely and may be further adapted. In an earlier study, Glick and Hays (1991) find evidence of a non-uniform diffusion process as state living will laws are amended and refined as opposed to being directly emulated. The manner of the policy response may vary – from direct emulation to refinement – and the motivation may stem from competition, policy learning or socialization (Glick and Hays, 1991; Gray, 1994). As the literature on state policy diffusion and adoption suggests, both of these will vary by context and circumstance (e.g., Berry and Berry, 2007; Graham et al., 2008). Whitford and Schrank (2011: p.274) point out that experimentation by U.S. states can, if successful, not only diffuse to other state governments but also trickle up to the federal level.

The fourth archetype – policy enhancement – comprises nested innovation policies where multiple levels of government implement reinforcing policies. This occurs when national policy yields a positive policy response from the subnational level. The inherent nature of innovation demands substantial investment, placing national governments in a critical position to initiate policy responses (Elder and Georghiou, 2007). Considering this within the context of the U.S., federal R&D programs in contrast to state investments are larger in scale[10] and aim to competitively fund R&D projects based on merit regardless of the location of the recipient. State innovation policies, in contrast, are smaller and target activity within their own political boundaries. State response to these federal initiatives can be viewed as an effort to garner a larger share of the federal funds and capture the resulting benefits. The role of state jurisdictions in innovation policy, nonetheless, is a question of the degree of involvement and mode of interaction (Fritsch and Stephan, 2005). These policies might be as simple as complementing the initial program by providing information to applicants to encourage more participation and to produce proposals that conform to the expectations of the federal program. A more aggressive policy response would be programs designed to augment the resources of the federal program; these may provide a financial incentive that rewards successful applicants with additional funding. A state's response is likely predicated on the nature of the national program and on the prevailing state context.

In sum, too often attention on public R&D conflates public investment as a single source when in fact public support comprises a multilevel policy mix. Policies are evaluated in isolation rather than considering the interplay and interdependencies between multiple policies enacted at different levels of government (Uyarra and Flanagan, 2010). The fourth archetype, policy enhancement, is the most prominent archetype for U.S. innovation-based policies given that the federal government has historically led in R&D efforts. While much of the literature is theoretical or uses illustrative case studies, the next section illustrates this archetype in greater detail with an empirical example: the federal SBIR program and supplemental state SBIR Outreach and SBIR Match programs.

3. Policy enhancement: U.S. small business innovation research programs

The U.S. portfolio of SBIR programs offers an example of a multilevel innovation policy mix in which states have reacted to the

[9] We would like to highlight that the discussion on European added value is still in debate and therefore inconclusive. This pertains particularly to discussions surrounding the European Commission and the level of efficiency in overseeing administrative support for SMES. We thank one of the anonymous reviewers for raising this issue.

[10] Sources: http://www.nsf.gov/statistics/infbrief/nsf13336/ and http://www.nsf.gov/statistics/infbrief/nsf14300/.

federal SBIR program by establishing a range of supplemental SBIR-related programs. Created through the Small Business Innovation Development Act of 1982, the federal legislation currently requires federal mission agencies with annual extramural R&D budgets in excess of $100 million to set aside up to 3.2% of their funds to provide financial resources for small businesses engaged in early-stage R&D activity.[11] Competitive funding is available through two phases[12] – Phase I (the proof-of-concept demonstration phase) and Phase II (the product development stage). Prior to 2012,[13] only those businesses that have been awarded a Phase I are eligible to apply for a much larger Phase II award.[14] Applications are evaluated primarily on their scientific, technical and commercial merit. As of 2013, over $30 billion has been obligated by these federal agencies to support the program, making this the largest U.S. public effort to support R&D activity for small businesses.[15]

Numerous academic studies have examined the federal SBIR program (e.g., Audretsch et al., 2002; Keller and Block, 2013; Lerner, 1999; Link and Scott, 2012; Wallsten, 2000; others). While the academic evidence is mixed, the program is widely regarded as a success from a policy perspective (Keller and Block, 2013; Wessner, 2008). The federal program has been reauthorized in 1992, 2000 and again in 2011. Domestically, 45 U.S. states have adopted programs designed to leverage the federal SBIR program, and internationally, seven countries[16] have adopted comparable programs.

The methodology used to gather information on these state SBIR-related programs broadly follows the approach used in Feldman et al.'s (2014) study of state-funded university research programs. Information on state SBIR-related programs was gathered from the State Science and Technology Institute's (SSTI) online archive of press releases, state legislative statutes, state program materials from individual states' websites and via correspondence with state and federal economic development officials. The Appendix provides more detail on the data collection efforts for the range of state SBIR-related programs.[17]

The state SBIR-related programs that have been implemented since the 1982 passing of the federal SBIR program can be classified into two broad categories – SBIR Outreach and SBIR Match programs. Viewed as a dichotomy, these responses can be viewed as efforts either to complement or augment the federal program, respectively. We define the former set of programs as SBIR Outreach programs, which provide information about the federal SBIR program to potential applicants that lower the costs of applying for federal funding. We define the latter set as SBIR Match programs, which more aggressively offer cash incentives in the form of prizes to firms that have successfully been awarded funding by the federal program.

Table 1 provides a comprehensive list of state SBIR-related programmatic activity that aim to promote R&D activity by complementing the federal SBIR program.[18] The SBIR Outreach programs can be further divided into three types – Phase 0, Phase 00 and Support Services. These state programs aim at increasing awareness of the federal SBIR program and supporting firms with federal SBIR proposal submissions. The SBIR Match programs are more aggressive state policies that provide matching funds for successful SBIR recipients to support technical aspects of their projects. These programs can be further divided into three types – SBIR State Match Phase I (SMP-I), SBIR State Match Phase II (SMP-II) and SBIR Limited Match (LM) programs.

3.1. Complementary policy responses: state SBIR Outreach programs

As of 2013, all but eight states[19] have established some form of SBIR Outreach program. Table 2 lists the states and their respective outreach programs. Reliable data on the year of adoption or the budget for these programs was difficult to find. The majority of the state statutes clarify that a portion of the initial funding for the programs came from the SBA's Federal State and Technology Partnerships (FAST) and Rural Outreach Programs (ROP) initiatives. With the first FAST and ROP competitions taking place in 1999 and 2001, respectively, these federal programs were designed to address variance in distribution of small high-technology firms across U.S. states. Recipients of these competitions – primarily state agencies – are required to provide a supplemental match.[20] As of 2013, there have been a total of six FAST and three ROP competitions.

In many cases with the top–down stimulus of initial federal funds, state governments have established their own Phase 0, Phase 00 and Support Service programs to improve the applicant base for the federal SBIR program. Nineteen states have established Phase 0 and/or Phase 00 programs that provide direct or in-kind funding to defray the costs of proposal writing for Phase I and Phase II grants, respectively. Grants typically have ranged from $1500[21] to $10,000[22] with the average size of $4000. In-kind funds are commonly used to cover consultant fees associated with proposal preparations.

In addition to Phase 0/00 programs, 31 states have established Support Services programs. These programs offer a range of services for firms interested in applying for the federal SBIR program. These services include proposal review, workshops, access to business

[11] 2.5% was the set aside rate when the 2011 reauthorization was initially passed, though the amount was set to increase between 0.1% and 0.2% annually up to 3.2% in 2017. Source: https://www.federalregister.gov/articles/2012/08/06/2012-18119/small-business-innovation-research-program-policy-directive.

[12] The federal SBIR program also defines a Phase III; however, federal funds are not available.

[13] For the fiscal years 2012–2017, the DHHS, DOD, and Department of Education have established pilot programs to issue Phase II SBIR awards to firms to pursue Phase I solicitation topics without requiring the applicant to have received a Phase I award for related work. The implementation of this pilot is at agency discretion. During the time frame of this analysis (1983–2010), only Phase I recipients are eligible to compete for the Phase II award. Source: https://www.sba.gov/content/key-changes-sbir-and-sttr-policy-directives.

[14] Phase I and Phase II awards are approximately $150,000 and $1,000,000, respectively.

[15] Source: www.sbir.gov.

[16] These include Sweden, Russia, the United Kingdom, the Netherlands, Japan, Korea, and Taiwan (Wessner, 2008).

[17] An abbreviated synthesis of this search on the programs is available upon request from the authors.

[18] We would like to note that the range of U.S. complementary SBIR programs extends beyond the federal SBIR program and state SBIR Outreach and Match programs. Notably, at the federal level, there are a number of additional programs designed to complement the SBIR program – Department of Energy's Clean Energy Alliance Partnership and the Industry and Growth Forum, the National Aeronautics and Space Administration's Space Alliance Technology Outreach Program (SATOP), the National Institutes of Standards and Technology's "Nanofab" Lab and the National Institute of Health's Niche Assessment Program. In addition, there are numerous non-profit, for-profit, and quasi-governmental programs that provide complementary support for SBIR firms (e.g., SC Launch). Overviewing the comprehensive list of nested policies and programs related to the SBIR program falls outside the scope of this research project. We introduce the concept of multilevel complementary policy looking at the federal SBIR program and all state government programs related to the SBIR program, rather than the broader set of programs that also include the federal government and private sector. Exploring these additional venues is an option for future research.

[19] These states include: Colorado, Maryland, Massachusetts, Michigan, Nevada, New Mexico, Rhode Island, and Texas.

[20] The size of the state Match is contingent on the relative SBIR performance of the state. Leading states require a larger Match than those that lag.

[21] South Dakota SBIR Center provides $1,500 support.

[22] PA's Innovation Partnership and Tennessee Technology Development Corporation provide up to $10,000 for the Phase 00 program.

Table 1
State SBIR-related programmatic activity.

State	SBIR Match programs			SBIR Outreach program		
	SMP-I	SMP-II	Limited Match	Phase 0	Phase 00	Support Services
Alabama[a]						1
Alaska				1	1	
Arizona						1
Arkansas						1
California						1
Colorado						
Connecticut	1					1
Delaware						1
Florida			1	1		
Georgia						1
Hawaii	1					1
Idaho						1
Illinois	1					1
Indiana	1		1			1
Iowa						1
Kansas	1	1				1
Kentucky	1	1				1
Louisiana				1		
Maine				1		
Maryland			1			
Massachusetts			1			
Michigan	1	1				
Minnesota						1
Mississippi				1		1
Missouri				1		
Montana	1			1		
Nebraska	1			1		
Nevada						
New Hampshire						1
New Jersey	1					1
New Mexico						
New York	1					1
North Carolina	1			1		1
North Dakota				1		1
Ohio						1
Oklahoma	1	1				1
Oregon				1		1
Pennsylvania				1	1	1
Rhode Island						
South Carolina				1		
South Dakota				1		1
Tennessee				1	1	
Texas[b]						
Utah						1
Vermont				1		
Virginia	1			1	1	1
Washington						1
West Virginia				1		1
Wisconsin						1
Wyoming				1		
Total	14	4	4	19	4	31

[a] At the time of writing this paper, an SBIR-SMP had been written into the accelerate Alabama economic development plan. As of June 2013, the program is under review. (http://www.madeinalabama.com/assets/2013/03/AccelerateAlabamaPlan.pdf).
[b] Although the state does not have a state SBIR-related program, the emerging technology (ETF) is a quasi-public program designed to provide matching funds for TX firms.

expertise and one-on-one mentoring. With each of the 11 federal mission agencies administering the SBIR competition, these programs are designed to assist prospective applicants in matching their project's concepts with agency solicitations. The features of these support services have greater variety across states than the Phase 0/00 programs.

3.2. Policy augmentation: state SBIR Match programs

The state SBIR Match programs constitute a second category of state policies designed to augment the federal SBIR program by offering a financial reward or prize to firms that received a federal SBIR award. As of 2013, 17 states have adopted at least one of three state Match programs – the SMP-I, SMP-II and LM programs. Table 3 lists the states, programs, program attributes and years of programmatic activity. This set of state policies is designed for successful SBIR applicants to bridge the funding gap from Phase I to Phase II or from Phase II to commercialization.[23] The SMP-I classifies the former and the SMP-II defines the latter. These matching programs differ from Phase 0/00 programs in that they only support successful federal SBIR recipients; in addition, the funds are notably larger than the proposal writing grants and are intended to aid technical aspects of the project. State governments are in essence relying on the federal SBIR program to identify firms with promising early-stage R&D projects. The size of the match varies

[23] The Federal SBIR program defines this point of the project as Phase III.

Table 2
List of state SBIR Outreach programs.

State	SBIR Outreach programs
Alabama	Alabama Small Business Development Center
Alaska	TREND in partnership with EPSCoR
Arizona	Arizona innovation
Arkansas	AR Risk Capital Matching Fund; AR S&T Authority
California	California SBIR/STTR
Connecticut	CT Innovations
Delaware	DE Small Business Technology Development Center (SBTDC)
Florida	Enterprise Florida – State University Research Commercialization Assistance Grant Program
Georgia	SBIR Assistance Program
Hawaii	High Technology Development Corporation
Idaho	Idaho Department of Commerce (with partners)
Illinois	Innovation Challenge Technical Assistance Grants
Indiana	Indiana Economic Development Corporation (IEDC) & 21st Fund
Iowa	Office of Intellectual Property and Technology Transfer
Kansas	KS Bioscience Authority
Kentucky	KY S&E Foundation
Louisiana	LA SBIR/STTR Phase Zero Part I Program
Maine	ME Technology Institute's SBIR/STTR Phase 0 Grants
Minnesota	Department of Employment and Economic Development[a]
Mississippi	MS-FAST Program
Missouri	MO Technology Incentive Program (MoTIP)
Montana	Montana SBIR Program
Nebraska	Nebraska Department of Economic Development
New Hampshire	New Hampshire Inspires Innovation[b]
New Jersey	NJ Small Business Development Center (SBDC)
New York	Division of Science, Technology and Innovation (NYSTAR)
North Carolina	SBIR-STTR Incentive Program; NC Small Business Technology Development Center (SBTDC)
North Dakota	Center for Innovation
Ohio	Team SBIR
Oklahoma	OK Center for the Advancement of Science and Technology (OCAST)
Oregon	SBIR/STTR Phase 0 Matching Grant Program; Portland State Business Accelerator
Pennsylvania	Innovation Partnerships (IPart)
South Carolina	SC Phase 0 Program
South Dakota	SD SBIR Center
Tennessee	TN Technology Development Corporation (TTDC) Phase 0/00 Program
Utah	SBIR/STTR Assistance Center (SSAC)
Vermont	SBIR Phase 0 Program
Virginia	Center for Innovative Technology
Washington	Innovate Washington & WA Biotechnology Biomedical Association (WBBA)
West Virginia	WV Small Business Development Center (WVSBDC) Research and Commercialization Assistance Program
Wisconsin	Technology Matching Grant Program & WI Entrepreneurs' Network (WEN)
Wyoming	WY SBIR/STTR Initiative (WSSI)

[a] Transferred from the Minnesota Project Innovation.
[b] NH Inspires Innovation is a collaboration between the NH Innovation Research Center and the NH Small Business Development Center.

by state with Michigan's Emerging Technologies Fund offering a 25% match on Phase I awards and Kentucky's SBIR/STTR Matching Funds program and New York's NYSTAR program offering dollar for dollar matches.

The SMP-I programs provide additional early-stage capital to successful Phase I SBIR recipients as they work to demonstrate proof-of-concept. More than a simple investment in a promising firm, this match can be viewed as a state investment aimed at increasing the chances for the firm to secure the larger Phase II award and thereby direct additional federal R&D funds to the state. Moreover, with an average time lapse of 14 months for successful Phase II recipients,[24] the state match serves as a bridge from Phase I to Phase II funding. All successful Phase I applicants qualify for this funding although the size and number of awards are subject to the availability of state funds. It is worth noting that Virginia's SMP-I is unique in limiting the matching funds only to firms that secure SBIR funds through the Department of Health of Human Services (DHHS). The state matching funds, however, are not competitive and are thus classified as an SMP-I.

The federal SBIR program was designed with the expectation that successful Phase II recipients would be able to secure non-federal funding as they move toward product commercialization. To assist firms in this effort, the SMP-II provides matching funds to successful Phase II SBIR recipients. Following in line with the structure of the federal SBIR program, the size of SMP-II matches is larger than SMP-I matches, ranging as high as $500,000 for KY-based firms. Of the states with an SMP-I program, only four states have an SMP-II program as well. These are the Kansas Bioscience Authority, Kentucky's SBIR/STTR Matching Funds program, Michigan's Emerging Technology Fund, and the Oklahoma Center for the Advancement of Science and Technology. Again, all successful Phase II applicants qualify for this funding although the size and number of awards are subject to the availability of state funds.

SBIR Limited Matching (LM) programs, in contrast with the other two types of non-competitive state matching programs, offer competitive funds to only a selection of SBIR recipients. Four states have been identified as having LM programs. Florida's High Tech Corridor Council Matching Funds Research Program has teamed up with three universities[25] offering a range of competitive awards

[24] This was derived using data from the population of SBIR awards (1983–2010) listed in the SBA TechNet database.

[25] University of Central Florida (UCF), University of South Florida (USF), and University of Florida (UF).

Table 3
State SBIR Match programs (listed in order of initial adoption).

State	Program	Program features	Policy years
New York	NY State Office of Science, Technology, and Academic Research (NYSTAR)	Up to 100% Match	1984–1991
Hawaii	High Technology Development Corporation	Funding amounts vary, up to $25,000 Match	1989
Oklahoma	OK Center for the Advancement of Science and Technology (OCAST) SBIR	Up to 50% Match	1989
Florida (LM)[a]	Florida High Tech Corridor Council Matching Funds Research Program	Participating universities in the corridor – UCF, USF and UF – administer competitive funds and request matching funds for recipients	1996
Indiana	Indiana 21st Century Research and Technology Fund	Approximately 400 Phase I matches were made from 2003–2011. In 2008-2009 12 LM awards were made for successful Phase II recipients	2003
Kansas	Kansas Bioscience Authority	Up to 50% Match	2004[b]
New Jersey	NJ SBIR Bridge Grant Program	Up to $50,000 Match	2005–2009
Kentucky	KY SBIR/STTR Matching Funds Program	Up to 100% Match	2006
North Carolina	One NC Small Business Program	Range from $30,000 to $100,000 (subject to availability of funds)	2006–2011; 2014
Illinois	IL Department of Commerce and Economic Opportunity	Up to 50% Match	2007–2008
Michigan	MI Emerging Technologies Fund	Up to 25% Match (until funds are exhausted)	2008–2011
Massachusetts (LM)	Massachusetts Life Science Center	Competitive matching funds up to $500,000 per company to Phase II recipient who secured federal funding within last 7 years	2008
	Mass Ventures: MA START	Competitive 3-phase program; up to $800,000 available for firms that secure Phase II funding	2012
Nebraska	NE SBIR Initiative	Total funds are capped at $1 M per year	2011
Connecticut	CT Innovations	Matches require 50% Match from third-party	2012
Montana	MT SBIR/STTR Matching Funds Program	Up to $30,000	2012
Virginia	Center for Innovative Technology	Matching funds for DHHS-SBIR recipients	2012
Maryland (LM)	MD Biotech SBIR and STTR Bridge Grant Program	Competitive funds up to $100,000 for firms that have applied for Phase II funds	2012

[a] Denotes limited Match program.
[b] First Match was made in 2007.

with the additional requirement that the firm secure external matching.[26] Massachusetts has two programs that offer matching funds specifically for SBIR recipients. MassVentures' START program is a three-stage program offering competitive funds up to $800,000 for early-stage R&D activity for SBIR Phase II recipient firms. The Massachusetts Life Science Center provides competitive matches for Phase II recipients focusing on life science research. Indiana's 21st Century Research and Technology Fund provided $4.1 million of competitive funds in 2008 for 12 successful Phase I SBIR recipient firms. Lastly, Maryland's Biotech SBIR and STTR Bridge Grant Program provides ten matching grants annually of up to $100,000.

Although there is commonality in the types of programs across states, the information in Table 1 highlights the range in the combination of state programs available to small firms engaged in early-stage R&D activity. Fourteen states[27] notably have offered both Outreach and Match programs. Kentucky stands out as having one of the more aggressive portfolios of state programs, offering up to a 100% match through its SMP-I and SMP-II programs in addition to the support services offered through the Kentucky S&E Foundation. These programs reveal a proactive approach both to foster early-stage R&D activity in firms within the state and to attract firms from outside the state.[28] North Carolina stands out as another proactive state with a slightly different portfolio of programs. These include the One NC Small Business Program (SMP-I), the NC SBIR-STTR Incentive Program offering up to $3000 for proposal preparations (Phase 0), and the NC SBTDC (Support Services), which provides a range of support services for firms interested in applying for the federal SBIR funds. Although NC's SMP-I ended in 2011, the state program was reinstated as of 2014. Virginia is another state offering a large range of SBIR-related programs including matching funds for successful DHHS SBIR recipients (SMP-I), training programs for prospective SBIR applicants (Support Services) and funding assistance for proposal development (Phase 0/00). Of the states that offer a more limited range of programs, three states (Massachusetts, Maryland, and Michigan) have only Match programs while 28 states have only Outreach programs.

4. Multilevel motivations of state responses: an empirical analysis

To build upon the theoretical framework defining the multilevel policy mix, we empirically examine the motivations multilevel policy responses for innovation policy.[29] Within the U.S. context, state SBIR policy responses serves as an illustrative example for analysis. In this section we focus on the most aggressive match program and empirically a range of motivating factors associated with this policy response.

While SBIR Outreach programs are more prevalent across U.S. state governments, they are more heterogeneous in terms of services offered to complement the federal SBIR program. The SBIR Match programs, however, represent more uniform and aggressive state policy responses designed to augment the federal program.[30]

[26] Source: http://www.floridahightech.com/research.php.

[27] Connecticut, Florida, Hawaii, Illinois, Indiana, Kansas, Kentucky, Montana, Nebraska, New Jersey, New York, North Carolina, Oklahoma, and Virginia.

[28] It is worth noting that many state officials from states other than KY were aware of KY's SBIR programs. Unprompted, many state officials mentioned that they looked to KY's portfolio as an exemplar for state SBIR programmatic activity.

[29] We focus on innovation policy given its appeal to multiple levels of government.

[30] It is worth emphasizing data limitations and methodological hurdles limit the analysis to the SMP-I program rather than the wider array of state SBIR Match and Outreach programs. Not only does the SMP-I programs have the feature of sharing a consistent structure across all states allowing for between state comparisons, the qualitative differences across the SBIR Outreach and even Limited Matching programs make such comparisons a notable empirical challenge. For example, the

Of the 17 states with some form of match, 14 share the most common program – the SMP-I program. Not only is this the most diffuse among the Match programs, it continues to gain traction as three additional states – Alabama, Nevada and Rhode Island – have publicly expressed interest in adopting the SMP-I program in the near future.[31]

4.1. Institutional overview

By reviewing press releases from SSTI and legislative statutes related to these SMP-I program adoptions and reauthorizations and through follow-up correspondences with each of the state agencies administering the program, we were able to gain a preliminary understanding of the conditions that motivate states to adopt and maintain this program. This preliminary understanding, coupled with a review of the broad literatures on state policy diffusion and science policy, inform the design of the empirical model. Below, we first overview the qualitative information we gathered on each SMP-I program and then couch this information within the broader theoretical literature.

Three states – New York, Hawaii, and Oklahoma – were the earliest adopters, implementing an SMP-I program within the first few years of the federal SBIR program tenure. When NY adopted its SMP-I program in 1984, which offered a one-to-one match, it was already among the leading states in R&D activity.[32] However, the program was only maintained for seven years. HI and OK, by contrast, have historically been less competitive on a series of R&D measures and have thus been identified as Experimental Program to Stimulate Competitive Research (EPSCoR) states.[33] Their early adoptions of SMP-I programs might be understood as proactive efforts to improve the lagging R&D performance in their states. In contrast to NY, both of these states' programs have been maintained to the present.

The remaining 11 states, however, all adopted after the 2000 federal SBIR reauthorization. Indiana's 21st Century Research and Technology Fund adopted the program in 2003 reportedly as a response to the state's declining per capita income.[34] Kansas followed in 2004 with the Kansas Bioscience Authority overseeing the program to leverage the state's R&D base and by ensuring it is "considered a national leader among investment professionals."[35] New Jersey's SBIR Bridge Grant Program, adopted in 2005, reportedly aimed to sustain the funding gap for early stage activity, which they note as often crippling small firms.[36] Kentucky, initially adopting the program in 2006, has one of the most aggressive programs offering a 1:1 match.[37] Not only are recipients required to spend the majority of the match funds within the state boundaries, the state program notes its explicit intention to attract firms from outside the state to relocate to KY to expand the state's innovative sectors. North Carolina's One NC Small Business Program and Illinois' Department of Commerce and Economic Activity were adopted in 2006 and 2007, respectively, with the explicit intention of moving their state economies toward the top tier for industrial R&D activity.[38] Michigan adopted in 2008 and established the Emerging Technologies Fund to award exceptional research within the state. In 2011 and 2012, Nebraska, Connecticut, Montana and Virginia all adopted noting similar motivations.

This institutional overview suggests that states have an implicit awareness of the spatially proximate benefits of innovative activity. This complements the broader themes and research findings within the literature (Greenstone et al., 2010; Hall et al., 2000; Jaffe et al., 2000; Lerner, 1999). It appears as though state interest in the program is likely attributable to a number of factors stemming from multiple levels of influence from national and state level conditions. At first glance, the timing of adoptions of the SMP-I – notably the upsurge in initial adoptions after 2000 – suggests that the federal program expansion in 2000 may have served as a catalyst for state interest. Additionally, state benchmarking, in terms of their innovative and economic capacity, appears to motivate a response. This suggests that motivations are multilevel, stemming both internally within the state and across borders (horizontally and vertically).

4.2. Multilevel motivations

The large policy diffusion literature (Berry and Berry, 1990; Boushey, 2010; Graham et al., 2008; Gray, 1973; Walker, 1969; others) offers a useful theoretical framework for identifying the range of factors that may influence this state response. Berry and Berry's (1990, 2007) seminal work on state lottery adoptions examines three broad groups of antecedent factors that influence state policy adoption – national interaction, Regional Diffusion, and internal determinants. This schematic is useful within the context of multilevel policy analysis by classifying antecedent variables across different levels of the federalist structure. This suggests that the structure of the policy mix itself shapes the process of the response. In addition, the broad literature on science policy and innovation (e.g., Cozzens, 2003; Hecker, 2005; Ruegg and Feller, 2003; Stephan, 2012; Teich, 2009) provides further guidance for identifying relevant economic and R&D-related factors. Taken together, we extend this discussion and examine three sets of multilevel factors for the empirical model – top–down, lateral and bottom–up.[39] Within each set we consider a range of political, economic and R&D-related factors that likely drive adoption. These factors are each discussed in turn.

4.2.1. Top–down

Since its inception, the federal SBIR program has undergone a series of reauthorizations that have expanded its scope and scale. We expect that states react to these federal policy actions and are more likely to adopt in the years immediately following one of the reauthorizations. Additionally, because the SMP-I program's broad aim is to leverage federal R&D expenditures, the size of federal investments for applied R&D likely plays a role in state government decisions to have the SMP-I program. The practice of states

state of Washington oversees an internship program that matches graduate students or postdocs with companies to assist in the proposal writing process, while Utah's SBIR/STTR Assistance Center offers more basic logistical support in terms of helping firms identify the most appropriate federal agency solicitation and assisting with proposal submissions. Different states' Outreach or Limited Match programs might be compared in terms of the size of the program budgets; however, this information is not easily accessible and this approach would overlook important qualitative differences in the structure of these programs.

[31] Alabama: Accelerate Alabama (http://www.madeinalabama.com/assets/2013/03/AccelerateAlabamaPlan.pdf); Nevada: Governor's Office of Economic Development (GOED) (http://www.diversifynevada.com/documents/state_plan/2012_NVGOED_StatePlan_Full.pdf); Rhode Island: Sen. James Sheehan expressed interest in 2012 (http://webserver.rilin.state.ri.us/News/pr1.asp?prid=8509).

[32] Research by Feldman et al. (2014) on state university R&D programs shows that the state has been active by promoting economic activity via S&T programs.

[33] EPSCoR is a federal program designation that gives preferential treatment for low R&D performing states.

[34] Source: http://www.elevate-ventures.com/programs/sbir-sttr.

[35] Source: http://www.kansasbioauthority.org/working-with-kba/funding-programs/.

[36] Source: http://www.state.nj.us/scitech/entassist/sbir/.

[37] Source: http://ksef.kstc.com/index.php?option=com_content&view=article&id=113&Itemid=205.

[38] Sources: http://www.ssti.org/Digest/1999/032699.htm; http://www.ssti.org/Digest/2005/082905.htm.

[39] We thank the anonymous reviewers for helping to develop this section.

looking to federal policy actions is certainly not unique to this portfolio of programs; Baumgartner et al. (2009), for example, find in their review of energy-stabilizing programs that federal policy activity directly coerces and stimulates complementary state policy activity.

Looking more closely at the structure of the federal SBIR program, the amount of funding available depends on the participating federal mission agencies' research budgets, with the Department of Defense (DOD) accounting disproportionally for the largest share of SBIR activity (Wessner, 2008). There is great heterogeneity in the industrial structure of states, which determines their ability to benefit from the federal program and thus their incentive to implement complementary policies. We expect that states with more defense-related activity, as demonstrated by their capacity to secure federal DOD funding, are more likely to have the SMP-I policy.

Turning to economic factors, a recent report issued by the Kauffman Foundation, "The State of Entrepreneurship: State and Local Governments Hold the Key to Accelerating Economic Growth in 2012,"[40] emphasizes the links between innovation policy and economic activity, specifically technology-based, skilled, high-wage employment. Nebraska Governor Dave Heineman's 2011–12 National Governor's Association Initiative, "Growing State Economies,"[41] asserts much of the same conclusion. Such national public reports and initiatives, coupled with the growing research linking the federal SBIR program with employment growth (Link and Scott, 2012) likely direct states' attention to SBIR-related programs as a means to bolster their economies.

4.2.2. Lateral

There is growing evidence to suggest that policymakers are constrained by limited resources (Karch, 2007) and bounded rationality (Simon, 1978). Research has found that in confronting such problems, state policymakers may emulate other state governments, notably those adjacent to them (e.g., Berry and Berry, 1990). Thus, we expect that states are more likely to adopt and maintain the program as the share of their neighbors with the program increases.

4.2.3. Bottom–up

Internal state conditions also likely influence state responses. Regarding political factors, there is a long standing political debate over the proper scope of public R&D support stemming back to Vannevar Bush's (1945)[42] influential report,[43] "Science, the Endless Frontier." We anticipate that Democratic Governors are more likely to support the SMP-I program. Besley and Case (1995) find that new program spending is higher under Democratic Governors, while republican governors are more likely to focus on tax cuts. More conservative politicians would likely withhold public support from R&D, arguing that government funds crowd-out private investment.

The challenge in using this measure, however, lies in the fact that we are considering a policy over a 30-year period where the preferences and priorities of the democratic and republican political parties have fluctuated along the political spectrum. In an effort to address this shortcoming, we consider an additional political variable that measures a state's early interest in science policy. In the early 1960s, after the 1957 launch of Sputnik and the subsequent upsurge in federal investment in R&D, a cohort of states followed the federal government's lead and established science policy advisory positions (Sapolsky, 1968).[44] This early policy activity suggests that certain states may have more of a proclivity toward science policy than others.

Turning to economic factors, implementing R&D and innovation-based programs not only entails a certain level of risk, but also requires slack resources to fund the SMP-I financial awards. Therefore, we anticipate that states with strong fiscal health are more likely to adopt and maintain this matching program.

While states surely consider their industrial structure and may seek to build upon their industrial strengths, the recent growth of state science and innovation-based activity can also be viewed as an effort by states to address weaknesses in their relative R&D capacity and economic competitiveness. Taylor's (2012) recent article on the role of governors as economic problem solvers highlights that states turn to R&D investment to curtail their lagging economies. We therefore anticipate that states lagging in R&D performance are more likely to adopt this program as a bottom–up effort to boost their economies. Of course, disentangling the causal direction between R&D performance and having the SMP-I program is certainly problematic, as we expect states to consider their R&D capacity as they implement a policy directed to improve this very vector of performance measures. Nevertheless, we include these R&D variables to estimate the strength of the associations.

4.3. Methods and data

While much of the policy diffusion literature employs event history analyzes (EHA) to examine the antecedent factors that may influence initial state policy adoptions, this article's focus on state policy responses within a policy mix framework necessitates a slightly different empirical approach. EHA is predominantly used to examine the risk of a discrete event with observations subject to only one transition. With a focus on policy responses, we are interested in a longer series of events that include state adoptions, reauthorizations and even terminations.[45] EHA analysis only considers the factors leading up to the initial adoption and ignores the factors associated with the program's continuation or termination. To account for this greater range of state activity, this study examines multilevel factors associated with adopting and maintaining an SMP-I program through OLS econometric methods.[46]

$$Pr(\mathrm{SMPI}_{it}) = \alpha_i + \beta_1 \mathrm{Top\_down}_t + \beta_2 \mathrm{Lateral}_{it} + \beta_3 \mathrm{Bottom\_up}_{it} + \epsilon_{it} \quad (1)$$

Eq. (1) is a state level fixed effects model estimating the relationship between three sets of factors and the dichotomous outcome variable SMP-I_{it}, where i denotes the state and t denotes the year. This analysis uses data from 1983 to 2010, a timeframe that was determined by the initial establishment of the federal SBIR program and the availability of data for the covariates; the four recent SMP-I adoptions since 2010, therefore, are not included. Table 4 details

[40] Source: http://www.kauffman.org/newsroom/the-state-of-entrepreneurship-state-and-local-governments-hold-the-key-to-accelerating-economic-growth-in-2012.aspx.

[41] Source: http://www.subnet.nga.org/ci/1112/.

[42] Vannevar Bush wrote this report in 1945. The 1980 reprinted version published by the National Science Foundation.

[43] Please note that this report was reprinted in 1980. The report was first published in 1945; however, we reference the more recent reprint in the reference section.

[44] These states include: Connecticut, Georgia, Hawaii, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, New York, North Carolina, Oklahoma, and Pennsylvania.

[45] Due to state budgetary limits, state policies are not ensured in perpetuity but rather are subject to a reauthorization process as frequently as on an annual basis. Initial policy adoption may demand greater political backing than its reauthorization does; nonetheless, the true tenure of a state program is rarely determined at the time of its adoption.

[46] Although a series of estimation procedures are employed – including the use of state fixed effects – to discern the causal relationships between the state and national level factors that affect the policy adoption, the authors are hesitant to claim causality with this model. Given that this analysis considers the tenure of the SMP-I program – as opposed to the initial adoption – disentangling the direction of causality is problematic as the relationships, especially among the state-level covariates, are likely endogenous.

Table 4
Indicators for empirical model.

Variable	Metric	Unit of analysis	Source
State Match	State Matching Program – Phase I_{it}	Binary	Various state government agencies, SSTI[a]
Multilevel motivating factors			
Top–down			
Federal Applied R&D[b]	Total Fedral Industrial $R\&D_t{}^{\dagger}$	Continuous, logged (adjusted for inflation)	NSF Survey of Federal Research Funds for R&D
Federal Reauthorization Window[c]	$\sum_{t+2}^{n}$ SBIR Federal Reauthorization $Window_t$	Binary	Derived
Industrial Specialization	DOC $Contrasts_{it}{}^{\dagger}$	Continuous, logged (adjusted for inflation)	Federal procurement data system
Lateral			
Regional Diffusion	Proportion of contiguous states with $SMP\text{-}I_{it}$	Continuous (ratio)	Derived from SMP-I policy variable
Bottom–up			
Democratic Governor[d]	Democratic $Governor_{it}$	Binary	Book of States: Council of State Governments
Early Science Advisor	Early Science $Advisor_i$	Binary	Sapolsky (1971)
State Revenue	State $Revenue_{it}{}^{\dagger}$	Continuous, logged (adjusted for inflation)	US Census State Government Finances
High Tech Employment[e]	High Tech $Employment_{it}$	Quartile binary rankings of continuous LQ	Derived from Bureau of Economic Analysis
Higher Education Capacity[f]	NIH & DOD Federal Agency Obligations for $R\&D_t{}^{\dagger}$	Continuous, logged (adjusted for inflation)	NSF Survey of Federal S&E[g]

Notes: *i* denotes state and *t* denotes year. † denotes that the variable has been adjusted for inflation using the July 2013 GDP implicit price deflators – base year 2005; in addition, the data on expenditures in real (2005) dollars are presented in logged form.

[a] For a more detailed discussion of how this information was gathered, see the Appendix.

[b] This indicator reports the sum of Applied Research obligations for Industrial Firms (excluding FFRDCs) for the 11 Federal mission agencies that participate in the SBIR/STTR Federal program.

[c] The window includes the year of the initial SBIR legislation and subsequent reauthorizations – 1982, 1992, and 2000 – and the two years following the federal legislation. The most recent SBIR reauthorization (2011) was not included since it fell outside the timeframe for this analysis.

[d] Nebraska was coded as missing for this indicator due to the unicameral structure of the state legislature.

[e] High tech employment was drawn from the list of high tech industries based on the BLS definition (Hecker, 2005). Location Quotient = $\frac{\text{high tech employment}_{it}/\text{total employment}_{it}}{\text{US high tech employment}_t/\text{US total employment}_t}$. The empirical models report the quartile rankings of the high tech employment location quotient with Q4, the quartile of states each year with the highest location quotient, serving as the referent category.

[f] This indicator reports the sum of NIH and DOD federal agency obligations for R&D for higher education institutions, respectively.

[g] NSF survey of federal S&E support to universities, colleges, and nonprofit Institutions.

the list of the variables, their data sources and functional forms. We have classified each of the motivating factors as top–down, lateral or bottom–up; however, we recognize that some measures may have implications across multiple levels. Each set of variables is discussed in turn.

Three variables are included to assess top–down, nationally driven factors – Federal Applied $R\&D_t$, Federal Reauthorization $Window_t$, and Industrial $Specialization_{it}$.[47] In lieu of using year fixed effects, which consume many degrees of freedom and pose a concern for state-level models, the former measure controls for annual macro-economic shocks that may be associated with state innovation policy actions. This variable measures total federal obligations for applied R&D for industrial firms. Federal Reauthorization $Window_t$ is a dichotomous variable coded 1 for the year of the federal SBIR program's implementation and Reauthorizations, as well as the two years following the federal policy actions. The program was initially implemented in 1982 and was reauthorized in 1992, 2000, and 2011. The most recent reauthorization in 2011 falls outside the timeframe for this analysis. Regarding the third variable, due to the greater level of DOD SBIR resources available, we include Industrial $Specialization_{it}$[48] as a measure of states' industrial specialization in defense-related activity. Specifically, this measures federal DOD contract activity within the state.[49]

We include one measure to directly assess lateral factors – Regional $Diffusion_{it}$. Drawing from Berry and Berry's (1990) work, we include a continuous variable measuring the relative proportion of contiguous states with the SMP-I program to assess state peer effects.

A series of bottom–up, state level political, economic and R&D-related variables are included as well. Democratic $Governor_{it}$ is a dichotomous indicator of the governor's political party – coded 1 in the years the state has a Democratic Governor. Recognizing the shortcomings of relying solely on the political partisanship of the governor,[50] we interact this measure with the binary variable Early Science $Advisor_i$ in case state political factors are driven by early-demonstrated political interest in science policy (Sapolsky, 1968). The baseline value is time-invariant and therefore is not reported in the state fixed effect model.

Turning to economic factors, we include State $Revenue_{it}$ to measure the health of the state's budget.[51] This variable enables us to

[47] In Eq. (1) we note that the variables vary only by year; however, this does not pertain to the Industrial $Specialization_{it}$ variable.

[48] We considered including data for DHHS since this federal mission agency also accounts for a disproportionately large amount of SBIR funds; however, data on contracts and grants is only available after 2000, thus significantly limiting the timeframe for the analysis.

[49] This is an example of a variable that has implications with top–down and bottom–up conditions. We thank our anonymous referee for drawing our attention to this cross over.

[50] We thank our anonymous referees for drawing our attention to this limitation.

[51] As noted in Table 4, all expenditure values in the model are adjusted for inflation and are presented in logged form.

Table 5
Descriptive statistics.

Variables	Mean	Standard deviation	Minimum	Maximum
SMP-I	0.06	0.24	0	1
Federal Applied R&D	22.03	0.18	21.71	22.33
Federal Reauthorization Window	0.29	0.45	0	1
Industrial Specialization (DOD contracts)	20.98	1.58	16.47	24.73
Regional Diffusion	0.05	0.11	0	0.75
Democratic Governor	0.51	0.50	0	1
Dem Gov × Early Sci Advisor	0.15	0.36	0	1
State Revenue	16.46	0.98	14.26	19.45
High Tech Employment (LQ)	0.88	0.24	0.27	1.87
High Tech Employment (LQ, Q3)	0.26	0.44	0	1
High Tech Employment (LQ, Q2)	0.24	0.43	0	1
High Tech Employment (LQ, Q1)	0.26	0.44	0	1
Higher Education Capacity (NIH)	17.91	1.85	11.61	21.66
Higher Education Capacity (DOD)	16.32	1.72	10.50	19.97

Notes: Unless other noted, the number of observations is 1400 (data on 50 states from 1983 to 2010). Nebraska was coded as missing for the Democratic Governor indicator due to the unicameral structure of the state legislature. Only 49 states are included; the total number of observations is 1372. Data on higher education capacity is available for the 50 states from 1983 to 2009. Thus, the number of observations for these variables is 1350. Additionally, four states received no DOD higher education support over the time period. Given that the data is reported in logged form, these were coded as missing. The total number of observations for higher education capacity (DOD) is 1346.

assess how the amount of slack funds available to the state government relative to that state's mean relates to the state policy adoption and maintenance. Additionally, we include a series of economic measures related to the state's R&D capacity – High Tech Employment$_{it}$ and Higher Education Capacity$_{it}$. The former measures the High Tech Employment capacity for a state. This is derived from employment data that is stratified by industry, and it relies on the Bureau of Labor Statistics' definition of high-tech industries (Hecker, 2005). Given that states likely benchmark their performance to that of other states, we use the quartile rankings of the location quotient functional form to measure the relative High Tech Employment capacity of states.[52] With states positioned in a zero-sum situation competing for limited federal funds, there is evidence to show that they pay greater attention to their relative standing rather than to their absolute performance (Feldman and Lanahan, 2015). The nature of this variable's functional form allows us to assess lateral effects as well.

While High Tech Employment$_{it}$ can be understood as a downstream R&D measure, we also include Higher Education Capacity$_{it}$ as a measure of states' R&D upstream capacity. Although the SBIR program is designed to support early-stage innovative activity among small firms, it is likely that many firms originate to some extent as spinouts from university research activity. Drawing upon data on state higher education research activity, we include two variables that assess the state's research strength in DHHS-related (specifically, the National Institute of Health (NIH)) and DOD-related fields.

We additionally considered including a measure of the state's SBIR capacity defined as the rate of Phase I recipients that end up securing Phase II federal funding. As with the High Tech Employment indicator, states may likely benchmark their SBIR performance to other states' given that they are competing for funds from the same program. However, complete SBIR funding activity was only recently made publicly available in 2011 through the SBA's central, user-friendly database. Prior to that time, award data was decentralized, unstandardized and difficult to access making it difficult for state policymakers to assess their own state's success or peer states' success in securing federal SBIR funding. For this reason, we determined that such a measure was not needed in this model.

Advocacy coalitions may significantly impact state policy activity; thus in earlier iterations of this research, we included a series of dummies to control for years when the National Governors Association focused on innovation and the economy. However, the results were not robust suggesting that this may be an insufficient measure. Additionally, we hoped to include variables measuring state-level private investments in private firms – notably seed, angel and venture capital funding – and state government investments in private firms. Unfortunately, accurate state-level data on all these measures are not accessible for our timeframe of interest. We attempt to address these empirical challenges by including state fixed effects, α_i, to control for state specific time-invariant factors. This approach is helpful for controlling for state and private investment trends, which are likely time-invariant, though we realize that we are unable to control for factors related to advocacy activity, which likely has greater variation.

Eq. (1) was estimated using a Linear Probability Model (LPM) with state fixed effects, pooled probit with year and state dummies and pooled cross-sectional LPM.[53] In addition, a series of specification strategies were employed to assess the potential influence of outliers and the functional forms of the state-level covariates. The results were generally robust across all specifications. This article presents the results for the LPM state fixed effect model due to the ease of interpretation it allows regarding the marginal effects and the more conservative nature of its estimates since it controls for state time-invariant unobserved factors.[54]

4.4. Results

Table 5 reports the descriptive statistics of the set of multi-level variables in Eq. (1); again, all expenditures are adjusted for inflation and are presented in logged form. Table 6 presents the correlation matrix for the variables in the empirical model.[55] Table 7 presents the coefficients from the LPM state fixed effects regression with each successive model including an additional set of multilevel covariates, respectively. To elaborate, Model 1 reports the baseline model with the top–down variables; Model 2 adds the

52 The U.S. average serves as the referent base in the location quotient, and the fourth quartile ranking of the location quotients, the leading cohort of states, serves as the referent category.

53 Both the pooled probit and LPM models were run with state clustered standard errors. We compared the direction and level of significance of the odds ratio, in addition to the average marginal effects from the probit models to the LPM fixed effects models. The LPM fixed effects models offered more conservative estimates.

54 Out-of-range predications ranged from 27% to 36% depending on the model. This article, however, is retrospective in nature and not concerned with predictions.

55 We determined that multicollinearity is not an issue for this model (Wooldridge, 2006). The VIF test was run after every model and did not exceed 2.6.

Table 6
Correlation matrix of variables in empirical model.[a]

	SMP-I	Federal R&D	FRW	Ind. Sp.	Regional Diffusion	Dem gov	Interaction	State Revenue	HTE (Q3)	HTE (Q2)	HTE (Q1)	HEC NIH	HEC DOD
SMP-I	1.00												
Federal R&D	0.09	1.00											
FRW	−0.08	−0.01	1.00										
Ind. Sp.	0.08	0.09	−0.09	1.00									
Regional Diffusion	0.11	0.10	−0.16	0.23	1.00								
Democratic Governor	0.10	−0.12	0.02	0.00	0.11	1.00							
Interaction	0.30	−0.08	0.02	0.18	0.03	0.42	1.00						
State Revenue	0.08	0.26	−0.07	0.81	0.18	−0.01	0.14	1.00					
HTE Q3	−0.06	0.00	0.00	0.18	0.10	0.02	−0.06	0.13	1.00				
HTE Q2	0.08	0.00	0.00	0.03	0.02	0.13	0.18	0.02	−0.33	1.00			
HTE Q1	0.03	0.00	0.00	−0.53	−0.15	−0.02	−0.05	−0.48	−0.35	−0.33	1.00		
HEC NIH	0.04	0.26	−0.05	0.78	0.21	0.00	0.18	0.84	0.25	0.05	−0.64	1.00	
HEC DOD	0.05	0.22	−0.05	0.75	0.13	−0.04	0.19	0.78	0.21	0.00	−0.50	0.82	1.00

[a] The variable labels have been abbreviated in this table. The order of the variables reflects the order presented in Tables 4, 5 and 7.

lateral Regional Diffusion variable; and Model 3 presents the full set of variables and includes the series of bottom–up variables that include political, economic and R&D-related measures.[56] Model 3 includes the quartile rankings of the location quotient functional form for High Tech Employment. The fourth quartile – the cohort with the leading rankings for High Tech Employment – serves as the referent category.

The variable Federal Applied R&D was included in all the models in lieu of year fixed effects and controls for federal R&D investments in industrial applied research. The association is positive and statistically significant for Models 1 and 2; however, it is no longer significant once the bottom–up, state variables were added. The coefficients for Federal Reauthorization Window, which denote the years of federal SBIR legislative activity as well as the two years following each reauthorization year, are negative, yet only statistically significant in the baseline model. Among the top–down variables, Industrial Specialization is positive and the only measure that is robustly statistically significant across all models. As for the lateral measure, Regional Diffusion, the coefficient is positive and robustly significant. The coefficient from the full model indicates that the marginal increase in the proportion of contiguous states with the SMP-I increases the probability of the state having the program by 0.122, ceteris paribus.

Turning to the set of bottom–up, internal state controls, the coefficient for Democratic Governor is positive, yet not statistically significant. The size of the differential effect, however, increases among those states with an early science policy advisor and is positive and jointly significant when the interaction term – Dem Gov × Early Sci Advisor – is added.[57] In the full model, states with a Democratic Governor and with an early science policy advisor position have a 0.065 greater probability of having the SMP-I program than those without these characteristics.[58] The baseline measure for Early Science Advisor was not reported since time invariant factors drop out in state-fixed effect models.[59] As for the state economic and R&D-related factors, the coefficient on State Revenue is positive and statistically significant indicating that states with greater slack resources are more likely to have the program. Next, the quartile dummies for High Tech Employment are significant and positive for all three quartile rankings. This indicates that states that are not leading in terms of High Tech Employment are more likely to have an SMP-I program. The two variables measuring Higher Education Capacity are not robust in the full model.

5. Discussion

The empirical component of this article was an exploratory exercise to move the theoretical discussion of the policy mix forward and identify trends among a range of multilevel factors that drive policy enhancement – specifically, policy augmentation – responses. It estimates the relationship between a series of multilevel factors and the response of states' adoption and maintenance of an SMP-I program – the most widely diffuse and traceable state SBIR Match program.

Among the top–down measures, the results from the industrial specialization variable suggest that states do consider their industrial structure in relation to the structure of the federal

[56] Out-of-range predications were 28.4% for Model 1; 27.3% for Model 2; and 36.2% for Model 3.

[57] Joint significance was determined by running *F* tests for Democratic Governor and Dem Gov × Early Sci Advisor for each model. The joint significance tests for model 3 was as follows: *F* test = 5.35 (***$p < 0.01$).

[58] $\delta y/\delta x = 0.014 + (1 \times 0.051) = 0.065$, where Early Science Advisor = 1.

[59] Additional specification tests were run with a pooled OLS model to include the baseline measure, and as expected the direction and significance were positive and robust.

Table 7
LPM state fixed effects model.

Variables	(1) SMP-I	(2) SMP-I	(3) SMP-I
Top–down			
Federal Applied R&D	0.065**	0.060**	−0.036
	(0.027)	(0.027)	(0.049)
Federal Reauthorization Window	−0.020*	−0.015	−0.009
	(0.011)	(0.011)	(0.011)
Industrial Specialization (DOD contracts)	0.067***	0.058***	0.052***
	(0.010)	(0.010)	(0.012)
Lateral			
Regional Diffusion		0.200***	0.122**
		(0.054)	(0.057)
Bottom–up			
Democratic Governor			0.014
			(0.012)
Dem Gov × Early Sci Advisor			0.051**
			(0.024)
State Revenue			0.055**
			(0.026)
High Tech Employment (LQ, Q3)			0.051**
			(0.021)
High Tech Employment (LQ, Q2)			0.053**
			(0.025)
High Tech Employment (LQ, Q1)			0.088***
			(0.033)
Higher Education Capacity (NIH)			0.013
			(0.015)
Higher Education Capacity (DOD)			0.005
			(0.008)
Constant	−2.759***	−2.469***	−1.518*
	(0.566)	(0.569)	(0.835)
Observations	1,400	1,400	1,319
R-squared	0.057	0.066	0.084
Number of statecode	50	50	49
State FE	YES	YES	YES

Notes: Data includes years from 1983 to 2010; complete case analysis is used. Coefficients are from a linear probability model (LPM) state fixed effect model. Model 1 offers a baseline that includes top–down variables. Model 2 adds the lateral Regional Diffusion variable. Model 3 presents the full model and includes the series of political, economic and R&D-related bottom–up variables. Note NE is removed from the model due to the unicameral legislature. The baseline value for Early Sci Advisor is not included given that it is time invariant.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

program when deciding whether or not to adopt or maintain the program.[60] Having the SMP-I program can be viewed as a state's effort to build upon its pre-existing industrial and innovative capacity that augments the existing program. While the other two top–down measures are not robust in the full model, the direction of the negative coefficients for the variable Federal Reauthorization Window are surprising. One would expect state policy actions to sequentially follow the federal actions given that the program is intentionally designed to complement the federal SBIR program. Yet the results are suggestive of the opposite – Federal SBIR legislative activity is associated with a decrease in the likelihood of having an SMP-I Match program.[61] It is worth noting that we only included the year of federal legislative activity and the two years following in our Federal Reauthorization Window variable. Perhaps any robustly significant federal influence on state policymaking activity takes place over a longer timeframe when the federal program is in a more stable state.[62] For this analysis, however, we were interested in the immediate Reauthorizations Window. Moreover, it is important to note that the upper time limit for this analysis is 2010 (due to data limitations), so the most recent state adoptions are not included. The most recent Federal Reauthorization in 2011, which was finally passed after fourteen short-term continuing resolutions that took place over a three-year period, resulted in a six-year extension and expansion of the current program. Seemingly in response to this, four states then adopted the program thereafter and three others publicly expressed interest in adopting. The sign for this coefficient may change with updated data that includes these years.

As for a lateral effect, the results from Regional Diffusion indicate that neighboring peer effects do exert pressure on states to consider adopting or maintaining the policy. Contrasting these results with those of the politically-driven top–down variable – Federal Reauthorization Window – we are led to conclude that external governmental pressures stem more from neighboring state actions than from federal policymaking. That is to say that lateral politics appear to outweigh top–down federal actions. This stands in contrast to what we might expect given the federal government's prominent role in science policy and R&D spending (e.g., Teich, 2009). Placing this discussion within the framework of the 2 × 2 matrix discussed above, this suggests that the policy response is not only an example of enhancement – a state response to national policy activity – but also experimentation – a state response to another state policy activity.

Turning to bottom–up factors, the differential effect on the interaction term notably increases for those states that have a

[60] We thank one of the anonymous reviewers for encouraging us to consider this measure as a top–down measure.
[61] Yet again, we recognize that these effects are not robust; and therefore, interpret with caution.
[62] This trend stands in contrast to that of the SBIR Outreach programs, many of which were initiated with partial federal funding.

Democratic Governor and that demonstrated early interests in science policy by establishing a science policy advisor position in the 1960s. It appears that certain states with this demonstrated interest have a greater proclivity toward science policy and innovation programs. Results from the State Revenue measure show that state governments tend to have the program in years when their revenue is up.[63] This makes sense insofar as the SMP-I program, in contrast to the SBIR Outreach programs, requires a greater level of investment.

Results from the High Tech Employment quartile dummies indicate that states with lagging High Tech Employment have a greater chance of having a match program. While we classify this as a bottom–up measure, the nature of the functional form has implications for lateral effects as well. This points to the SMP-I as a proactive, catch up effort by state policymakers. Indeed, looking more closely at the size of the coefficients for this series of variables, the likelihood of having the SMP-I is strongest for states in the lowest quartile. Placing this result next to the results from the industrial specialization variable, nevertheless, suggest that having the SMP-I program cannot be viewed entirely as a catch up effort; it must also be seen as a state's effort to build upon its pre-existing industrial and innovative capacity. High Tech Employment assesses more downstream R&D activity, while industrial specialization is a more upstream measure. Taken together, the results for these measures suggest that states are more likely to rely on the strength of their R&D capacity – as measured by their ability to secure DOD R&D funds – while lagging performance along a more downstream measure appears to incentivize state policy action.

6. Conclusions

This article examines multilevel innovation policy responses within a dynamic context, highlighting the interdependencies between different jurisdictions. By considering the level of government where policy originates and then the subsequent response by other levels of government, we bring greater focus to the policy mix. We highlight four archetypes of multilevel policy responses that are salient for the U.S. context. Most salient for our purposes is the concept of policy enhancement – state government policy responses that either complement or augment federal policy. We provide a detailed examination of state innovation programs that are designed to enhance the federal SBIR program and find evidence of two broad types of state SBIR programs that have been implemented in response to the federal SBIR program. The results from our empirical analysis indicate that state policy implementation is associated with a confluence of multilevel factors driven not only by top–down federal actions, but also from bottom–up, internal state political and economic factors as well as from lateral pressures from peer states.

The contributions of this article are twofold. First, we provide a theoretical framework that considers multilevel innovation policy responses broadly. Our specific context is calibrated to federalist systems like the U.S., Germany and Australia, among others. As we find that context matters in making policy endogenous, we hope that others will build upon our work and add other dimension to considerations of multilevel innovation policy mixes. Our second contribution is to provide an empirical analysis of the multilevel conditions that motivate state policy responses. We employ a large-scale assessment of a multilevel innovation mix by focusing on state responses designed to enhance the U.S. federal SBIR program. The results from the empirical analysis complement the qualitative information gathered on state SBIR responses and point to a confluence of multilevel factors – top–down, lateral and bottom–up – that are associated with the state policy adoption and maintenance. In other words, we find an assemblage of multilevel motivating factors associated with the subsequent state response. Most pointedly the results indicate the endogeneity of policy activity at the subnational level.

Until now, the majority of research on innovation policy activity has focused on national or subnational policies, respectively, without taking into consideration how they overlap and interact. Building upon discussions initiated by Uyarra (2010) and Flanagan et al. (2011), "public policies, just like innovations [. . .] are adopted not on a tabula rasa but in a context of pre-existing policy mixes and institutional frameworks which have been shaped through successive policy changes" (Flanagan et al., 2011: p.708). The analysis adds to these discussions and draws attention to innovation policy agendas that comprise multiple levels of activity. By examining the motivating factors associated with state policy responses, the analysis demonstrates that policy responses are shaped by the nature of the multilevel mix itself. In short, public policy is dynamic and contextual. Attention on innovation policy actions conflates public investment as a single source when in fact public support comprises a multilevel policy mix. It is important to bring focus to this and consider how multiple levels of government interact.

Additional work on this topic certainly remains and we hope our efforts encourage others to investigate this topic. However, certain obstacles stand in the way. For one, the lack of data on policy actions – at either national or subnational levels – makes data collection for the complete set of participating jurisdictions cumbersome. Moreover, this study has focused on policy activity within the U.S. and has not considered multilevel policy mixes in other regional, national and international contexts. Future empirical research could examine how the policy mix varies across different political systems and policy agendas. Once the requisite data has been gathered and studies have been conducted on the factors associated with adopting and maintaining these policies, the next step is to consider the efficacy and implications of the broader mix.

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Appendix.

Data collection methods for identifying state SBIR-related programs.

Data on state SBIR-related programs were gathered in two stages (January 2012 and November 2012, respectively). The initial search focused on gathering information on SMP-I programs. The following search terms "state", "SBIR", "STTR" and "match" were

[63] The expenditures have been adjusted for inflation allowing for comparisons over this time frame. By including state fixed effects, the positive coefficients indicate that states are more likely to have the SMP-I program in the years when their state revenue exceeds that state's mean.

used in Google searches. In looking through 30 pages of results for these terms, 16 states were initially identified as having characteristics of an SMP-I program. Each state was then contacted for additional information on the program. Of the original 16, 12 states matched the definition of an SMP-I program: state-run grant program; matching funds for successful Phase I recipients; funds are not limited to Phase II application costs, but rather are intended to cover the technical aspects of project. During this initial stage, it became apparent that there was a wider range of state SBIR-related program.

The second data-gathering phase took place in November 2012. This more extensive data collection effort was conducted to gain a comprehensive understanding of all state SBIR-related programs. Press releases, news articles, legislative statutes and web sources were gathered from the SSTI online archives. The search terms for this collection effort included: "state", "match", "SBIR", "STTR", and "bridge". The information from this collection effort provided a broader overview of the range of state policies.

As a result, a series of SSTI online and Google web searches were conducted on the following topics: "SBIR/STTR", "SBA FAST", "ROP", "federal technical support programs", "SBIR reauthorizations", "Phase 0/00", and "SBIR bridge programs". In addition, the authors conducted fifty state-specific searches for the following terms: "SBIR", "STTR", "bridge", "match", "Phase 0", "Phase 00" to learn about state SBIR-related activity.

All references of state financial support were followed up with an email to the state office to inquire about the nature of funding. This information was then compiled into a word document, which is available upon request. This document has been shared with Dr. John Hardin, Executive Director for the North Carolina Board of Science & Technology, and Rick Shindell, author of the widely disseminated SBIR Insider Newsletter. Dr. Hardin responded with comments.

As an additional validity check, the authors crosschecked the information on the state agencies with NASA's list of state technical programs.[64] For the majority of cases, the author's search matched NASA's list, however, in some cases it was more up to date. This was a useful exercise to confirm that the data collection search was directed to the appropriate state agency.

In addition to contacting the state agencies, numerous representatives affiliated with the federal SBIR program were contacted. These included program officers from the SBA, NSF and DOD. Additional information on the SBIR, FAST, and ROP programs was gathered at this time.

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[64] http://sbir.gsfc.nasa.gov/SBIR/states.htm.

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