

Science, Technology, and Innovation (STI) Legislative Landscape: Mapping State-Level STI Legislation in the US

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Abstract - The Office of Policy Analysis and Research (OPAR) at the Georgia Tech Research Institute conducts applied policy research on state-level science, technology, and innovation (STI) policy. Since 2009, OPAR has been collecting, tracking, and analyzing state-level legislation on advanced and emerging STI topics (e.g. smart grid, electronic medical record, stem cells). This research project, called the STI Legislative Landscape, provides a comparative analysis of each state's public policy towards STI across the country. As the project matures, the authors are interested in its potential for answering previously unexplored legislation-related questions. For instance, is there a connection between a state's legislation on STI and the strength of its STI environment? If so, under what conditions? The STI Legislative Landscape is the first step towards answering these questions and can provide a crucial framework for structuring future research to explore a state government's level of engagement and its effect in fostering measurable outcomes. This paper outlines the methodology of OPAR's Legislative Landscape and presents observations which suggest that it can be used for further research on the relationship between legislation and the STI environment.

Introduction

It wasn't until the 1980s that states fully realized the potential of utilizing science and technology as mechanisms for economic growth, job creation, and building human capital (Plosila, 2004). Since then, states have taken measures to incorporate the advancements in science and technology in their social, political, and economic policy agendas. In the last three decades, state governments' efforts to assert a greater role in the development and management of STI policies have increased in parallel with their own interest in cultivating an STI-based economy (Geiger and Sá, 2005). Accounts of best practices and reports on policy recommendations are readily available. Reports such as "Cluster-Based Strategies for Growing State Economies" (2005) and "Investing in Innovation" (2007) from organizations like the National Governors Association provide recommendations of best practices and successes across the fifty states. In contrast, studies assessing state governments' legislative activity on STI topics in concert with the overall role on the STI economy are in short supply.

Each state, with its own set of resources and priorities, legislates on STI topics differently. With this assumption, the authors began to question whether the differences in a state's approach towards STI legislation can be linked to the health of its STI environment. In other words, can STI legislation serve as a unit of analysis to measure the level of government's engagement and approach in the STI environment? This question cannot be answered on a broad scale without a framework that can allow researchers to identify and compare STI legislation across the country. In an effort to address this need, the authors propose OPAR's Legislative Landscape as a methodology toward systematic and meaningful analysis of state-level legislation. This paper outlines the methodology of OPAR's Legislative Landscape and presents observations which suggest that it can be used for further research on the relationship between legislation and the STI environment.

Literature Review

A literature review was conducted to understand relevant studies on the relationship between STI legislation, the state government, and the STI environment. The authors conducted searches using various journal databases within the subject areas of public policy, political science, economics, science policy and others. A list of search terms applied by the researchers included: "state legislative analysis", "analysis of legislation impact", "science and technology legislative analysis", "impact of state regulation", and "legislation and innovation". These searches yielded few studies on analyses of state-level legislation as it relates to the STI environment and the role of the government.

Most studies that offered legislative analysis and implication on the economy focused on a single piece of legislation or a group of regulations. For example, ICF Consulting conducted a study for the EPA on how the Clean Air Act Amendments of 1990 (CAAA) impacted the industries. The study revealed that the strict standards of the CAAA legislation pushed the industries to innovate, resulting in lower emissions at a lower cost and a sturdier economy (2005). Related studies on single policy or legislation include analyses of the California Health Benefits Review Program and its role in state health policy plan (Oliver and Singer, 2006), the potential effect of the climate change legislation to the agriculture industry (Laws, 2010), and the federal incentive legislation with regards to the development of solar energy (Battelle Labs, 1978). The aforementioned studies focus on individual pieces of landmark legislation offering content analysis rather than measurable assessments on legislative activity as an indicator of government's role in the economy.

With respect to state-by-state legislative activity, the authors were able to find several studies that offered comparative analysis across states over time, albeit the subjects were not relevant to STI environment. Newmark (2005) examined state lobbying regulation from 1990-2003 to show trends over the years. Recognizing the lack of measures of lobbying regulation, Newmark devised an index of state lobbying regulation that other scholars can use to study the legislative process between lobbyists and policymakers. Newmark's index was based on several sources, one of which was called the Book of the States that served as the primary source of the data he used to construct the measures. Newmark's research highlighted the scarcity of comparative data across states over time and the need for replicable measures to understand legislative process, both of which are relevant to OPAR's research presented in this paper.

Another relevant research study was from Grady (1987), who used a comprehensive inventory of business incentive legislation across the fifty states to analyze possible associations between increases in incentives with certain economic conditions in the region. The incentives were weighted based on input from industry experts and were used to score each state based on their presence or absence of such incentives. Such measurements allowed Grady to offer insights on the behavior of the state government with regards to business incentives. One of the observations from the study was that states tend to enact incentives due to regional competition and that there were no associations with the strength of industry groups in the legislature and the amount of incentives enacted. Of all the studies reviewed, this article was the most relevant in terms of the unit of analysis and the subject for OPAR's research. However, the authors note that Grady's research was on specific legislative output (business incentive) as weighted in significance by industry players to understand regional conditions that drive states to compete. In contrast, OPAR is interested in the potential use of STI legislation as an indicator of state government's approach to STI and related industries.

Furthermore, the literature review revealed a collection of entities that perform legislative analysis for profit. MayaTech is one of several examples of consulting organizations that perform policy and legislative analysis for lobbyists and other interested organizations. Such groups provide insight into what is currently available to decision makers and policy practitioners. However, there is very little suggestion that such organizations offer state-by-state analysis of government behavior towards STI-based economy and affected industries.

In summary, of the relevant legislative analyses and research from the literature review, the authors observed that (a) the focus of the studies was on a single issue or the impact of a single piece of legislation on a particular industry sector; (b) most studies offered content analysis and were less about the potential correlation between legislative input and output; and (c) the studies did not attempt to consider or address what role policy/legislation could have on the STI environment or a particular STI sector. The literature review offered few studies to build upon, and offered even fewer frameworks for comparative analysis. Nevertheless, the lack of studies points to the need to analyze state legislation as a way of understanding government's role in building the STI environment.

Research Objective

STI as a public policy field is quite young, and most of the information the state policymakers have at their disposal relies on anecdotal evidence and best practices for cultivating the STI environment. The lack of study of the broad implications of state-level legislation leaves open a series of important questions. Specifically, does STI legislation play a role in fostering a favorable STI environment in the state? If yes, then under what conditions? Are there differences in STI legislation among states? If so, do these differences lead to varying implications and outcomes on the STI environment? Do certain types of legislation affect STI industries differently?

Answering these questions requires a comprehensive analysis of STI legislation and alternative factors that could affect the STI environment. The authors propose that this process has three fundamental activities: a) understanding and measuring legislation, b) controlling for alternative factors, and c) understanding and measuring the outcomes in the STI environment. Parts b) and c) of the process have been conducted before in other studies and can easily be referenced to further quantify factors that could affect the STI environment and vice versa. For instance, relationships between factors like science and engineering college graduates and the STI industry have been studied (Beeson and Montgomery, 1990). These outcomes are easily quantifiable (e.g., number of graduates, number of high-tech jobs created) and can be compared state to state. On the other hand, part a), understanding and measuring legislation presents a challenge as it is qualitative in nature and requires a classification scheme in order for it to be a consistent unit of analysis across states.

Until now, public policy scholars have not had a systematic methodology for analyzing legislation beyond the scope of a single bill or topic. The lack of such a framework has hampered the possibility of a comparative analysis across states in a broad way. This paper suggests that OPAR's Legislative Landscape can serve as an analytical framework to help study the implications of legislation on the STI environment.

OPAR's Legislative Landscape

Although data collection is the least complex part of many research projects, it can be a challenge in the case of STI legislation. Due to the sheer number of legislation across the fifty states, identifying and analyzing relevant legislation can entail obstacles. This process is further complicated because states often legislate on multiple topics within a single bill; group related topics under an umbrella term; or, alternatively, mention a topic without necessarily legislating on it in that particular bill. These nuances are further amplified by the fact that "science, technology, and innovation" involve topics which cut across many areas and can vary in meaning. OPAR's Legislative Landscape addresses these challenges by utilizing a set of criteria that bills must meet in order to be included in the dataset.

Data Collection and Inclusion Methodology

OPAR utilizes a list of STI "keywords" to query for relevant bills using a legislative tracking service of all fifty states. Examples of keywords include *cloud computing*, *radio frequency identification*, *renewable energy*, and *smart grid*. Each keyword serves as an identifier used to capture state bills that include relevant STI topics of interest. The bills are then validated against a set of criteria to determine if they should be included in the final dataset.

OPAR has two criteria to determine whether a bill will be included in the final dataset: frequency and location. The researchers assume that the more often a keyword appears, and the more prominent the placement (e.g. title or abstract), the higher the likelihood that the legislation will be relevant to that keyword. These criteria for inclusion comprise a bill's "level of focus". There are four designations of levels of focus: high, medium, low, and none. Each level has a specified minimum number of keyword occurrences that must be satisfied. Additionally, the location of the keyword within the bill is also given a unique significance. As an example, a bill is assigned a high level of focus on cloud computing, if "cloud computing" occurs at least three times throughout the bill text and appears in the bill title or abstract. Bills with "none" as the level of focus (less than two occurrences of the keyword) are not included into the final dataset.

In 2010, the OPAR research team selected 70 STI keywords on which to identify and collect relevant pieces of legislation. Based on the 70 STI keywords, the research team collected and analyzed over 7,000 bills across the fifty states, but only 3,364 bills passed the inclusion criteria and thus included in the final set of data. Of these 3,364 STI bills, 555 were passed into law, for an average enactment rate of 16% across the country¹. See Appendix A for a complete list of STI keywords and total legislation for each state.

¹ Four states did not have regular sessions in 2010 because they are on an odd year legislative cycle: Montana, Nevada, North Dakota, and Texas.

Observations

As this is OPAR's initial foray into associating legislation with possible outcomes, the researchers selected several different indicators for comparison: a nationally recognized ranking survey of state-level STI economies; use of electric vehicles; CO₂ levels; and capacity of legislatures. As this first step, OPAR was looking for relationships rather than explanations. The discussion below outlines the observations of each of these comparisons.

Using the database of STI legislation collected through OPAR's Legislative Landscape methodology, the authors began to analyze its correlation with the overall STI environment of each state. Each state's total count of STI bills introduced and enacted in 2010 was compared to its ranking from the 2010 Milken Institute's State Technology and Science Index (referred here throughout as the Milken Index). Biannually, the Milken Institute ranks states based on the favorability of their STI environment by tracking a variety of factors, including research and development, entrepreneurial infrastructure, workforce, and technology concentration. The authors chose this metric because a state's ranking in the Milken Index is broadly accepted as an indication of the vibrancy of the state's STI environment. In performing this comparison, the authors expected to answer the question, "Do states with more STI legislation have a more favorable STI environment?"

For ease of comparison, the states were grouped into quintiles, 1st quintile representing the highest rank and the 5th quintile representing the lowest. Hence, the top ten states that ranked the highest were grouped into the 1st quintile, the next highest ten states into 2nd quintile, and so on. Figure 1 provides the total number of STI bills introduced and enacted in 2010 for each quintile and Figure 2 shows the averages. The averages are adjusted to reflect the four states that did not have an active legislative session in 2010.

Figure 1. Total STI Bills by Quintiles of 2010 Milken Index

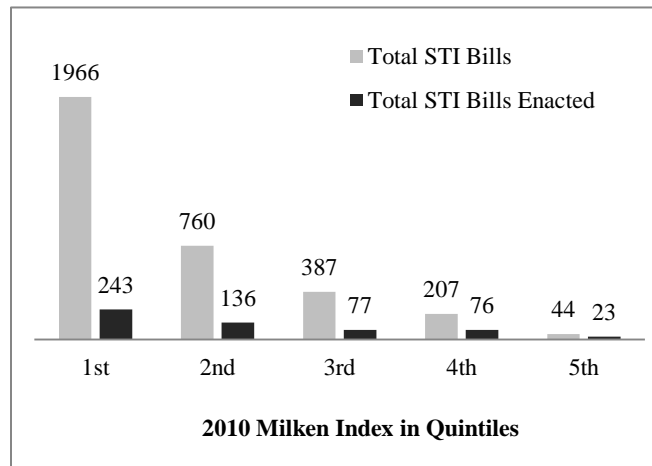
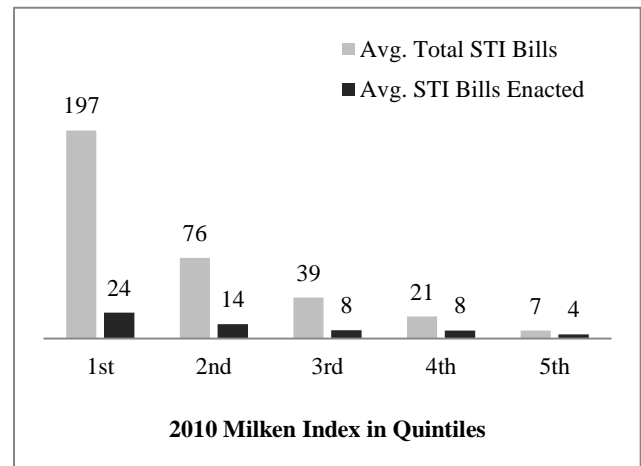


Figure 2. Average STI Bills by Quintiles of 2010 Milken Index



The comparisons yielded a strong correlation between the state's number of bills introduced and enacted and its Milken Index ranking. The 1st quintile states introduced more STI bills in 2010 than the total STI bills in the remaining quintiles combined. These results suggest that there is a measurable relationship between a state's STI legislation and its STI environment. See Appendix A for the complete Milken Index and STI legislation total for each state.

While the Milken Index comparison provided a strong indication that STI legislation can serve as a unit of analysis in examining a state's overall STI environment, it did not provide clear insight as to whether this relationship is true for specific STI topics or industries. To explore this further, the authors conducted a broad comparison of STI legislation on specific topics to metrics specific to those topics. One example is the case of electric vehicles.

The authors compared legislation on electric vehicles in 2010 that passed OPAR's inclusion criteria with the price of gasoline in 2010. The choice for this comparison included two assumptions. The first assumption is that legislation on electric vehicles can increase the number of such vehicles in that state. The second assumption is that an increase

in the amount of electric vehicles in the state will lead to a decrease of the number of conventional (petroleum powered) vehicles on the road. Based on these two assumptions, comparing relevant legislation on electric vehicles to the price of gasoline can be a measure of whether legislation can impact the state's energy consumption.

The authors collected data on the average price of gasoline across the fifty states from the U.S. Energy Information Administration (EIA). The EIA is the statistical agency within the Department of Energy, charged with collecting, analyzing, and disseminating energy data and information. Since the EIA reports average gasoline prices across the country by grouping the fifty states into five distinct regions², the authors used the same grouping in order to establish an average number of bills introduced in those regions. Each region's average gasoline price in 2010 and 2011 was compared to the total number of electric vehicle bills that region introduced in 2010. Figures 3 and 4 show the trend observed.

Figure 3. Total STI bills vs. Regional Average Price of Gasoline (2010)

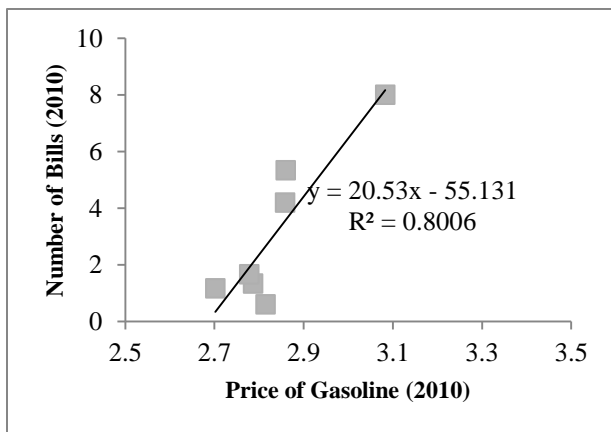
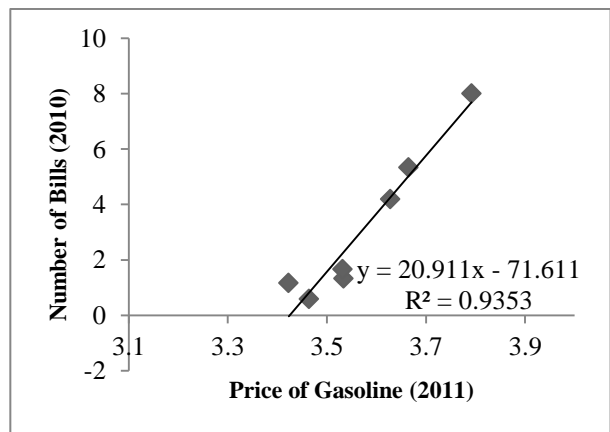


Figure 4. Total STI bills vs. Regional Average Price of Gasoline (2011)



The price of gasoline in both years showed a strong positive correlation with the number of bills introduced on electric vehicles. These observations suggest that states with higher prices of gasoline consistently enact more bills on electric vehicles than their peers. This trend mirrors the results of the comparison of legislation with the Milken Index. In other comparisons, however, this positive relationship did not remain. One such example is the comparison of electric vehicle legislation to CO₂ emissions in each state.

The choice of CO₂ emissions as a metric was based on the same two assumptions as in the previous example. First, the authors assumed that legislation on electric vehicles can increase the number of such vehicles in that state. Second, the authors assumed that an increase in the number of electric vehicles in the state will lead to a decrease of the number of conventional (CO₂ emitting) vehicles on the road. Based on the assumptions above, the authors expected a higher number of electric vehicle bills in the state to be correlated with lower CO₂ emissions. Using EIA data, the number of electric vehicle bills that passed OPAR's inclusion criteria in each state in 2010 was compared to the CO₂ emissions of each state in 2009 and 2010. Figures 5 and 6 show the results of these comparisons.

² The regions used by the EIA and mirrored by the researchers for this comparison are: **New England** (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont), **Central Atlantic** (Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania), **Lower Atlantic** (Florida, Georgia, North Carolina, South Carolina, Virginia, West Virginia), **Midwest** (Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Wisconsin), **Gulf Coast** (Alabama, Arkansas, Louisiana, Mississippi, New Mexico, Texas), **Rocky Mountain** (Colorado, Idaho, Montana, Utah, Wyoming), and **West Coast** (Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington).

Figure 5. Total STI bills vs. CO₂ Emissions per Capita (2009)

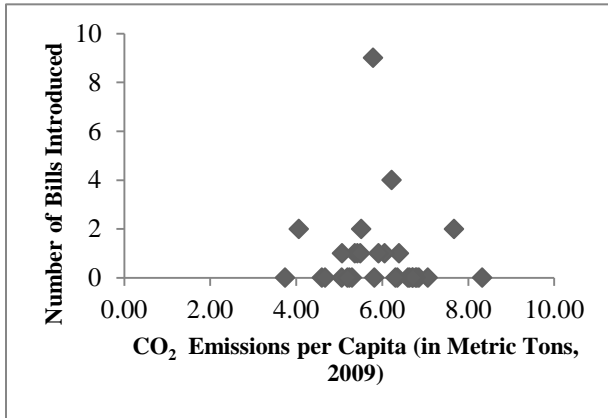
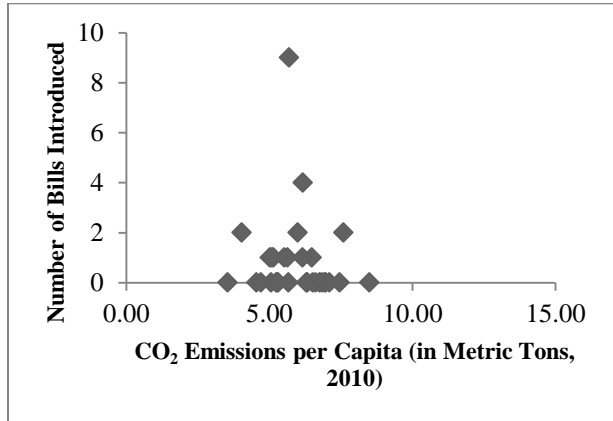


Figure 6. Total STI bills vs. CO₂ Emissions per Capita (2010)



Across both years of comparison, there was no discernible correlation between a state’s CO₂ emissions and the number of electric vehicle bills introduced in its legislature. The lack of (either positive or negative) correlation is especially interesting when juxtaposed to the clear correlation between electric vehicle legislation and the price of gasoline. The choice of both metrics was based on the same assumptions, so a similar correlation should have been observed. This discrepancy leads to two possible conclusions: (1) a simple count of STI legislation cannot be used as a broad-based measure across all industries and topics, and/or (2) STI legislation differs significantly from bill to bill. Both of these possibilities highlight the necessity for a deeper analysis of STI bills and suggest that the number of STI bills in each state is a likelier measure of *capacity* rather than *capability* of the legislature.

The National Conference of State Legislatures (NCSL) defines *capacity* as a combination of the time legislators spend on the job, their average annual compensation, and the number of staff available for the legislature. Based on these characteristics, the fifty state legislatures are grouped into three categories, Red, White, and Blue, where the former represents the legislatures with high capacity and the latter represents those with lower capacity. The authors mapped each state’s total of STI legislation in 2010 to NCSL’s classification. Figure 7 presents the total number of STI bills introduced and enacted in 2010 for each NCSL legislature type, whereas Figure 8 presents the averages. See Appendix B for the description of each classification and the states that belong in the grouping.

Figure 7. 2010 Total STI bills by Legislature Type

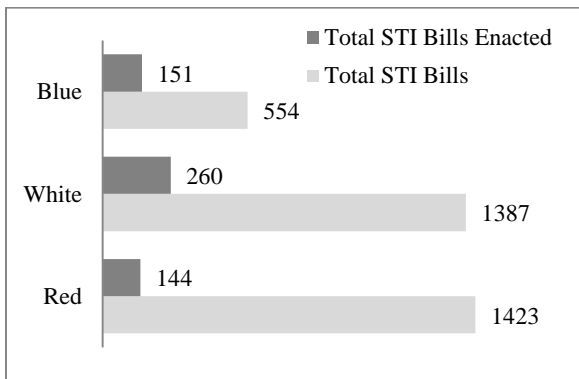
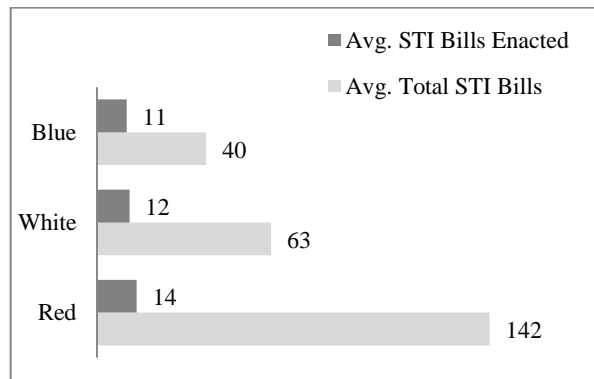


Figure 8. 2010 Average STI bills by Legislature Type



The above comparison confirms that legislatures with a higher capacity to perform tend to consider more STI legislation than those with lower capacity. A Red state, associated with higher capacity, on average introduced over twice as many STI bills than the White states and over three times as many STI bills than the Blue states. Given that the amount of legislation is an indicator of the state’s legislative *capacity* rather than *capability*, what sort of analysis

is needed to measure *capability*? How do certain bills differ from others even if they legislate on the same overall topic? How is an STI bill in one state different from an STI bill in another? In summary, the authors agree that as a result of these comparisons, there is evidence to conduct further analysis towards explaining the relationship between legislation and outcomes.

Next Steps

While OPAR's data collection and inclusion methodology successfully narrows down state legislation relevant to STI, the initial observations described above show that mere comparison of count is not enough in order to conduct a broad comparative analysis. Answering the question "how many?" serves a reliable indicator of the overall STI environment of the state, but in order to compare the role of legislation across industries or topics, the questions of "why?" and "how?" states legislate on STI must also be addressed. OPAR's Legislative Landscape attempts to answer the question of "why" using a typology of four intents that encapsulate the overall goal of each piece of legislation and the question of "how" by examining the policy tools used in each bill in order to accomplish that intent.

OPAR has built on the inclusion criteria in the Legislative Landscape by analyzing each bill for its intent with regards to the STI keyword under consideration. This typology is based on the assumption that the bill promotes, regulates, limits, or studies the STI keyword by expanding or reducing (or neither) the availability of the keyword. For instance, the 2010 Georgia House Bill 1416 on the STI keyword *broadband* calls for tax incentives on the purchase of broadband equipment. HB 1416 encourages the purchase of such broadband equipment, and hence will increase the availability or use of broadband by virtue of this incentive. Therefore, the intent of HB 1416 is to *promote* the STI keyword broadband.

While the intent of a bill is an important criterion, bills with similar intents often utilize different tools in order to accomplish that intent. In what structured way does a bill promote, regulate, limit, or study an STI topic? Based on analysis of thousands of bills, OPAR has developed a list of policy tools that are commonly used by the legislature. Bills are classified into six distinct policy tool categories: funding, commission, standards, tax/fee, tax incentive and other.

Incorporating the filters of intent and policy tool as a way to categorize legislation is the key next step towards understanding the relationship between STI legislation and the STI environment in the state. Once complete data on the typology and policy tools of STI legislation is available, the authors intend on conducting a comparative analysis across industries and topics in order to assess the viability of these categorizations.

Questions of interest include: Do states that introduce and enact more STI bills that "promote" have a stronger STI industry? Is this relationship similar across different industries? What is the association of social and environmental metrics and the various legislative intents? And finally, which policy tool is best for accomplishing a particular intent? Once these questions are answered, public policy scholars can begin examining the effect of legislation across states in a more systematic way – identifying trends and outliers – and equip legislators with much needed information.

Conclusion

While there is a reasonable amount of research on specific legislation and its immediate domain, there is a significant lack of broad comparative analyses of state-level legislation. Up to this point, a major deterrent to such research has been the challenge of differentiation among bills and the lack of a common framework for analyzing them. OPAR's Legislative Landscape presents such a framework that helps identify, collect, and classify legislation based on key attributes. The initial data comparisons performed by the authors illustrate that the Legislative Landscape can serve as just such a framework. The combination of the inclusion, typology, and policy tool criteria can create a standardized set of legislative data that can be used for comparative analysis across the fifty states. With a useable framework that allows for the identification of bills similar enough to be comparable, the effectiveness of these bills can finally be analyzed.

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APPENDIX A

State	2010 Total STI Bills	2010 STI Bills Enacted	NCSL Legislature Type	2010 Milken Index
Alabama	18	2	White	31
Alaska	27	3	White	37
Arizona	47	11	White	15
Arkansas	0	0	White	50
California	238	65	Red	4
Colorado	26	23	White	3
Connecticut	47	7	White	9
Delaware	14	11	White	10
Florida	31	2	Red	40
Georgia	32	5	Blue	25
Hawaii	306	24	White	36
Idaho	12	7	Blue	27
Illinois	148	27	Red	20
Indiana	17	1	Blue	28
Iowa	92	13	White	32
Kansas	51	6	Blue	23
Kentucky	12	3	White	47
Louisiana	15	8	White	45
Maine	60	30	Blue	42
Maryland	39	13	White	2
Massachusetts	130	5	Red	1
Michigan	125	7	Red	26
Minnesota	143	17	White	12
Mississippi	51	8	Blue	48
Missouri	34	1	White	30
Montana*	0	0	Blue	35
Nebraska	22	4	White	34
Nevada*	0	0	Blue	46
New Hampshire	45	25	Blue	7

State	2010 Total STI Bills	2010 STI Bills Enacted	NCSL Legislature Type	2010 Milken Index
New Jersey	168	4	Red	11
New Mexico	20	4	Blue	18
New York	398	23	Red	16
North Carolina	74	23	White	13
North Dakota*	0	0	Blue	33
Ohio	51	7	Red	29
Oklahoma	118	22	White	39
Oregon	18	9	White	21
Pennsylvania	111	1	Red	14
Rhode Island	130	34	Blue	22
South Carolina	35	4	White	43
South Dakota	4	1	Blue	38
Tennessee	22	5	White	41
Texas*	0	0	White	19
Utah	26	17	Blue	5
Vermont	54	6	Blue	17
Virginia	98	20	White	8
Washington	180	37	White	6
West Virginia	50	6	Blue	49
Wisconsin	23	3	Red	24
Wyoming	2	1	Blue	44

* States that did not have a regular legislative session in 2010 because of their odd year cycles.

APPENDIX B

National Conference of State Legislatures (NCSL) Classification of State Legislatures

Type	Characteristics	States
“Red” Legislatures	<ul style="list-style-type: none"> • Legislators spend 80 percent or more of a full-time job doing legislative work • Compensation enough to make a living without outside sources of income • Largest legislative staffs • Tend to be in states with large populations 	<p>Red California, Michigan, New York, Pennsylvania</p> <p>Red Light Illinois, Florida, Ohio, Massachusetts, New Jersey, Wisconsin</p>
“White” Legislatures	<ul style="list-style-type: none"> • Hybrids of red and blue models • Legislators spend more than two-thirds of a full-time job doing legislative work • Compensation higher than blue states, but not enough to make a living without outside sources of income • Intermediate-sized legislative staffs • Tend to be in states with medium-sized populations 	Alabama, Alaska, Arizona, Arkansas, Colorado, Connecticut, Delaware, Hawaii, Iowa, Kentucky, Louisiana, Maryland, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, Oregon, South Carolina, Tennessee, Texas*, Virginia, Washington
“Blue” Legislatures	<ul style="list-style-type: none"> • “Traditional” or “citizen” legislatures • Legislators spend equivalent of half of a full-time job doing legislative work • Low compensation that requires outside sources of income to make a living • Relatively small legislative staffs • Tend to be in small population, rural states 	<p>Blue Georgia, Idaho, Indiana, Kansas, Maine, Mississippi, Nevada*, New Mexico, Rhode Island, Vermont, West Virginia</p> <p>Blue Light Montana*, New Hampshire, North Dakota*, South Dakota, Utah, Wyoming</p>

Source: National Conference of State Legislatures (NCSL) and the American Association of State Highway and Transportation Officials (AASHTO) Center for Excellence in Project Finance (2011). *Transportation Governance and Finance: A 50-State Review of State Legislatures and Departments of Transportation*.

*States that did not have a legislative session in 2010.