

IDEAS *for* PENNSYLVANIA INNOVATION
Examining efforts by competitor states and national leaders

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Executive summary

Recent attention to the “winner-take-most” nature of the current tech-driven economy has highlighted the stakes for places. Whether it likes it or not, Pennsylvania is engaged in a competition with other U.S. regions, and countries across the globe, to secure the economic well-being of its citizens.

Innovation has long been a source of economic growth and prosperity for the most successful states, and has only grown more important in this era of divergent outcomes and rapid technological change. As such, it will be critical to jumpstarting Pennsylvania’s economy.

The commonwealth has historically been an innovation leader, and Pennsylvania retains a stable of effective, scalable innovation assets. This includes a robust university system that generates significant R&D, as well as a set of capable technology-based economic development programs that operate across the state.

However, in recent years, Pennsylvania’s innovation economy has gone flat, and the state has scaled back public investment in its most significant innovation resources. As a result, Pennsylvania’s innovation economy now faces a set of discrete challenges. They include:

- The absence of a comprehensive state innovation strategy grounded in an evidence-based understanding of the state’s industries and innovation status
- Below-average industry R&D that has stagnated in recent years
- Reduced investment in state resources for early stage companies, combined with declining venture capital in the state
- Significant spatial divergence between the largest innovation centers (Philadelphia and Pittsburgh) and the rest of the state

While Pennsylvania is not alone in facing these types of challenges, other states are working proactively to overcome their own. This report documents ongoing initiatives in both competitor states and national innovation leaders that contend with challenges similar to Pennsylvania’s. To that end, it surfaces 20 initiatives currently underway that states designed to achieve the following outcomes:

- Create an evidence-based state innovation strategy
- Strengthen business R&D in the state
- Bolster state investment in early stage financing
- Mitigate significant spatial divergence

Some are incremental initiatives that address a narrow problem or leverage relatively few public resources, while others are aspirational measures that required substantial time, financial resources, and/or political will to enact. Regardless, they are all currently underway, and help illustrate the depth of competition that Pennsylvania faces in today’s innovation-driven economy.

While Pennsylvania’s innovation economy has lagged in recent years, another path exists. Through a renewed commitment to inclusive innovation-oriented economic development, the commonwealth can chart a new course that bolsters economic growth and improves the living standards of its citizens throughout the state.

1. Introduction

A global revolution is underway. Over the past 30 years, the rise of the tech-enabled knowledge economy has helped a small group of “superstar” places pull away from the rest.¹ Nor is this trend likely to abate any time soon. On the contrary, as new forms of technology like artificial intelligence (AI) and other forms of emerging tech become widespread, the divergence of places is prone to accelerate, further upping the stakes for places.²

In keeping with this, states and communities now find themselves in a pitched battle with competitors worldwide to secure their economic well-being. Whether it likes it or not, Pennsylvania is engaged in this competition—and in recent years questions have been raised about how well it is faring.

For example, while Philadelphia remains integrated into the prosperous Northeast Corridor, it is being outpaced by competitor cities on key measures of innovation capacity and performance. Moreover, smaller areas in Pennsylvania have fared even worse in recent

years, showing outright declines in employment and population over the past decade. These lagging economic outcomes negatively affect people’s lives, stress the state’s political and economic cohesion, and threaten future growth and prosperity.

Therefore, innovation will be critical to jumpstarting Pennsylvania’s economic growth. Innovation has long been a source of economic growth and prosperity for the most successful states—and has only grown in importance in this era of divergent economic outcomes and rapid technological change.³ In this regard, innovation,



which encompasses creating new ideas and putting them into commercial use, helps state economies in many ways:

- R&D is a significant source of economic growth, and brings with it not only high private sector returns, but also high social returns;⁴
- New products and processes make workers and firms more productive, increase workers' wages, decrease the prices of goods and services, and improve the overall standard of living;⁵
- Highly innovative industries produce a disproportionate share of exports, and have extensive supply chains that lead to other forms of ancillary economic activity;⁶
- Finally, unlike capital and labor, there are no diminishing returns to knowledge, innovation, and technology—in fact, the creation of new knowledge frequently increases the returns to existing knowledge or processes.⁷

It should be no surprise, then, that places with stronger innovation outputs have stronger economic performance.⁸

The 50 manufacturing, services, and energy industries that make up America's "advanced industries" sector anchor the U.S. innovation economy.⁹ Across the United States, advanced industries account for 9.6 percent of employment and 17.2 percent of output. However, despite these modest topline numbers, advanced industries have significant spillover effects that generate growth throughout the entire economy. For example, these industries employ 80 percent of the nation's engineers, perform 90 percent of its private-sector R&D, generate 85 percent of its patents, and account for 60 percent of its exports.¹⁰ They are quite literally America's innovation base.

Likewise, advanced industries jobs pay better and generate more output per worker than jobs in other industries. In 2018, the average advanced industries worker earned \$103,000 in total compensation, double the \$51,000 in total compensation that workers in other industries earned. And each advanced industries worker

generated approximately \$260,000 in output, compared to \$120,000 for the average worker in a non-advanced industry job.¹¹ Furthermore, this distinction has been growing over time, as productivity in advanced industries grew at over twice the rate of the overall economy (3.2 percent per year versus 1.3 percent per year) from 1980 to 2013.¹²

Finally, advanced industries have significant economic multiplier effects, creating 2.2 jobs domestically for every new advanced industry job—0.8 jobs locally and 1.4 jobs outside of the region.¹³ This is significantly higher than non-advanced industries, which have a multiplier effect of only one additional domestic job (just 0.4 jobs locally and 0.6 jobs outside the region). Moreover, the local multiplier effect of 0.8 local jobs for every new advanced industry job is twice as high as the local multiplier effect of 0.4 local jobs for every new non-advanced industry job, meaning advanced industries generate growth in regional economies as well as across the country as a whole.

Unfortunately, Pennsylvania lags the United States as a whole when it comes to both advanced industries output and employment, with advanced industries accounting for only 8.9 percent of employment, and 15.3 percent of output.¹⁴ This means the state receives fewer of the spillover benefits that advanced industries provide, putting a damper on economic performance across the state's entire economy.

Furthermore, Pennsylvania's innovation economy has gone flat at the wrong time. While the commonwealth has a rich innovation history, its formerly robust investments have floundered. Pennsylvania retains a stable of nationally-renown research universities that produce a rich base of university R&D; however, the state lags on other aspects of the innovation value chain. This includes stagnant industry R&D, a declining share of venture capital, and lagging outcomes, such as lower utility patent (patents for invention) rates than the national average. Spatial divergence exacerbates these issues, as both the inputs and outputs from innovation primarily flow to just a few areas in the state. This means many Pennsylvanians are being excluded from the benefits of innovation.

However, while Pennsylvania has moved away from investing in innovation in recent years, other states have been doubling down on their innovation economies. These include national leaders, like Massachusetts, which have made substantial investments in their innovation assets, and are increasingly pulling away from other states in economic performance. However, they also include some of Pennsylvania's closest competitor states, as well as states that have historically trailed Pennsylvania on innovation outcomes and economic performance. Thus, Pennsylvania risks not only falling further behind national leaders, but also being surpassed by its primary competitors.

To reverse these trends and remain competitive into the future, Pennsylvania will need to redouble its commitment to innovation. This report aims to spur a conversation aimed at bolstering innovation in the commonwealth.

To that end, the report first takes stock of the current state of Pennsylvania's innovation economy by reviewing the status of the state's

current pro-innovation policy framework as well as the state's current innovation performance. Through that stock-taking, the report identifies four ongoing innovation issues that the commonwealth faces and, with those in mind, presents the results of a multi-state scan of the programs and initiatives that peer states and national leaders have implemented to solve similar problems. These exemplary programs may not all be feasible in Pennsylvania, but nevertheless they serve to display the kind of problem solving on relevant issues now underway in other states.

Ultimately, then, this report is less a set of recommendations than an effort to illustrate that other states are not waiting, and that Pennsylvania, in turn, must raise its sights and respond to these competitive challenges. By heeding this call to action, Pennsylvania can begin to change its state narrative from one of divergence and stagnation to one of inclusive and sustainable statewide growth.

2. Approach

To situate the state’s innovation policy framework in the context of national best practices, the report that follows both assesses the state’s current innovation performance using multiple data sets and surveys relatively new initiatives across an array of peer and leadership states.

The report is divided into three sections. The initial section is an overview of the current state of the Pennsylvania innovation economy. It provides a benchmark of Pennsylvania’s innovation inputs and outputs, and identifies four major challenges that Pennsylvania will need to overcome to bolster its innovation performance.

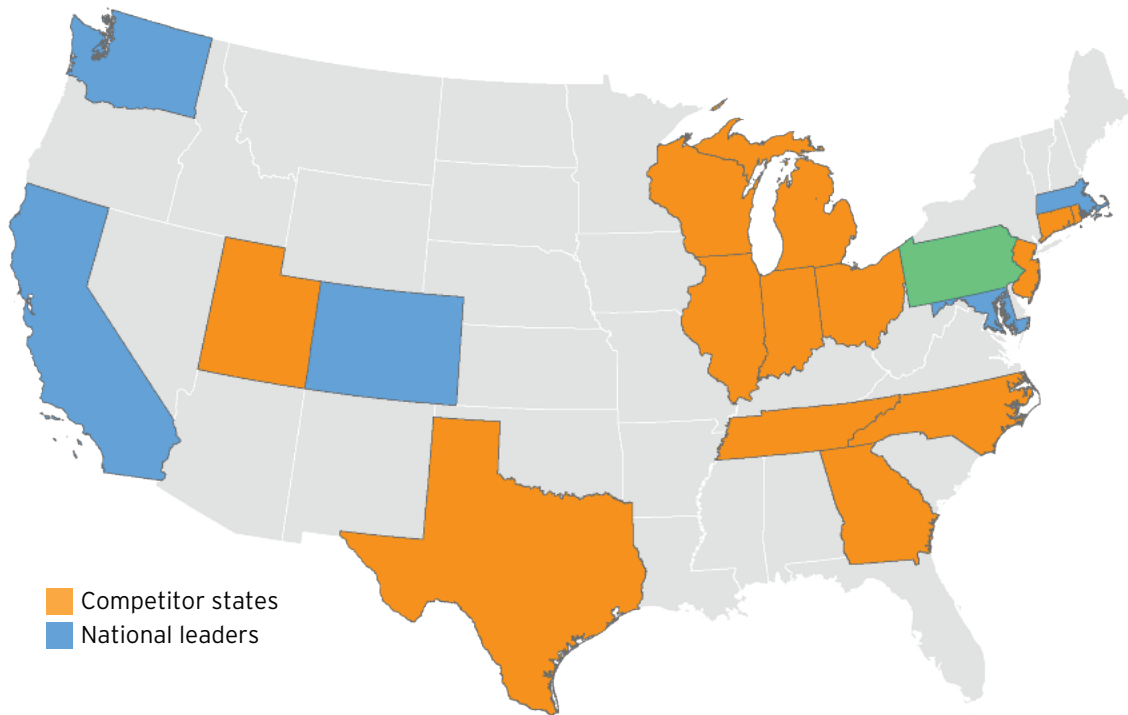
In the section that follows, the report outlines 20 efforts and initiatives that are currently being leveraged across competitor states and national leaders to solve for challenges similar to those that Pennsylvania faces. Finally, the report concludes with reflections and analysis containing several takeaways for policymakers and other stakeholders in the commonwealth.

The scan reviewed innovation policies and programs in 18 states. 13 are designated Pennsylvania’s competitors: Connecticut, Georgia, Illinois, Indiana, Michigan, New Jersey, North Carolina, Ohio, Rhode Island, Tennessee, Texas, Utah, and Wisconsin. These states were identified by using innovation rankings from the Information Technology and Innovation Foundation and the Milken Institute, as well as through interviews with policymakers and practitioners in Pennsylvania. An additional five states were designated as national leaders due to their consistently strong standing in innovation rankings: California, Colorado, Maryland, Massachusetts, and Washington.



FIGURE 1

Competitor states and national leaders



Source: The Brookings Institution

Each state innovation initiative is classified as either **incremental** or **aspirational**. Incremental initiatives are those that have a relatively narrow focus or that leverage fewer public resources. Aspirational programs are those that required more significant financial resources or governmental restructuring to enact and would be expected to have a correspondingly larger impact on the state’s innovation economy. Given Pennsylvania’s current political and budgetary constraints, incremental programs are more likely to be feasible in the short term.

It is important to note several things. First, these programs are likely not directly implementable in their current form in Pennsylvania. Nor are they meant to be. Rather, they are illustrative examples of the types of programs that competing states have established, and are designed to give a sense of the scale of resource

deployment required to maintain the same pace as competitor states and national leaders.

Second, each programmatic overview includes the relative size of the implementing state’s economy compared to Pennsylvania. This is to give a sense of the relative scale of these programs, and a rough sense of how large of an investment would be needed to deploy something similar in Pennsylvania.

Finally, every effort was made to obtain information about impact and return on investment of these programs. However, given that many of them are relatively new, that type of data was not always available. Moreover, even some programs that have been in existence for a significant period of time had limited impact data available. When impact or return on investment data was available, it is included.

3. Pennsylvania's innovation economy: A baseline assessment

Pennsylvania has a rich innovation history. For decades, the commonwealth's enviable stock of research institutions, commercialization programs, and financial supports has spurred vital activity across the entirety of the innovation lifecycle.

The state's innovation prowess has always been anchored with research. For many years, the commonwealth has had one of the strongest cadres of research universities and institutions in the United States. According to the Milken Institute, no less than three universities and institutions rank in the top 25 in the nation for technology transfer and commercialization: University of Pennsylvania, Carnegie Mellon University, and University of Pittsburgh. Three more institutions, meanwhile—Drexel University, Pennsylvania State University, and Temple University—rank in the top 100 nationwide.¹⁵ These institutions anchor the commonwealth's innovation ecosystem by attracting top-tier

research talent to the state, generating new product and process discoveries, and training a skilled state workforce.

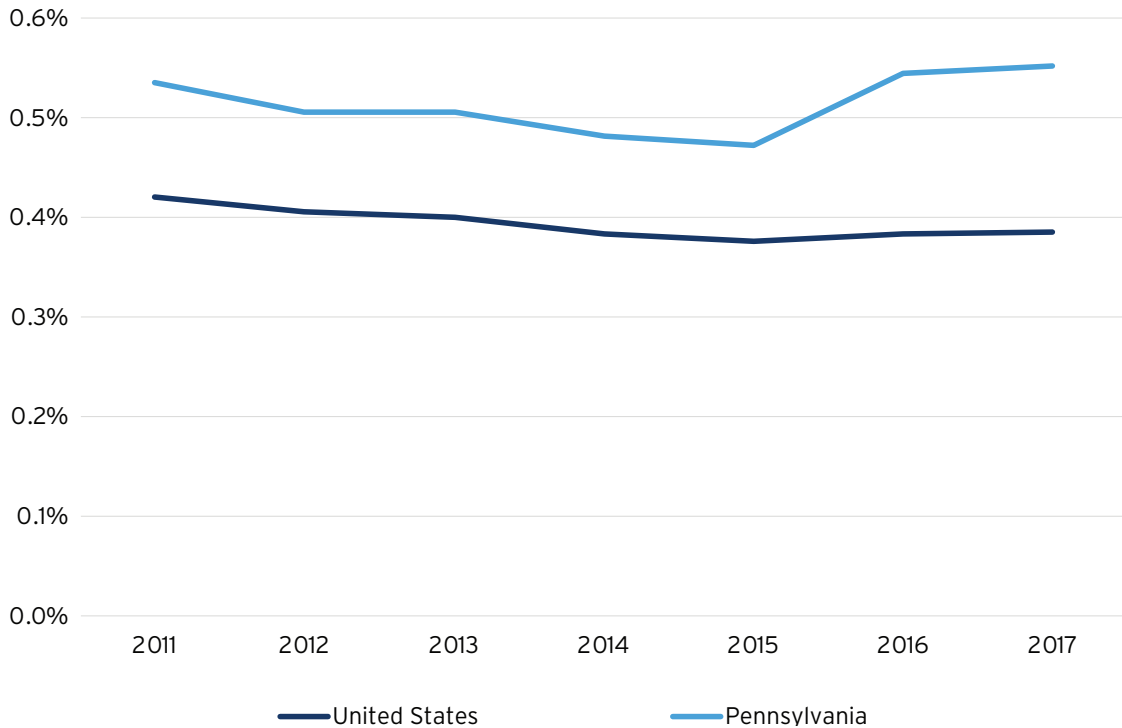
In fact, Pennsylvania's universities outperform the United States when it comes to R&D. As a share of GDP, Pennsylvania outpaces the rest of the nation, and the gap has widened in recent years.

The state's research institutions have historically been coupled with a strong set of innovation promotion programs across the state. This list includes several pioneering initiatives in innovation policy, such as the Philadelphia



FIGURE 2

University R&D as a share of GDP



Source: Brookings analysis of National Science Foundation (NSF) Higher Education Research and Development Survey (HERD) and Bureau of Economic Analysis (BEA) data

University City Science Center, one of the first urban innovation districts in the United States; and the Ben Franklin Technology Partnership, a statewide early stage investor that has been cited as a national model for technology-based economic development. In 2001, Pennsylvania leveraged its Tobacco Settlement Fund to create two significant innovation programs: the Life Sciences Greenhouse Initiative, which has provided critical funding and expertise to startups in Pennsylvania’s life sciences industry, and the Health Venture Investment Account to fund venture capital investments in health-related businesses.¹⁶ In recent years, the state has experimented with new programs to fill needs in the state’s innovation economy. These include the Keystone Innovation Zone tax credits that support companies in state priority industries that locate within designated innovation areas; the Venture Investment Program, which provided an injection of \$10.5 million to five venture capital firms across the state; and the Manufacturing

PA program, which supports advanced manufacturing in priority sectors throughout the state.¹⁷

Supporting innovation has been a bipartisan tradition in Pennsylvania. For example, Republican Governor Dick Thornburgh created the Ben Franklin Technology Partners, and his Democratic successor Robert Casey continued it. This bipartisan approach to innovation and technological development has been reflected in other state efforts, such as Republican Governor Tom Ridge’s technology strategy and Democratic Governor Ed Rendell’s TechFormation, which laid out a statewide strategy for advancing technology-based economic development, among others.¹⁸

But the state has long struggled to marshal its innovation assets. For example, a 2003 Brookings report found that while Pennsylvania possessed strong fundamental assets, it lagged

peer states in competitiveness and economic performance. Among its proposed solutions, the report recommended that the commonwealth develop more partnerships and programs to facilitate innovation.¹⁹

It takes extensive cooperation by a variety of statewide actors, including the governor, state legislature, economic development agencies, universities, companies, non-profits, and other stakeholders to become an innovation leader. Unfortunately, in recent years Pennsylvania has often struggled to get its stakeholders on the same page. TechFormation, released in 2005, was the last major statewide effort to assess its innovation economy and make recommendations. In the intervening years, the state has lacked a unified strategy for promoting innovation, entrepreneurship, and technology-based economic development.

In today's fast-paced knowledge-oriented global economy, even states that have maintained a widespread consensus on the importance of innovation and technology development still risk falling behind. For example, in contrast to Pennsylvania, Ohio's political leaders have managed to maintain a more consistent commitment to innovation over the past two decades, including in the wake of the Great Recession.²⁰ Nonetheless, as a recent report by the Ohio Chamber of Commerce Foundation observed, even states like Ohio that have been proactive about innovation and economic development will need to embrace new paradigms as the economy continues to evolve.²¹ Meanwhile, states that have failed to maintain their innovation ecosystems will face an even steeper climb.

Despite this imperative, in recent years Pennsylvania has scaled back investments in innovation inputs. This underinvestment has prevented Pennsylvania from becoming a national innovation leader, and has put the state on the wrong trajectory. While some of Pennsylvania's innovation funding began to stall the 1990s or early-2000s, most of the decline happened post-2008. In the aftermath of the financial crisis, Pennsylvania reduced expenditures across the innovation lifecycle, starting with basic R&D and running throughout the commercialization and funding process.

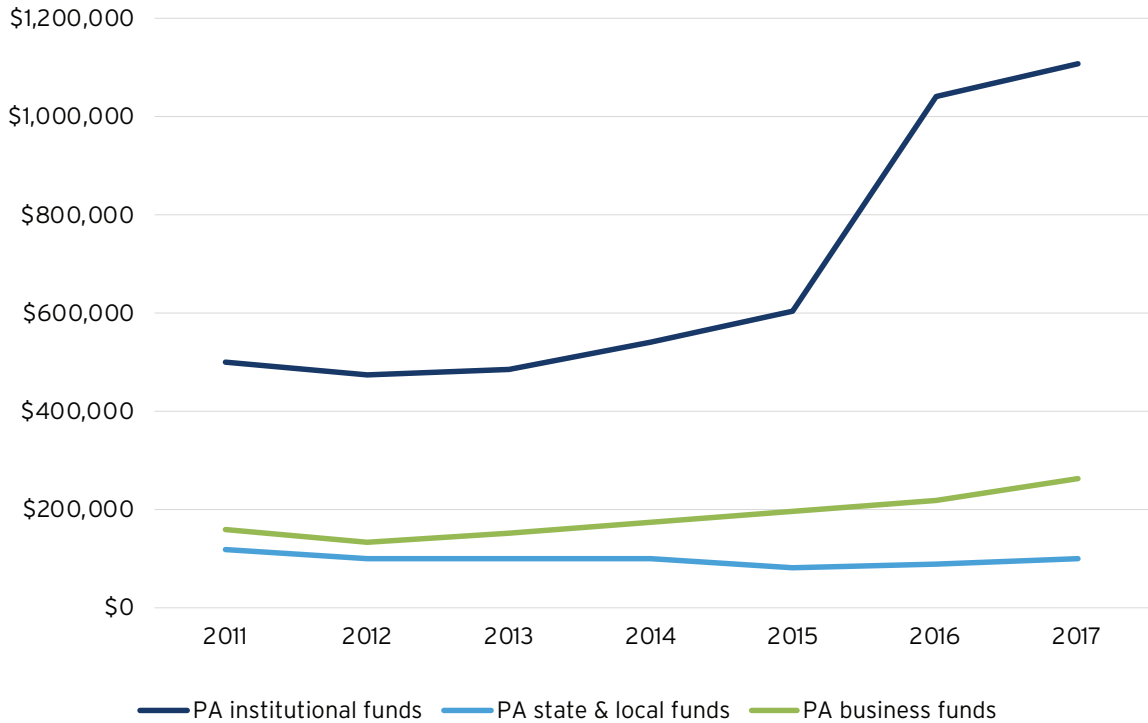
Scarce state budgetary resources during the downturn were a significant factor in the initial scale back of innovation support, but the trend was exacerbated by a breakdown in the political consensus that economic development should receive state support.²² Continuing disagreement over the state's role in economic development remains a major reason why state public support for innovation initiatives remains below pre-recession levels. However, that is not the case elsewhere in the country. Some competitor states have been doubling down on effective legacy programs, while others have been scaling up new models for promoting innovation. Ohio's Third Frontier program, the primary technology-based economic development program in the state, has increased its annual spending on research and development projects from just under \$58 million in FY 2014 to over \$71 million in FY2017, and the state has authorized it to spend up to \$110.8 million per year through FY2019.²³ Likewise, Colorado established its Advanced Industries Accelerator program with a dedicated funding source, which has allowed it to invest \$50 million into advanced industries firms in the state since 2013, catalyzing an additional \$360 million in outside investment.²⁴ Finally, Massachusetts recently reauthorized its Life Sciences initiative with \$623 million in bond authorization and tax credits over the next five years.²⁵

While Pennsylvania is a national leader in university R&D, much of the state's over-performance comes from the institutions themselves, with positive contributions from industry. State- and local-government support for university R&D, meanwhile, has declined in absolute terms.

Pennsylvania's university-based R&D remains strong due to significant university investment coupled with increasing support from industry. Indeed, industry-funded R&D at Pennsylvania universities has increased 64 percent since 2011. However, R&D conducted by Pennsylvania businesses themselves has been volatile at a time when industry R&D is growing as a share of the overall U.S. economy. So, while it is encouraging that universities have been stepping up when it comes to supporting industry R&D, it hasn't been enough to compensate for the broader trend of stagnating industry R&D in the state. This is because, despite its rapid growth, industry-

FIGURE 3

Funding for Pennsylvania university R&D



Source: National Science Foundation (NSF) Higher Education Research and Development Survey (HERD)

funded R&D at universities in Pennsylvania is less than 3 percent of the amount of R&D paid for and performed by companies themselves in the state.²⁶

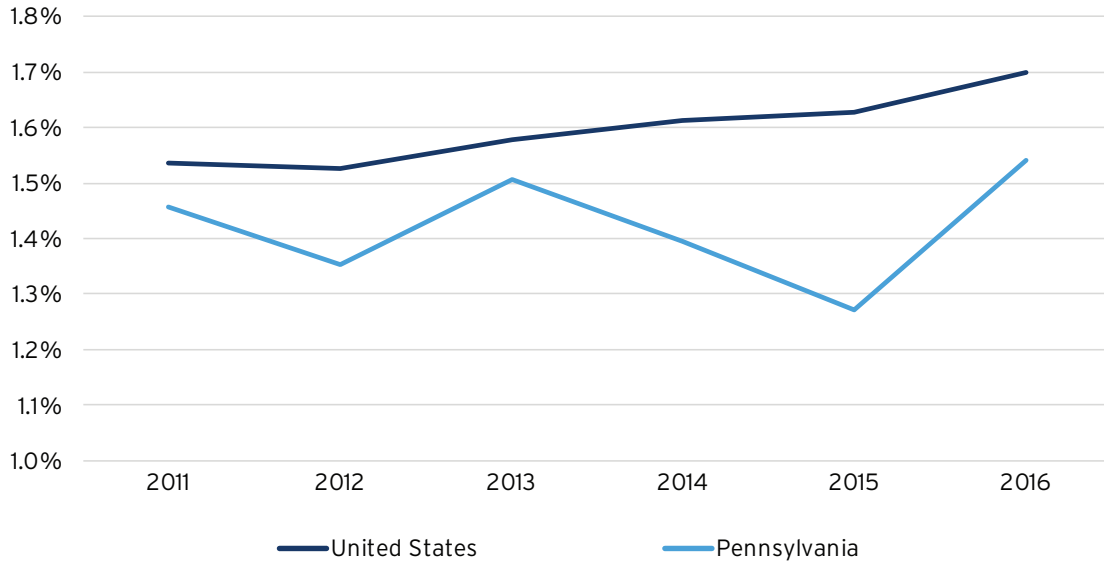
Likewise, while the state still has some of the leading universities for technology transfer and commercialization, state effort has declined in recent years. According to the State Science and Technology Institute (SSTI), spending on R&D, technology transfer, and commercialization in Pennsylvania has declined 65 percent since 2009.²⁷

These cuts mirror a long-running erosion in funding for the Ben Franklin Technology Partners, a cornerstone innovation program in the state. In recent years this deterioration was mitigated to a degree through the Innovate in PA program, which sold \$100 million of insurance premium tax credits to shore up funding for the Ben Franklin Technology Partners, the Venture Investment Program, and the Life Sciences Greenhouses. However, that funding has since expired, which has led to a significant real decline in funding for innovation in the state.

FIGURE 4

Industrial R&D as a share of GDP

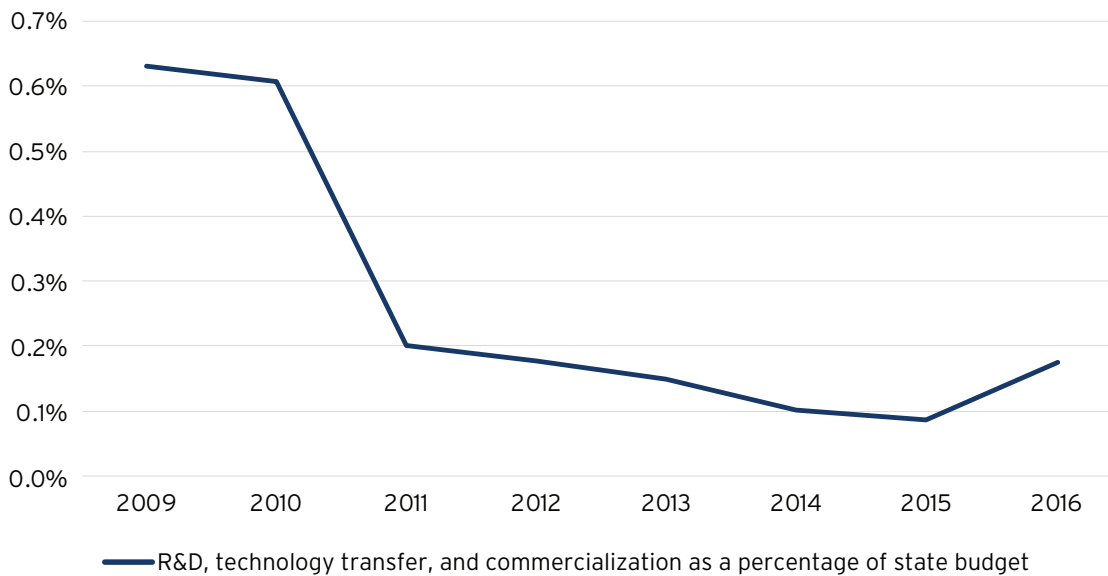
R&D paid for and performed by companies



Source: Brookings analysis of NSF Business Research and Development and Innovation Survey (BRDIS) and Bureau of Economic Analysis (BEA) data

FIGURE 5

R&D, technology transfer, and commercialization as a percentage of state budget



Source: SSTI analysis of data from C2ER; Pennsylvania Office of the Budget

FIGURE 6

Real funding for Ben Franklin Technology Partners has been declining over time

FYs 1984-2019



Source: Ben Franklin Technology Partners

This reduction in funding has forced the Ben Franklin Technology Development Authority (the entity that oversees the Ben Franklin Technology Partners network) to zero out support for a variety of innovation-oriented programs in recent years.²⁸ These include:

- **The Keystone Innovation Zone (KIZ) grant program:** Operational grants for Pennsylvania’s 29 designated KIZs, with the goal of improving Pennsylvania’s research and development efforts, technology commercialization, and entrepreneurship programs within designated geographic areas.
- **Technology Development Grants:** Grants that advanced the adoption of new technologies by Pennsylvania companies, and supported the creation of new companies that provided high-wage, high-skilled jobs in Pennsylvania.

- **University Research Grants:** Grants that fostered stronger synergies between university-based R&D and state economic and workforce development.
- **Pennsylvania Angel Network:** A network of angel investing groups that operate throughout the commonwealth that help syndicate investment deals, share best practices, provide training for angel investors, and create new angel groups. While the program still exists today, its activities have been greatly scaled back due to the lack of state support.

Programs like the Ben Franklin Technology Partners have long been the centerpiece of technology-based economic development in Pennsylvania, and if fully funded, could serve as a platform for both implementing new innovation programs and reviving former ones. Indeed, while the Bens are best known for their early-

stage funding in technology-oriented companies, they have also historically possessed a broad economic development mission.

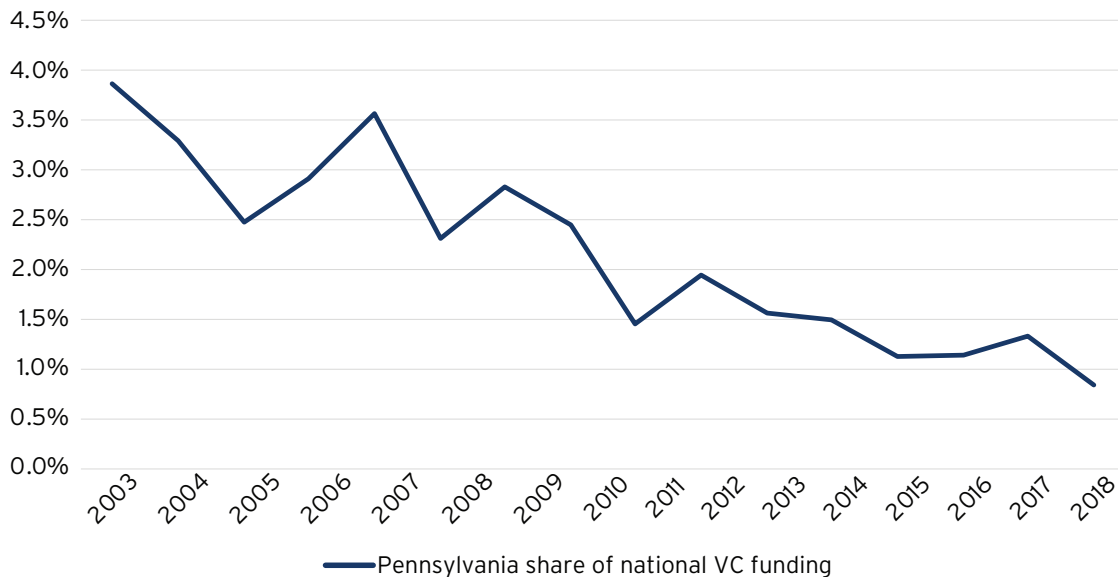
For example, the 1993 Ben Franklin/Industrial Resource Center (IRC) Partnership Act laid out a variety of responsibilities for the Ben Franklin Technology Partners that are relevant for solving the challenges that Pennsylvania faces today. These included developing joint research and development efforts with companies, establishing technology parks for manufacturing-oriented research and development, assisting small business incubators to bolster early-stage support for companies, and supporting regional development in all areas of the state through regional business consortiums. Likewise, the Ben Franklin/IRC Partnership played a role in developing state and regional plans to ensure efforts were effectively coordinated among regions.²⁹ In addition, the Bens were charged with providing training and curriculum development in order to develop a workforce equipped to secure employment in advanced technology industries.³⁰

Importantly, the Ben Franklin Technology Partners still maintain a significant statewide network of offices, anchored in its four regional affiliates: Northeastern PA, Southeastern PA, Southwestern PA, and Central and Northern PA. This existing statewide infrastructure gives them a foothold to help mitigate the substantial spatial divergence that the commonwealth currently faces.

So, while the infrastructure to support innovation in Pennsylvania still exists, chronic underinvestment has greatly diminished its capacity. This pattern seems likely to continue, as the state's newest budget proposal is stagnant on innovation. For example, funding for the Ben Franklin Technology Development Authority Fund and Manufacturing PA remains flat and is projected to continue to be so for the next five years. And while the state budget did double the funding for the Pennsylvania First economic development program, that program is focused on general economic development rather than innovation in the state.³¹

FIGURE 7

Pennsylvania share of national venture capital funding



Source: PriceWaterhouseCoopers MoneyTree

In addition, Pennsylvania's drift extends beyond just commercialization and early stage support. Over the past 15-plus years, the state has captured a declining share of national venture capital (as evidenced by Figure 7).

In an era increasingly driven by emerging technologies, innovation underperformance poses a significant challenge to Pennsylvania's future economic vitality. In addition to declining innovation effort, Pennsylvania continues to lag national leaders, and the U.S. as a whole, in several key innovation output measures. Closing these gaps will be essential to keeping Pennsylvania competitive in an increasingly knowledge-driven economy.

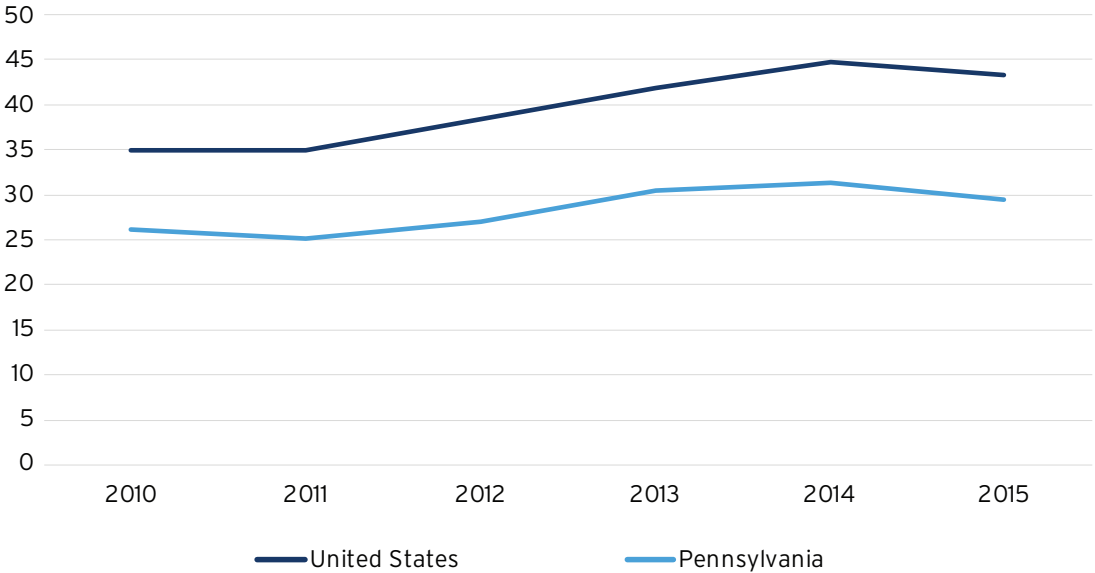
For example, Pennsylvania lags in the number of utility patents (i.e. patents for invention) that it produces relative to its share of the

population. This indicates weakness in the kinds of innovations that lead directly to new products and processes. Not only that, but the gap between Pennsylvania and the rest of the nation is widening (see Figure 8 below).

The state not only produces fewer patents, but also creates fewer new companies than the country as a whole. While startups have been declining across the United States, Pennsylvania has consistently lagged the U.S. average for the past 40 years. Likewise, the number of jobs at young firms in Pennsylvania, a proxy for the economic impacts of entrepreneurship, lags the nation overall, although the state has been converging with the national average in recent years. This lag occurs both with jobs at young firms as a share of the state's workforce, as well as with growth in the absolute number of jobs at young firms.³²

FIGURE 8

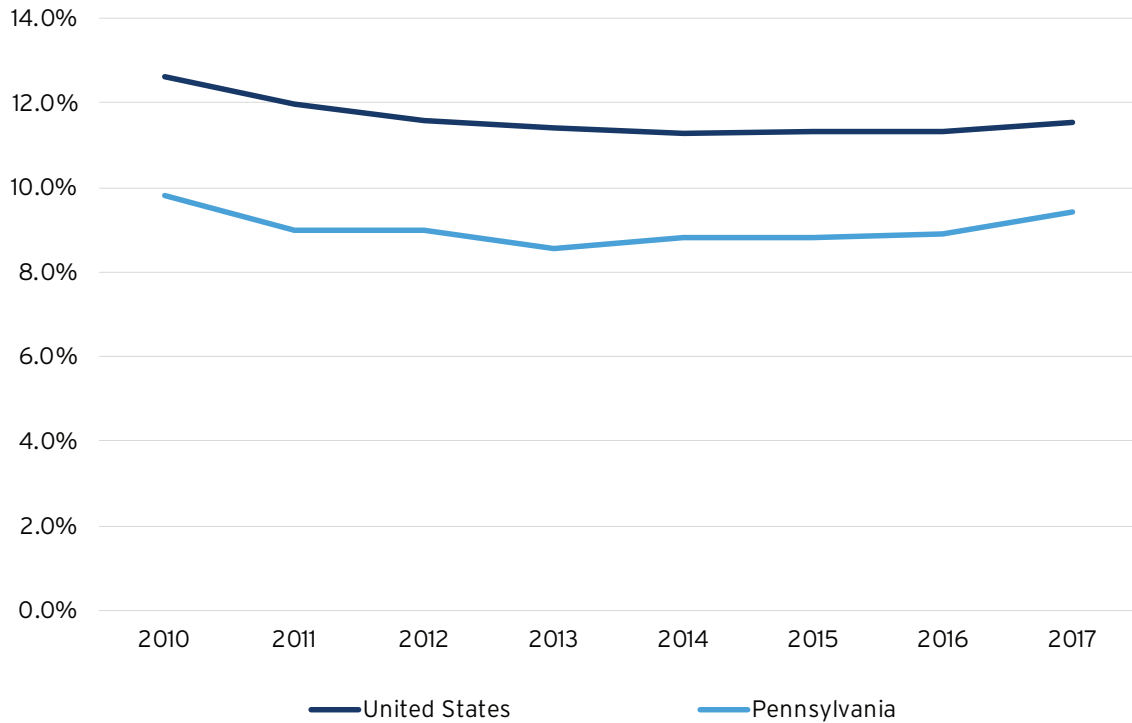
Utility patents per 100,000 people



Source: U.S. Patent and Trademark Office

FIGURE 9

Share of jobs at young firms



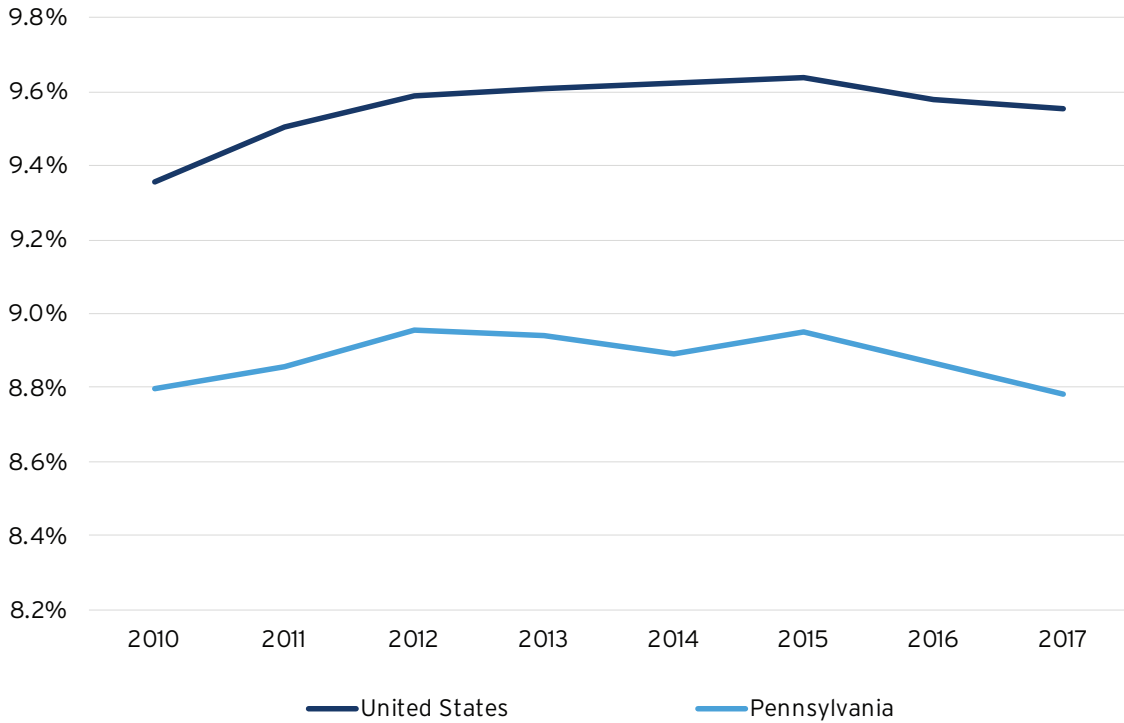
Source: Census Bureau Longitudinal Employer-Household Dynamics (LEHD) Quarterly Workforce Indicators (QWI)

Furthermore, when it comes to catalyzing desirable innovation-driven industrial activity, Pennsylvania has a weaker advanced industries presence than the United States as a whole. As mentioned, advanced industries are the 50 manufacturing, energy, and services industries that conduct the most private-sector R&D and employ the highest proportion of science, technology, engineering, and mathematics (STEM) workers.³³ Advanced Industries have outsized economic impacts, including producing the majority of American exports, generating

90 percent of the country’s private-sector R&D, and creating extensive positive economic multiplier effects because of their long supply chains. Workers in advanced industries earn nearly twice as much as the average worker in other industries. However, when it comes to employment in these industries, Pennsylvania lags the country as a whole. In that sense, Pennsylvania is deriving less of the high-value economic activity than one might expect to be associated with its great universities.

FIGURE 10

Advanced industries employment share



Source: Emsi

Pennsylvania is also contending with significant spatial divergence, which exacerbates economic performance issues.

In recent years, scholars and policymakers have begun to focus more intensely on the divergence between so-called “superstar” places, particularly large metropolitan areas, and the rest of the country.³⁴ Pennsylvania has not been immune to increasing divergence. The state’s innovation issues are compounded by significant performance differences between high-achieving university-anchored areas and the rest of the state.

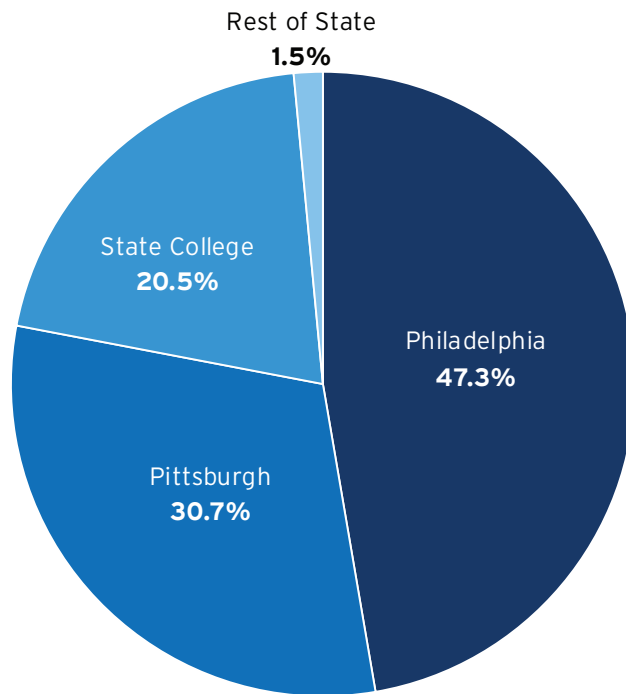
For example, over 98 percent of state’s higher education R&D is concentrated in just three metro areas: Philadelphia, Pittsburgh, and State College. This is driven in large part because the state’s six “R1” research universities, the highest research classification level by the Carnegie

Classification of Institutions of Higher Education, are all located in one of those three metropolitan areas. In fact, of the state’s 10 R1 (indicating very high research activity) and R2 (indicating high research activity) universities, only one, Lehigh University, is located outside of the Philadelphia, Pittsburgh, or State College metro areas.³⁵

Meanwhile, Pennsylvania’s two largest metropolitan areas make the most significant contributions to the state’s innovation outputs. Pennsylvania counties in the Philadelphia and Pittsburgh metropolitan statistical areas account for 50.4 percent of the state’s population and 53.3 percent of its employment, however they play an outsized role in the state’s innovation economy. For example, they account for 60.6 percent of the state’s advanced industries employment, and 69.3 percent of its utility patents.³⁶

FIGURE 11

Percentage of Pennsylvania higher education R&D expenditures by metropolitan statistical area 2017



Source: NSF HERD

Furthermore, this concentration of innovation assets in the largest places has grown over time. Since 2001, the Philadelphia and Pittsburgh metro areas' share of overall state population has declined by 0.7 percentage points and their share of overall employment has declined by 0.3 percentage points. However, due in large part to the hollowing out of advanced industries, particularly advanced manufacturing, elsewhere in the state, Philadelphia and Pittsburgh's share of statewide advanced industries employment has increased by 3.2 percentage points, and their share of utility patents has increased by 6.1 percentage points³⁷

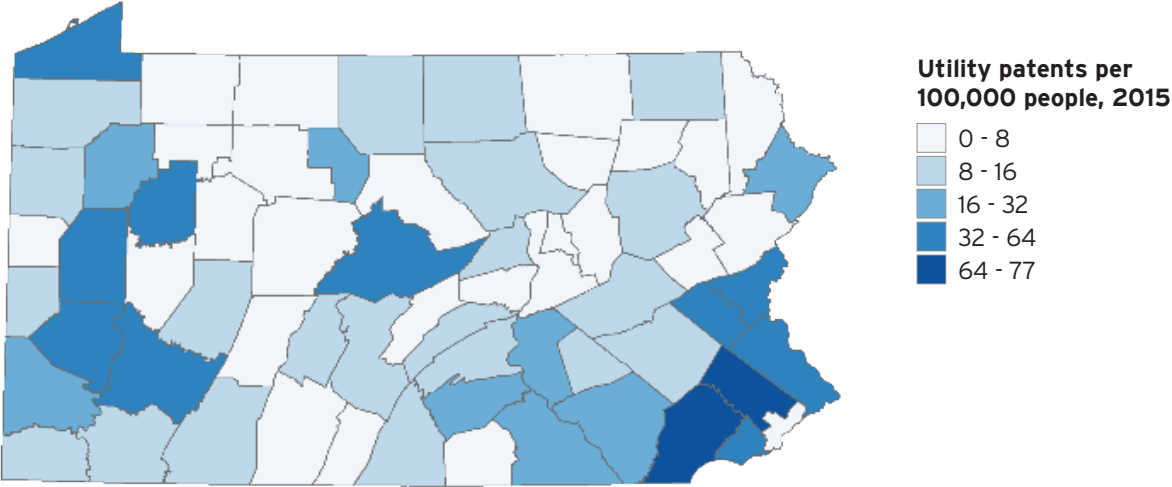
Without a doubt there are other places in the state that make noteworthy contributions to the state's innovation ecosystem. As Figure 12 below demonstrates, counties like State College and Erie county produce significant numbers of patents relative to the size of their populations. However, they are still overwhelmed by the state's two largest metros.

And while advanced industries employment is more diffuse throughout the state due to the presence of advanced manufacturing and energy industries in some smaller counties, Philadelphia and Pittsburgh still have a disproportionate share.

Unsurprisingly, economic performance in Pennsylvania over the past decade has tracked closely with community size. Indeed, the only group of Pennsylvania counties that have seen net employment growth since 2008 are those in medium and large metropolitan areas (which have between 250,000 and 1 million people, and 1 million+ people, respectively). Pennsylvania counties in metropolitan areas with fewer than 250,000 people have, on net, lost employment. This includes small metropolitan areas (between 50,000 and 250,000 people), micropolitan areas (10,000 to 50,000 people), and rural areas (fewer than 10,000 people).

FIGURE 12

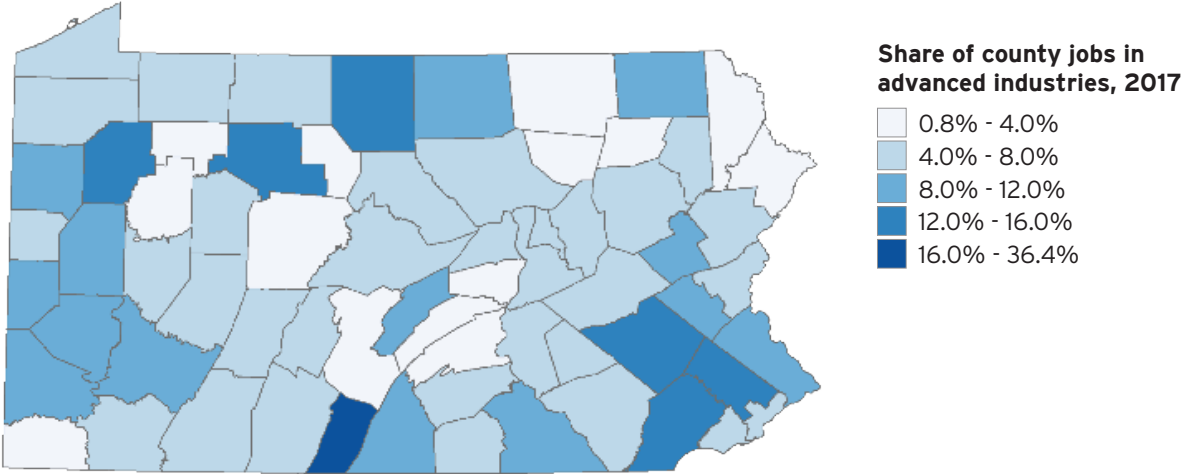
Pennsylvania per capita utility patents by county, 2015



Source: U.S. Patent and Trademark Office

FIGURE 13

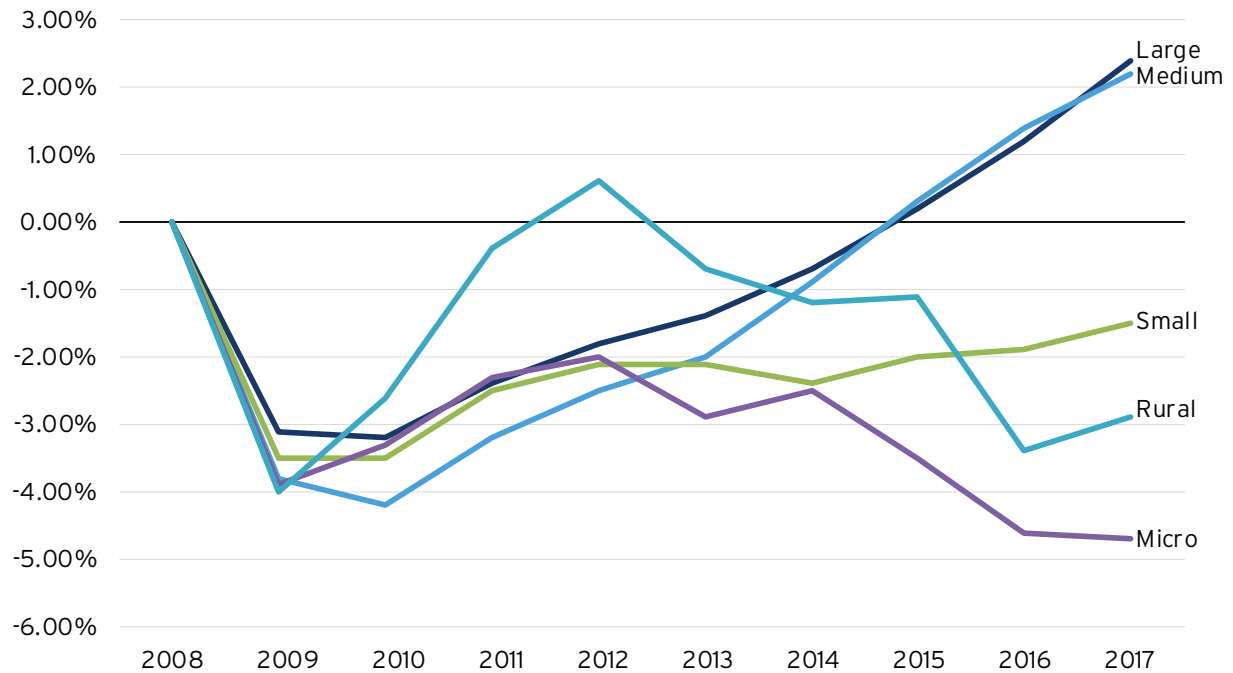
Pennsylvania advanced industry employment by county, 2017



Source: Emsi

FIGURE 14

Pennsylvania counties in large and medium-sized metropolitan areas have dominated employment growth, while those in smaller areas have seen absolute declines



Source: Emsi

Without a reversal of these spatial dynamics, a significant number of people, places, and companies risk falling further behind. This will increase hardship in the state and hinder overall economic performance, and risks exacerbating political divides between the largest metropolitan areas and the rest of the state. While reversing these trends will not be easy, it should be noted that Pennsylvania is a state with a proud tradition of innovation in rural areas and small- and medium-sized metro areas. From the powdered metals industry in northern Pennsylvania, to machining and transportation in the northwest, and mini-industry clusters in metro areas such as York and Scranton, Pennsylvania’s history indicates that a renewed effort in supporting smaller areas could make a difference. Likewise, while the tech-driven knowledge economy has exacerbated spatial inequalities in Pennsylvania, it also provides opportunity. If leveraged correctly, emerging technologies such as AI, autonomous vehicles, new materials, and new energy capabilities all have the potential to help

solve distinct challenges facing smaller areas in the state.

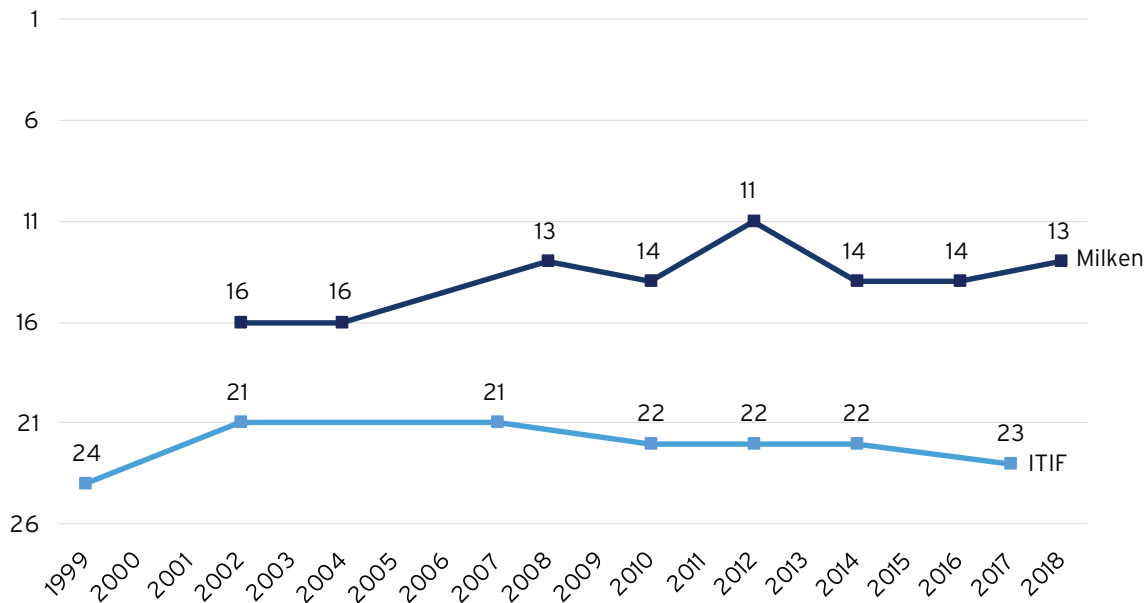
These issues have combined to keep Pennsylvania middle-of-the pack. The commonwealth’s inability to organize an effective innovation strategy, its underinvestment in innovation resources, and its middling innovation outcomes, have been reflected in its consistent middle-of-the-pack rankings by major innovation benchmarks over the last two decades.

In its first State New Economy Index in 1999, the Informational Technology and Innovation Foundation (ITIF) ranked Pennsylvania 23rd out of 50 states. Pennsylvania’s improved in 2002, when it was ranked 21st in the country. However, in surveys since the state has flat lined, receding to 23rd in the most recent rankings in 2017.³⁸

Pennsylvania performs better in another well-known ranking of state innovation capacity, the Milken State Technology and Science Index.

FIGURE 15

Pennsylvania ranking over time in major state innovation indices



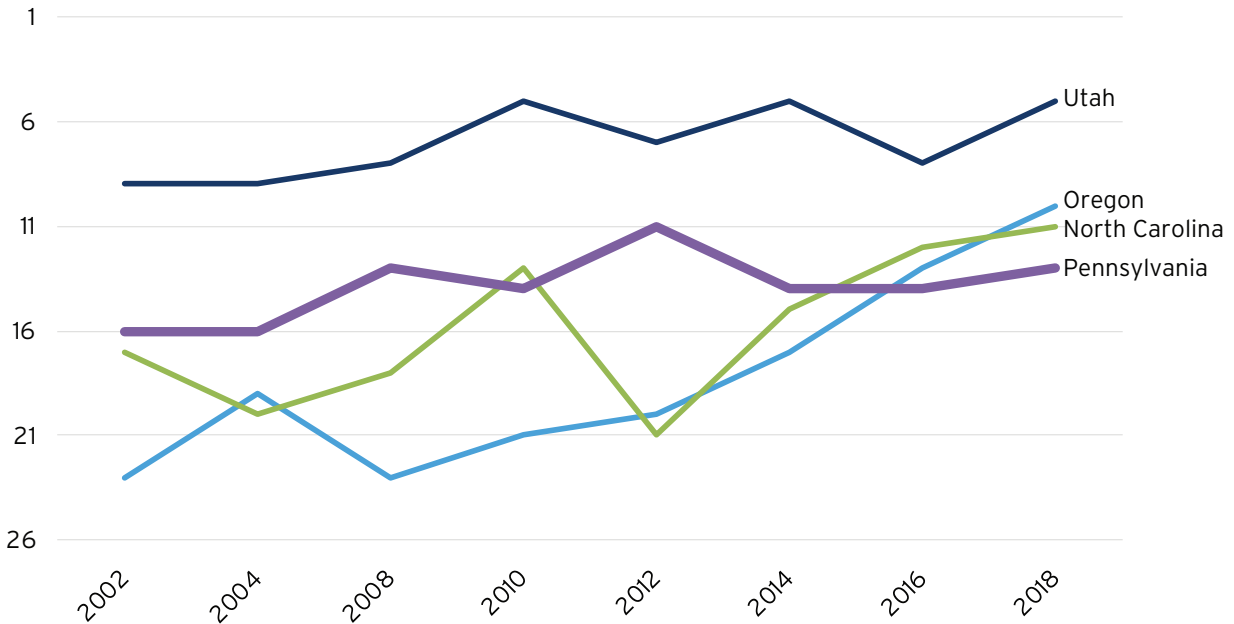
Source: Milken State Technology And Science Index, ITIF State New Economy Index

However, like with the ITIF rankings, Pennsylvania has been unable to break into the top-tier of states, and has been trending sideways in recent years. Milken ranked Pennsylvania 16th in its initial set of rankings in 2002. The state climbed to 11th overall in the country by 2012, but it regressed to 14th in 2016 before ticking up one place to 13th overall in 2018.³⁹ However, while Pennsylvania climbed one position in its ranking, it is worth noting that the state’s raw score has fallen every year since 2012.⁴⁰ This indicates that while the state’s relative position may not be declining, its absolute score is worsening—and in fact, the gap between Pennsylvania and the national leader, Massachusetts, has grown in size.⁴¹ Indeed, Pennsylvania’s raw 2018 score of 59.58 would have only ranked 22nd overall in 2012. Given the increasingly “winner-take-most” dynamics of the current era, this growing concentration of high scores in fewer places is worrisome.

Meanwhile, competitor states that have invested in their innovation ecosystems have now surpassed Pennsylvania. For example, Utah has prioritized technology-based economic development over the past decade and has seen its rankings climb correspondingly. North Carolina, meanwhile, has made smaller investments, but has focused on supporting innovation economies outside of the Research Triangle and Charlotte. The result has been modest gains that have helped it pull ahead of Pennsylvania on the latest iteration of both major rankings. Oregon meanwhile has had one of the most consistent upward trajectories among the Milken Institute’s rankings over the past decade. During that period, Oregon developed a state Innovation Council, which has published biennial state plans for innovation and economic competitiveness that have helped coordinate innovation efforts across the state.⁴²

FIGURE 16

Comparative Milken rankings for Utah, Oregon, North Carolina, and Pennsylvania



Source: Milken State Technology and Science Index

These rankings reflect the broader story in Pennsylvania’s innovation capacity—one of stalled progress and unfulfilled potential. As the economic development firm Fourth Economy notes in a recently released assessment of Pennsylvania’s innovation economy, while Pennsylvania fares better than many other places, today’s knowledge-driven economy is becoming increasingly dominated by a few superstar cities and states—and Pennsylvania is not among them.⁴³ Furthermore, if the current trends and underinvestment continue, the state risks slipping into a more negative trajectory.

Today, Pennsylvania faces a set of discrete challenges to improve its innovation ecosystem. Based on interviews with key stakeholders in the state, outside experts, and

the analysis conducted here, this assessment has identified four ongoing challenges that Pennsylvania will need to overcome in order to become a national innovation leader:

The absence of a comprehensive state innovation strategy grounded in an evidence-based understanding of the state’s industries and innovation status.

Pennsylvania has lacked a statewide innovation strategy for over a decade, meaning there has been no framework for how industries and regions in the state can best interact and grow. Many leading and competitor states leverage statewide strategies to categorize their strengths and develop nuanced and sophisticated homegrown areas of competitive advantage. A state innovation strategy would

help Pennsylvania identify shortcomings in the innovation lifecycle across the state and concentrate improvement efforts on areas of greatest need.

Below-average industry R&D that has stagnated in recent years. Pennsylvania's business R&D has been stagnant at a time when overall business R&D in the country has started growing as a percentage of the economy. Changing this trend will be crucial for Pennsylvania's economic growth. Business R&D typically has a greater focus on applied research than academic R&D, and thus is important for generating new products and processes in the private sector. In addition to generating new knowledge, business R&D has a variety of positive economic effects: It boosts productivity, increases the likelihood that startups will survive to increase hiring, and improves firms' international competitiveness.⁴⁴

Reduced investment in state resources for early stage companies, combined with declining venture capital in the state. In the early 2000s, nearly 4 percent of U.S. venture capital flowed to Pennsylvania, a number that has declined by nearly 80 percent since. Meanwhile, Pennsylvania has been reducing its public investments in state resources that provide needed capital for startups. Early stage and venture capital are essential for turning academic and other research breakthroughs into commercial products with positive benefits for the economy. Without adequate early stage and venture capital, some of the breakthroughs developed at Pennsylvania universities will never be commercialized, while

the entrepreneurs that do successfully develop products or companies will be more likely to leave for states with more developed financing systems.

Significant spatial divergence between the largest innovation centers (Philadelphia and Pittsburgh) and the rest of the state.

These large innovation centers receive a disproportionate share of state innovation inputs, and produce a disparate share of state output. Smaller areas, meanwhile, have struggled with fewer investments, which has contributed to harmful economic trends like negative real employment growth over the past decade. Even if Pennsylvania's topline innovation performance is improved, if the benefits are concentrated in only a few areas then it will depress the overall positive impact for citizens and communities. Likewise, growing spatial divergence in the state will continue to inflame political tensions, making it increasingly difficult to solve the growing competitive challenges that Pennsylvania faces.

*

However, the recent past does not need to be prologue. Pennsylvania can use this moment to shore up its innovation assets, pioneer new state innovation efforts, and foster regional inclusion. To respond effectively to this downturn in innovation capacity, Pennsylvania must work to both fully resource its existing crop of innovation assets, as well as incorporate new relevant practices drawn from both peer states and national leaders.

4. Scan of competitor- and leadership-state innovation efforts

Pennsylvania is not unique in the challenges it faces to its innovation ecosystem. However, other states have taken action to spur their respective innovation ecosystems, as well as mitigate the most severe impacts of divergence. The following section highlights 20 initiatives underway in both competitor states and national leaders that address challenges like the ones Pennsylvania faces.

These states have diverse political leadership, which shows that bolstering innovation and enhancing inclusive growth are bipartisan. Some initiatives are a major financial investment, or are longstanding initiatives within their respective states; others are smaller or were created in recent years. This shows that while there are a handful of national leaders, more and more states recognize the importance that innovation plays to their state economies—and are proactively investing to enhance it.

This section is organized to align with the four challenges that Pennsylvania faces. Each contains a brief one-page recap of the

challenge and then presents between four and six initiatives underway in competitor states and leading states. For each initiative, there is a summary, information on when the program was created, and a brief description. Likewise, with the exception of the four state innovation strategies highlighted, there is also information on the budget and financing mechanism for each initiative, as well as the relative size of the state economy compared to Pennsylvania. Finally, where available, return-on-investment (ROI) data is included. It is important to note that not every initiative had ROI data available, and many of those that did only had limited public data.



CHALLENGE 1

Create an evidence-based state innovation strategy

A well-researched innovation strategy can help states identify their unique assets and competitive advantages in the modern economy and coordinate state resources to support areas of future growth. Such programs also typically benchmark how states are doing relative to competitors, track state progress over time, and provide recommendations for forward-looking programs and initiatives.

Pennsylvania last conducted a statewide inventory of its innovation ecosystem in 2005. That report, known as TechFormation, assessed how Pennsylvania performed across different stages of the innovation lifecycle and provided a variety of metrics, presenting a fact-based profile of the commonwealth's innovation economy.⁴⁵ TechFormation was intended as the first in a series of status reports on the Pennsylvania innovation economy.⁴⁶ However, follow-on reports that further fleshed out Pennsylvania's innovation strengths and weaknesses were never published.

During the intervening years, the commonwealth weathered the late-2000s financial crisis and its aftermath and faced several years of budget shortfalls and difficult fiscal decisions. An evidence-based innovation strategy that assesses how industries and regions in the state can best interact and grow would help its efforts to become a national innovation leader.

Many leading and competitor states leverage statewide strategies to categorize their strengths and develop nuanced and sophisticated homegrown areas of competitive advantage. Some of those states have done so at the onset of a new gubernatorial administration and have then leveraged those plans to guide economic policymaking over the course of the next few years. Examples of this approach include Rhode Island in 2016 and New Jersey in 2018.

Meanwhile, some of the most innovation-oriented states go further, including publishing regular updates of their strategy or annual assessments of their innovation economies. Massachusetts, for example, has published its annual *Index of the Massachusetts Innovation Economy* every year since 1997. It assesses status, including innovation investments and outputs across a variety of metrics, and benchmarks the state against top competitors.

However, a single, comprehensive statewide strategy is not necessarily the only starting point. For example, some states have successfully leveraged strategies that focused on one or several key sectors of their economy. This includes Tennessee, which leveraged a 2013 sectoral strategy for the state's automotive industry to explore policy options that enhanced the state's broader innovation economy.

A state innovation strategy would help Pennsylvania identify shortcomings in the innovation lifecycle across the state, and concentrate improvement efforts on areas of greatest need. Doing so would also help maximize the return on efforts to confront other shortcomings in the state's innovation economy.

The State of Innovation: Building a Stronger and Fairer Economy in New Jersey

State: New Jersey

Summary: Economic plan unveiled in 2018 by Governor Phil Murphy and the New Jersey Economic Development Authority that puts an emphasis on leveraging innovation to drive equitable growth in New Jersey.

Year: 2018

Site: <https://www.njeda.com/about/Public-Information/Economic-Plan>

In October 2018, Governor Phil Murphy unveiled an ambitious economic plan centered on leveraging innovation to bolster economic growth and make New Jersey more inclusive.

The strategy sets out five main goals to achieve by 2025:

1. Driving faster job growth over this period than all Northeast peer states by fostering a better, more supportive business climate
2. Achieving faster median wage growth than all Northeast peer states
3. Creating the most diverse innovation ecosystem in the nation and doubling venture capital investment in the state
4. Closing the racial and gender wage and employment gaps
5. Encouraging thriving and inclusive New Jersey urban centers and downtowns, with a focus on reducing poverty

To attain these goals, the plan lays out a set of initiatives and programs to bolster innovation in the state.

On workforce, the state is seeking to attract and retain entrepreneurs, as well as educate and train more STEM students and professionals. This includes enhancing STEM at the K-12 level, exploring student loan forgiveness for STEM higher education students, and expanding education programs that have a focus on 21st century skills.

The state is also looking to bolster its innovation ecosystem. This includes expanding incubators and workspaces, better connecting educational institutions to the innovation economy, and repurposing “stranded assets” across the state for use in the innovation economy.

Additional efforts include supporting high-wage, high-growth innovation sectors such as life sciences, advanced manufacturing, and advanced transportation, among others. Furthermore, the state has committed to a goal of 100 percent clean energy by 2050, and to making corresponding investments in clean energy innovation to reach that goal.

Finally, the state is working to increase the availability of public and private investment capital in the state. This includes working to attract more federal innovation dollars, modernizing the state’s R&D tax credit, enhancing its Angel Investor Tax Credit, and creating a New Jersey Innovation Evergreen Fund to attract entrepreneurs in priority sectors.⁴⁷

Rhode Island Innovates: A Competitive Strategy for the Ocean State

State: Rhode Island

Summary: A statewide plan to boost innovation-led competitiveness in Rhode Island, with a focus on multiple industries that have potential for high-growth.

Year: 2016

Site: <https://www.brookings.edu/research/rhode-island-innovates-a-competitive-strategy-for-the-ocean-state/>

“Rhode Island innovates: A competitive strategy for the Ocean State” is a competitive strategy produced by the Metropolitan Policy Program at Brookings, in association with Battelle Technology Partnership Practice (now TEconomy Partners, LLC). The strategy begins with a broad assessment of Rhode Island’s competitive position in the national innovation economy. In particular, it notes several core problems, including deteriorated growth capacity, shrinking advanced industries, and stagnant median income. Likewise, the plan observes that, unlike some larger states, Rhode Island lacks obvious anchor industries that would make the strategy a simpler process.

In response, the plan recommends a focus on building resilient future-oriented industry specializations in smaller clusters with significant growth potential. To do so, it identifies five advanced industry growth areas, and two “opportunity industry” growth areas that hold high growth potential for the state. For each industry, the plan provides as a baseline look at the industry in Rhode Island and a description of why it can be a key industry moving forward.

The plan’s recommendations address shortcomings across the full innovation value chain. This begins with improving R&D in the state by creating programs to recruit commercially oriented faculty and create an Entrepreneurs in Residence program. It also focuses on bolstering startups and technology transfer through programs like a state innovation challenge and an artificial intelligence tech collaboration center between industry, universities, and laboratories. It then recommends boosting the state’s industry R&D through reforming the state R&D tax credit, including by raising the cap on deductions and making it refundable.

The plan also includes recommendations in complementary policy areas that would have positive impacts for the state’s innovation economy. These include bolstering the state’s skilled workforce for innovation-focused sectors, such as through better STEAM (STEM plus arts) education and a statewide coding initiative; and strengthening the state’s business environment, through efforts such as improved transportation links and more pad-ready commercial and industrial sites. Finally, it concludes with a recommendation to establish a high-level business-civic organization to deliver on transformative statewide initiatives.⁴⁸

Drive! Moving Tennessee's Automotive Sector Up the Value Chain

State: Tennessee

Summary: An innovation-focused sectoral economic development plan that assessed the competitive position of the Tennessee automotive sector and proposed a vision and strategy for continuing to strengthen the sector.

Year: 2013

Site: <https://www.brookings.edu/research/drive-moving-tennessees-automotive-sector-up-the-value-chain/>

“Drive! Moving Tennessee’s Automotive Sector Up the Value Chain” was a sectoral plan created by the Metropolitan Policy Program at Brookings to assess Tennessee’s automotive industry and determine how the state could best grow the industry moving forward.⁴⁹ The plan featured a specific focus on enhancing innovation in the industry as part of a broader industry growth strategy.

The automotive industry is a major sector in Tennessee, with significant economic impact throughout the state. In states with industries that play a significant role in the state economy, such as the roles that industries like advanced materials, life sciences, or energy production play in Pennsylvania, sectoral plans can be useful to coordinate statewide growth and development.

The plan began by providing a baseline analysis of the sector’s importance to the state, as well as a review of how the sector has fared in the recent past. This included spatial analysis to determine which areas had the greatest auto sector presence. It then provided forward-looking analysis on the competitive challenges for the industry. Among these challenges were constraints in the state’s innovation system, such as limited technology transfer and weak industry R&D.

It concluded with steps that private industry and the state government could take to bolster the sector’s health and long-term competitiveness, well as how the federal government could support those efforts. Action was divided among three main themes: driving continuous industry development, developing the workforce pipeline and strengthening the state’s advanced industries skills base, and committing to innovation at all levels of the supply chain.

In terms of innovation, the plan had specific recommendations for both private industry and state entities. These included pushing the private sector to enhance its R&D and engage in an innovation commons to grow the state’s ecosystem, as well as recommending the state take actions such as creating a dedicated sector lead in state government, prioritizing technology development and diffusion, and enhancing state R&D through an R&D tax credit or innovation voucher program.

Finally, while the plan focused on the automotive industry, it discussed the sector in the broader context of bolstering advanced industries in the state. This is because different advanced industries are frequently interlinked, particularly when it comes to areas like workforce development or innovation ecosystem development. As a result, this plan and its recommendations had implications beyond the automotive industry.

Index of the Massachusetts Innovation Economy

State: Massachusetts

Summary: Long-running annual publication providing an overview of the state of the Massachusetts innovation economy and benchmarking it against the progress of other leading states.

Years: 1997-present, annual publication

Site: <https://www.masstech.org/index>

Every year since 1997, the Massachusetts Technology Collaborative (MassTech), a public agency that supports business formation and growth in the state's technology sector, has published the *Index of the Massachusetts Innovation Economy*.⁵⁰ By doing so, the state has not only signaled a long-running commitment to supporting innovation, but has also been able to track the progress of the state's innovation economy with regularity, giving policymakers a strong fact base as they plan future innovation investments.

The report assesses the Massachusetts innovation economy across six dimensions: economic impact, research, technology development, business development, capital, and talent. Each of these dimensions, in turn, has between two and six indicators that are tracked in detail. These metrics provide a broad cross-section of the Massachusetts innovation economy, tracking it across industries and socioeconomic groups, as well as comparing Massachusetts against top competitors domestically and internationally.⁵¹

Furthermore, the report also benchmarks innovation metrics and major innovation programs in 14 other states that they have designated "leading technology states." Leading technology states are those that have significant economic concentration and size in 11 key sectors that Massachusetts deems essential to the innovation economy. The metrics used to select leading technology states are intensity of employment concentration in the 11 key sectors, overall innovation economy employment relative to the nation as a whole, and total innovation economy employment.

For each leading technology state, the report includes data points such as key economic sectors, significant universities and research institutions, and important innovation economy employers. It also provides three examples of public, private, and non-profit initiatives underway in each state that support the innovation economy.⁵² For its part, Pennsylvania has long been selected as a leading technology state that Massachusetts has benchmarked against.

CHALLENGE 2

Strengthen business R&D in the state

Business R&D is unique from academic and government-led R&D. Compared to other forms of R&D, business R&D typically has a greater focus on applied research, and thus is important for generating new products and processes in the private sector. In addition to generating new knowledge, business R&D has a variety of positive economic effects: It boosts productivity, increases the likelihood that startups will survive to grow their hiring, and improves firms' international competitiveness.

Pennsylvania's business R&D has been stagnant at a time when overall business R&D in the country has started growing as a percentage of the economy. Changing this trend will be crucial for Pennsylvania's economic growth. Competitor states and national leaders in innovation are pursuing a variety of policies to enhance business R&D in their states. One of the most ambitious efforts comes from Ohio, where JobsOhio is investing \$100 million in helping firms establish new business R&D infrastructure across an array of priority sectors.

Rhode Island has used a more tailored approach by leveraging innovation vouchers to spur greater small business and startup R&D. This policy has the added benefit of increasing connections across the state's innovation ecosystem by connecting businesses to universities and federal labs in the state. Such a policy would fit well with Pennsylvania's existing stock of R&D infrastructure. Maryland's Industrial Partnerships program provides another potential pathway to leverage the state's strong university system.

It offers matching grants to facilitate industry-university research partnerships throughout the state.

The Indiana Biosciences Research Institute helps generate increased business R&D through robust infrastructure investment and a concentrated focus on a major economic sector. It is helping to make Indiana a world-class biosciences research destination, and has catalyzed new industry and university R&D investment in the state.

Finally, several states have worked to modernize their R&D tax credits in recent years. R&D tax credits have been shown to bolster business R&D, and have a high social rate of return.⁵³ Pennsylvania has worked in recent years to expand its R&D credit and make it easier to use, which has been positively received by industry. However, other states, such as New Jersey, have taken additional steps to better align their credits with federal credits, and make them more predictable for firms.

Rhode Island Innovation Vouchers

State: Rhode Island

Summary: Rhode Island businesses with fewer than 500 employees can receive grants of up to \$50,000 to fund R&D assistance from a Rhode Island university, research center, or medical center.

Year created: 2015

Budget and funding mechanism: \$4.5 million since 2015; funded through state general revenue appropriations

Relative size of state economy: 7.8 percent of Pennsylvania

The Rhode Island Innovation Voucher program helps small businesses in the state increase their R&D capacity. Businesses in the state with fewer than 500 employees can apply to receive up to \$50,000 in grants to pay for R&D assistance from a state university research centers or medical center.

Vouchers can be used for R&D activities such as:

- Technological exploration or development
- Product, service, or market development
- Access to research or scientific expertise
- Improved business practices that grow a business or create operational efficiencies

Furthermore, manufacturing companies can use the vouchers to pay for in-house research and development projects.

Since the program was created, it has been extremely popular with companies in the state. Based on high demand in the first year of operations, program funding was tripled from \$500,000 in FY 2016 to \$1.5 million in FY 2017. Since then demand has remained high, and 62 Rhode Island companies had received nearly \$3 million in funding as of November 2018.⁵⁵

Vouchers have gone to fund projects across a variety of industries in the state, including medical device and pharmaceutical manufacturing, life sciences, data and analytics, media, and engineering and shipbuilding, among others.⁵⁶

Other innovation voucher programs exist throughout the U.S. and globally. For example, the RevV! program in Tennessee allows certain manufacturing companies in the state to access Oak Ridge National Lab.⁵⁷ The Canadian province of Alberta runs an even more robust innovation voucher program, allowing companies to access vouchers for up to CAN \$100,000 to fund R&D.⁵⁸ Other innovation voucher programs exist in Austria, Belgium, Canada, Denmark, Germany, the Netherlands, Ireland, and Sweden.⁵⁹

Maryland Industrial Partnerships

State: Maryland

Summary: A matching grant program that helps firms pay for university-based commercial research projects and develop education and training programs for their employees.

Year created: 1987

Budget and funding mechanism:

Annual state funding of \$1 million to \$2.4 million; funded through an allocation from the University of Maryland's budget for technology and economic development.⁶⁰

Relative size of state economy: 52.5 percent of Pennsylvania

Industry-funded university R&D is growing in Pennsylvania, as companies increasingly turn toward the commonwealth's strong stable of research universities to support their R&D efforts. Nonetheless, it remains a small share of overall R&D in the state, dwarfed by both academic R&D paid for by universities, as well as business R&D conducted by businesses themselves. However, with business R&D falling in the state, and public funding for academic research flatlined, enhancing university-business R&D partnerships provides an opportunity to enhance R&D in a way that benefits both firms and universities.

For over 30 years, the Maryland Industrial Partnerships (MIPS) program has enhanced industry-funded R&D at Maryland universities. MIPS provides matching grants to help firms pay for university-based commercial research projects. Established companies (small or large) can apply for annual grants of up to \$100,000, while startups can apply for annual grants of up to \$90,000. Grants can be used toward firm R&D projects, with a focus on engineering, computer science, physical sciences, and life sciences. However, companies can also use grants to develop education and training programs for their employees.⁶¹

MIPS was designed to help companies leverage the facilities, resources, and experts within public universities in Maryland to create new products. As such, it focuses on applied and translational research and development, rather than basic research.

Companies can use MIPS funding to conduct research in partnership with 14 universities across the state—the 12 schools in the University System of Maryland as well as Morgan State University and St. Mary's College of Maryland.⁶² This model of leveraging assistance at universities across the state could be particularly useful in Pennsylvania. For example, it could be leveraged to increase industry-funded R&D in areas with a university outside of Philadelphia, Pittsburgh, or State College. This could help alleviate some of the spatial biases that exist in Pennsylvania.

California formerly ran a similar program, known as Discovery Grants. The program began in 1997 and at its height in 2006 facilitated nearly \$60 million per year in state, industry, and university funding for research.⁶³ However, due to budget cuts in the University of California System, the Discovery Grant program was downsized and eventually eliminated in 2011.⁶⁴

Return on investment: In 2017 MIPS commissioned an economic impact study, leveraging the IMPLAN input-output model. The study found that over 30 years, \$46.2 million in state funding in MIPS had yielded \$34.9 billion in company revenues from products benefitting from MIPS. This revenue generated \$1.75 billion in tax revenue for the state of Maryland, resulting in an ROI of 38 to 1. Furthermore, the study estimated that companies with products benefitting from MIPS projects created 7,150 direct jobs in Maryland.⁶⁵

JobsOhio R&D Center Grant

State: Ohio

Summary: A multi-year grant that helps Ohio companies create new R&D Centers to support the development and commercialization of new technologies and products in targeted industries.

Year created: 2016

Budget and funding mechanism: \$100 million; JobsOhio funded through sale of state liquor enterprise and special-obligation private revenue bonds

Relative size of state economy: 85.2 percent of Pennsylvania

JobsOhio created the R&D Center Grant in 2016 to stimulate greater corporate innovation in Ohio. JobsOhio is a private non-profit entity that serves as the primary state economic development organization.

The R&D Center Grant program provides qualified companies with multi-year grants to establish new R&D Centers in Ohio. R&D Centers are defined as either a newly created physical space, or repurposed existing space, dedicated to an area of innovation or a broad platform technology. To receive the grant, companies must make an upfront commitment to developing and commercializing multiple products or innovations at the R&D Center over a 10-plus year life expectancy. Recipient companies must have a minimum of five years of operating history and annual revenue of greater than \$10 million. Furthermore, centers must represent at least \$3 million in new cash investment by a corporation.

An R&D Center Grant provides funding on a reimbursement basis for a portion of the costs related to a new center for five years. Funding can be used for qualified research expenses, as well as to satisfy operational, equipment, or facility needs. Reimbursements are disbursed first with respect to fixed assets, and second with respect to non-fixed assets. Any equipment purchased using grant funds must stay in Ohio, and any operational activity funded with grant funds must take place in Ohio.

The R&D Center Grant allows JobsOhio to make strategic investments in new R&D centers that support target industries and the evolution of the Ohio economy. Target sectors are advanced manufacturing, aerospace and aviation, automotive, health care, financial services, food processing, information technology, logistics and distribution, and shale energy and petrochemicals.⁶⁶

Corporate interest in the program has been high. As a result, JobsOhio doubled its funding for the program from an initial authorization of \$50 million to its current level of \$100 million.⁶⁷

Return on investment: Through the end of 2018, \$44 million in grants had been issued. Companies had committed an additional \$137 million in fixed asset capital, and committed to creating 704 new jobs and retaining 10,622 others.⁶⁸

Indiana Biosciences Research Institute

State: Indiana

Summary: A non-profit applied research center created as a joint effort between state, local, academic, and industry stakeholders to enhance biosciences research in Indiana.

Year created: 2013

Budget and funding mechanism: \$45 million appropriated from state general fund (\$25 million in 2013 and \$20 million in 2017); more than \$110 million in additional funding provided by private sector and philanthropic partners⁶⁹

Relative size of state economy: 46.8 percent of Pennsylvania

The Indiana Biosciences Research Institute (IBRI) is a non-profit independent applied research center formed as a partnership between the Indiana state government, the city of Indianapolis, major biosciences firms operating in Indiana, and major university health research centers in the state.

The IBRI was founded in 2013, in response to calls by Indiana state, civic, corporate, and academic leaders for a bridge between industry and academic research. Prior to the IBRI, leading academic researchers and practitioners who worked with Indiana's biosciences industry tended to live outside the state, meaning industry-sponsored research funding from Indiana's biosciences companies flowed elsewhere.⁷⁰

The IBRI works as a vehicle to facilitate both industry-sponsored and publicly funded research, and brings together companies and universities in the state to collaborate on applied health research issues.⁷¹ It currently leverages research partnerships with four universities and four major biosciences companies in the state. Moving forward, the IBRI is aiming to expand its research partnerships with life sciences and IT companies across the state, in order to enhance Indiana's bioscience R&D output.⁷²

Research at the IBRI will focus on three broad areas: metabolic and cardiovascular health, diabetes, and nutrition. Within those themes it has three core research competencies, with plans to scale up to five.⁷³

The IBRI will eventually become an anchor for 16 Tech, a 60-acre innovation district under development on the near-westside of Indianapolis, that will serve as a world-class space for bioscience research in the state. IBRI's portion of 16 Tech will help enhance the Indiana innovation ecosystem by hosting an accelerator for life science and IT startups.⁷⁴

New Jersey R&D Tax Credit Modernization

State: New Jersey

Summary: New Jersey aligned its R&D tax credit with federal law, making it substantially easier to use for firms in the state. It also does not cap the amount of credits available each year.

Year created: 2018

Budget and funding mechanism: \$80 million in tax credits claimed in 2018 (expected to increase in 2019)

Relative size of state economy: 79.5 percent of Pennsylvania

Business R&D has substantial benefits for firms. However, it also has broader social benefits, as products and processes that firms develop through R&D have applications across the economy. R&D tax credits exist to incentivize companies to increase their R&D expenditures above what they would spend if they only took private returns into account.

As part of its plan to jumpstart its innovation economy, New Jersey modernized its R&D tax credit in 2018, the most significant overhaul since creating it in 1992.

The revised credit allows companies to leverage the Alternative Simplified Calculation (ASC) used in the federal R&D tax credit. Previously, companies needed to track their expenditures back to 1984 (or their first year with qualified research expenditures if later) to calculate their “base amount” of research expenditures (i.e. the amount of R&D the company did in the absence of the credit). Using the ASC, companies only need to track their research expenditures for the past three years to calculate their base amount. This reduces administrative burden, and means companies can use the same period for both the federal and the New Jersey credit.

Pennsylvania has an R&D tax credit that is among the most user-friendly in the United States.⁷⁵ Both New Jersey and Pennsylvania provide a credit of 10 percent for research expenditures above the base amount that a company performs in state (small businesses in Pennsylvania get a 20 percent rate). Nonetheless, there are distinctions between Pennsylvania’s credit and New Jersey’s. For example, Pennsylvania requires companies to track their past four years of R&D expenditures, rather than the past three.⁷⁶ While this is a minor difference, it may create some administrative burden if companies must do different calculations for state and federal credits.

More substantially, Pennsylvania caps its credits at a total of \$55 million per year (\$11 million of which is set aside for small businesses), regardless of how many companies claim the credit. When total credits claimed in the state exceed \$55 million, each individual company’s credit is prorated.⁷⁷ So while New Jersey has the same rate as Pennsylvania, the lack of a cap means the real credit companies receive in New Jersey is effectively higher. A lack of cap also means the credit is more predictable every year, as it is solely dependent on a company’s R&D expenditures, rather than the amount of credits claimed by other firms. Without the \$55 million cap, \$108.1 million in credits would have been awarded in 2016.⁷⁸

In 2015, the latest year with data available, New Jersey had \$12.9 billion in business R&D, accounting for 2.22 percent of gross state product. This compared to \$11.1 billion in R&D in Pennsylvania, accounting for 1.54 percent of gross state product.⁷⁹

CHALLENGE 3

Bolster state investment in early stage financing

Early stage and venture capital are essential for turning academic and other research breakthroughs into commercial products with positive benefits for the economy. Without adequate early stage and venture capital, some of the breakthroughs developed at Pennsylvania universities will never be commercialized, while the entrepreneurs that do successfully develop products or companies will be more likely to leave for states with more developed financing systems.

In the early 2000s, nearly 4 percent of U.S. venture capital flowed to Pennsylvania, a share that has declined by nearly 80 percent since. At the same time, Pennsylvania has been reducing its public investments in state resources that provide needed capital for startups.

Pennsylvania still retains a stable of organizations that can serve as a strong source of early stage financing. However, the commonwealth will need to recommit to funding those, as well as explore new avenues to bolstering capital.

Meanwhile, other states have established new programs to increase early stage capital or expanded the mission of long-serving early stage resources. Colorado, for example, has created an advanced industries accelerator that provides early stage financial and operations support for companies in the state's advanced industries sector. Furthermore, it has increased funding for the program in recent years in response to overwhelming demand.

In Wisconsin, modest new programs to help finance community-led seed funds and seed accelerators have been created. Tennessee has leveraged an Angel Tax Credit to help direct capital to innovative startups with high growth potential.

Georgia has spun a venture development program and venture fund out of its longstanding Georgia Research Alliance, which is best known for its efforts to recruit scientists and scholars to the state. The GRA Venture Fund has gone on to become one of the largest venture capital funds in Georgia.⁸⁰

Finally, Maryland has continued to maintain its robust public investments in early stage financing programs. Its Technology Development Corporation (TEDCO) oversees a variety of programs focused on different aspects of the innovation lifecycle, and also manages the state-backed Maryland Venture Fund.

Colorado Advanced Industries Accelerator

State: Colorado

Summary: Funds companies in select advanced industries at various stages of the product development and launch cycle, supports companies in achieving new commercial milestones, and positions them for follow-on investment. Also provides support for exports and ecosystem development.

Year created: 2013

Budget and funding mechanism: Annual budget of \$14 to \$20 million (varies by year); funded through an annual allocation of \$5.5 billion of gaming revenue (for use in biosciences sector only), and 50 percent of bioscience and clean technology company income tax withholding growth (measured on a three-year rolling average). State provided \$5 million in general fund revenue for initial startup

Relative size of state economy: 46.1 percent of Pennsylvania

Colorado's Advanced Industries Accelerator provides grants and technological expertise for researchers, companies, and other actors in the state advanced industry ecosystem to support innovative startups, promote product development and market expansion, and enhance the state's advanced industries ecosystem.

Four types of grants anchor the program:

- **Proof of Concept grants:** fund research with commercial applications at Colorado research universities, federal labs in Colorado, and other Colorado labs with technology transfer offices
- **Early Stage Capital and Retention grants:** fund early state startups that have created viable products that meet a market need
- **Infrastructure Funding grants:** fund projects that substantially build or utilize existing infrastructure to enhance Colorado's advanced industry ecosystem
- **Export Accelerator grants:** fund aspiring (new to export) and current (market expansion) Colorado exporters

The program complements grant funding with export training programs and a global consultant network, which help build export readiness and connect Colorado companies to foreign markets.⁸¹

Colorado's state legislature started the program in 2013 with an initial \$15 million investment, and the program has been oversubscribed since. In subsequent years, Colorado's legislature has provided an additional \$35 million for the program. This \$50 million in state investment has catalyzed an additional \$360 million in outside grants and investments to support researchers, firms, and products in the state.⁸² In Pennsylvania, such a program could complement ongoing efforts by the Ben Franklin Technology Partners or could even be added under their purview.

Supporting advanced industries has significant positive impacts for a state's economy. Workers in advanced industries are roughly twice as productive as workers in the rest of the economy, and have an average wage nearly twice as high. Additionally, advanced industries generate significant supply chains that support other economic activity. Each advanced industry job supports 2.2 other domestic jobs, compared to just 0.8 for jobs in non-advanced industries.⁸³

Return on investment: Through the end of June 2018, approximately \$50 million in grants had been issued. These funds have spurred an additional \$360 million in further grants and investments, created 763 new jobs, and retained 870 others.⁸⁴

Wisconsin Capital Catalyst and Seed Accelerator

State: Wisconsin

Summary: Provides matching grants to seed funds and seed accelerators managed by local communities and other eligible entities in the state.

Year created: **Capital Catalyst:** 2012, **Seed Accelerator:** 2013

Budget and funding mechanism: Capital Catalyst: \$1.5 million, Seed Accelerator: \$1 million; funded through Wisconsin Economic Development Corporation general fund, which in turn is funded by a combination of state general purpose revenue, a 3 percent gross tax levy on corporations, and other intergovernmental revenues⁸⁵

Relative size of state economy: 42.5 percent of Pennsylvania

Capital Catalyst provides matching grants to seed funds in the state created and managed by local communities and other entities, with the goal of providing capital to high-growth startups and emerging growth companies.

Seed funds supported by Capital Catalyst are required to make grants, debt, royalty-based investments, or equity-based investments in startups, early stage, and emerging growth companies in Wisconsin or that will locate in Wisconsin. Priority sectors are advanced manufacturing, agriculture and food processing, information systems and software, medical devices, biosciences, and energy.

Capital Catalyst recipients may include governmental organizations, educational institutions, foundations or other non-profit entities, or investment holding entities established by otherwise eligible entities. All Capital Catalyst grants must be matched by the recipient at a 1:1 rate.⁸⁶

The Seed Accelerator program follows a similar model, providing grants to entities operating local not-for-profit seed accelerators. Recipients can include communities, organizations, or other entities that operate a not-for-profit seed accelerator.

Seed accelerators provide cohorts of startup companies a set (typically three to six month) curriculum of intense business development, including coaching, mentorship, technical expertise, and market and customer validation. Seed accelerators also typically provide small amounts of funding, as well as access to investors.

Some seed accelerators may be industry-based, while others focus on other factors. For industry-based accelerators, priority sectors are broadly the same as the Capital Catalyst program. Other factors of focus may include geography, educational institutions, or underrepresented groups.

As with Capital Catalyst, the Seed Accelerator program requires a 1:1 match. However, matching contributions may be in cash or in-kind.⁸⁷

Targeted return on investment: Award five seed funds and six seed accelerators, with the goal of assisting 60 startups and early-stage companies.⁸⁸

Tennessee Angel Tax Credit

State: Tennessee

Summary: Investors can receive up to \$50,000 in credits when investing in pre-qualified innovative startups with high growth potential.

Year created: 2016

Budget and funding mechanism: \$5 million in tax credits available per year

Relative size of state economy: 46.3 percent of Pennsylvania

Launch Tennessee, the state's public-private partnership for supporting entrepreneurship, created the Angel Tax Credit in 2016 as part of its multi-pronged approach to capital formation.

Accredited investors that pay the Hall Income Tax (a state tax on investment interest and dividends) can choose to invest their own money into pre-qualified high growth early stage companies. If they do, they can claim a tax credit equal to 33 percent of the amount of the investment. To incentivize investment in companies located in hardship-affected areas, investors can receive a credit equal to 50 percent of the amount of their investment in companies located in Tier 4 Enhancement Counties (a designation for certain at risk and distressed counties in the state).

Investors can receive up to \$50,000 in credits per year. Credits are not refundable, but they can be carried forward for up to five years. Beginning in 2019, Tennessee is making up to \$5 million in credits available for investors on a first-come, first-served basis.

Companies can be approved as a qualifying business if they meet at least one of the following three criteria:

- Has received Small Business Innovation Research (SBIR) or Small Business Technology Transfer (STTR) funding
- Is commercializing technology developed at a Tennessee-based research institution
- Is an innovative small business with high growth potential

For companies seeking to qualify under the third criteria, Launch Tennessee leverages a variety of factors to determine whether a company is an "innovative small business with high growth potential." These include assessing the company's business model, ability to scale, nature of innovations, management team, and likelihood of obtaining future capital, among others.

To become a qualified business, at least 60 percent of a company's employees must perform a majority of their duties in Tennessee. Additionally, the company must have been in business for fewer than five years, have \$3 million or less in annual gross revenue, and 50 or fewer full-time employees at the time of the investment.⁸⁹

Return on investment: Through the end of June 2018, approximately \$1.9 million in tax credits had been issued. These credits were tied to investments of \$6.8 million. In total, 29 companies have received an average investment of over \$73,000 each.⁹⁰

Georgia Research Alliance Venture Development Program and GRA Venture Fund

State: Georgia

Summary: A set of programs that support startups through seed funding, executive guidance, and as one of the largest venture capital funds in Georgia.

Year created: Georgia Research Alliance: 1990, GRA Ventures: 2009

Budget and funding mechanism: Georgia Research Alliance: \$5 million allocated from state general fund in FY2019 (down from \$25 million historical average since 1993)⁹¹

GRA Ventures: Seeded with \$7.5 million from state general fund in FY2009, raised over \$35 million in additional private capital from two fundraising rounds⁹²

Relative size of state economy: 74.5 percent of Pennsylvania

Georgia Research Alliance (GRA) is a public-private partnership that promotes research, commercialization, and startup growth in Georgia. GRA's Venture Development Program is a non-profit catalyst aimed at seeding and shaping companies that grow out of research from Georgia universities. The program proactively identifies university discoveries with market potential and provides early-stage funding for ventures leveraging these discoveries. Additionally, the program maintains a pool of CEOs, mentors, and experts to support newly launched enterprises. GRA has some 180 university-based companies in its portfolio.⁹³

GRA Venture Fund, LLC is an independent venture fund that was spun out of GRA in 2009 with a \$7.5 million "evergreen" investment from the state of Georgia. Since then, investors have provided more than \$35 million in additional capital to GRA Venture Fund.

GRA Venture Fund currently has over a dozen companies in its portfolio. These companies have leveraged GRA early stage funding to raise an additional \$460 million in outside capital.⁹⁴

To receive funding from GRA Venture Fund, a firm must have their principal place of business in Georgia. Emphasis is placed on firms conducting innovative work in an area such as technology, life sciences, manufacturing, agriculture, and information-related services.

In addition to funding, each company in the GRA Venture Fund portfolio is assigned to a member or observer of the fund's board, who provides additional resources to the company. These include mentoring and guidance, as well as identifying how GRA and GRA Venture Fund can further support the company.⁹⁵

GRA Venture Fund may also provide subsequent financings of companies in its portfolio. Investments are typically long-term, supporting the company through an acquisition or initial public offering.⁹⁶

Return on investment: As of 2018, there were 180 university-based companies in the GRA portfolio. These companies generated more than \$660 million in revenue, and employed more than 1,300 people. Since 2010, GRA provided \$27 million in commercialization grants to advance some 300 distinct university technologies to market.⁹⁷

Through 2018, GRA Venture Fund has raised \$45 million, of which \$20 million has been committed to 16 companies. This funding has helped catalyze \$460 million in follow-on investment and has generated over 600 jobs.⁹⁸

Maryland Technology Development Corporation (TEDCO) and Maryland Venture Fund

State: Maryland

Summary: A robustly-funded comprehensive set of early stage financing programs for tech and life sciences companies, combined with a state-backed venture fund.

Year created: TEDCO: 1998, Maryland Venture Fund: 1994

Budget and funding mechanism: TEDCO: \$18.5 in state general funds⁹⁹

Maryland Venture Fund: Founded with \$25 million state investment in 1994.¹⁰⁰ Received \$20.6 million in 2016 from InvestMaryland insurance premium tax credit sale (modeled after Innovate in PA).¹⁰¹ Operating budget of \$7.3 million per year.¹⁰²

Relative size of state economy: 52.5 percent of Pennsylvania

Maryland boasts the nation's largest concentration of federal laboratories, as well as an array of R1 research universities and a noteworthy biotechnology cluster.¹⁰³ TEDCO is a state-backed investment organization created to commercialize R&D from Maryland's significant innovation assets.

TEDCO operates a variety of programs focused across three primary areas: technology transfer and commercialization, technology incubator support, and gateway services (i.e. start-up assistance). Some selected programs are:

Technology Transfer and Commercialization

- **Maryland Technology Commercialization Fund:** Provides up to \$200,000 for technology and product development by start-up companies deemed too early in their development to gain the interest of traditional venture capital investments. Additional special funds exist to support life sciences and cybersecurity.
- **Maryland Innovation Initiative:** Provides funding to increase the rate of commercializing technologies developed in Maryland's research universities.
- **Gap Investment Fund:** Provides funding to help bridge the gap between seed funding and venture capital investments.

Technology Incubator Program

- **Incubator Development Fund:** Provides funding to develop business incubators throughout the state
- **Business Assistance Fund:** Provides funding for business assistance services that incubators would not have been able to provide in-house

Gateway Services

- **Builder Fund:** Supports the development of startup companies run by entrepreneurs who demonstrate a socially or economically disadvantaged background that hinders access to traditional forms of capital and executive networks at the pre-seed stage
- **Rural Business Initiative:** Covered in detail on page 49

The Maryland Venture Fund is a state-backed, early-stage evergreen venture fund with over \$135 million in assets under management.¹⁰⁴ The fund was created in 1994 from a \$25 million initial investment, and came under the purview of TEDCO in 2015.

In 2016, the state of Maryland raised \$84 million through its InvestMaryland premium tax credit auction, which was modeled on Innovate in PA. Of that \$84 million, \$56 million was allocated

to private venture capital firms, \$21 million was allocated to the Maryland Venture Fund for direct investment, and \$7 million was allocated to the Maryland Small Business Development Financing Authority.¹⁰⁵

Return on investment: An economic impact analysis by the University of Baltimore and Teconomy Partners found that TEDCO's programs generated \$1.6 billion in Maryland economic activity in 2018, supported over 7,700 jobs (direct, indirect, and induced), and produced \$37.6 million in tax revenue for the Maryland state government.¹⁰⁶

Of that, companies backed by the Maryland Venture Fund were found to have generated nearly 3,000 jobs (direct, indirect, and induced) and \$607 million in economic activity, as well as contributing approximately \$14 million in tax revenues for the state.¹⁰⁷

CHALLENGE 4

Mitigate significant spatial divergence

Much of Pennsylvania's innovation infrastructure is concentrated in its two largest cities, Philadelphia and Pittsburgh, as well as State College, home to Pennsylvania State University. These large innovation centers receive a disproportionate share of state innovation inputs and produce a disparate share of state output, above-and-beyond their share of employment and population. Smaller areas, meanwhile, have struggled with fewer investments, which has contributed to harmful economic trends like negative real employment growth over the past decade. This extends to physical investments, including broadband, necessary to spur growth in the modern economy.

While some disparity is to be expected given the returns of scale in the knowledge economy, if the benefits to innovation are too concentrated then it will depress the positive impacts for citizens and communities. Likewise, growing spatial divergence in the state will continue to inflame political tensions, making it increasingly difficult to solve the growing competitive challenges that Pennsylvania faces.

Pennsylvania is not alone in facing an increase in spatial divergence, and other states are combating these trends in a variety of ways. Some, such as North Carolina and Connecticut, are leveraging competitive grants to improve the innovation ecosystems in places outside of their highest-growth cities. Rhode Island, meanwhile, takes a cluster approach, focusing on providing resources to create new clusters or build up existing clusters throughout the state.

Maryland take a more explicit approach with its Rural Business Innovation Initiative, by providing dedicated supports to rural counties in the state.

For its part, Massachusetts has undertaken one of the most substantial broadband expansion programs in the U.S., focused particularly on connecting unserved and underserved communities outside of the Boston area.

Finally, Illinois has begun one of the most ambitious spatially oriented innovation projects in the nation with its Illinois Innovation Network. This effort is envisioned as an over-\$1 billion statewide network that would connect universities and research centers across the state, in areas both big and small.

InnovateNC

State: North Carolina

Summary: A two-year cross-city learning collaborative to enhance innovation capacity in five cities outside of the Research Triangle and Charlotte.

Year created: 2015

Budget and funding mechanism: Approx. \$1.25 million, primarily in-kind support

Relative size of state economy: 71.7 percent of Pennsylvania

North Carolina faces many of the same innovation challenges as Pennsylvania. While the state has two strong innovation centers, the Raleigh-Durham-Chapel Hill Research Triangle and Charlotte, it lags in innovation and economic performance elsewhere. Like Pennsylvania, these spatial dynamics dampen economic outcomes in the state—the state has historically ranked in the middle-of-the-pack by major innovation ratings, although it has seen some modest improvement in recent years.

In 2015, the state launched InnovateNC, a two-year economic development initiative aimed at bolstering innovation capacity in cities beyond Raleigh-Durham and Charlotte. Five communities were selected from among a pool of 18 applicants: Asheville, Greensboro, Pembroke, Wilmington, and Wilson.¹⁰⁸

Selected cities received approximately \$250,000 in in-kind support from the state and non-profit partners. Among the benefits were:

- Guided development of a strategic plan for the community
- Data-driven asset mapping and gap analysis of local innovation ecosystems
- Cross-city convenings to develop new relationships and connections across communities
- Technical assistance to advance local innovation projects
- Support and exposure through public-facing outreach and storytelling
- Assistance with securing additional support from state and national innovation programs¹⁰⁹

InnovateNC is smaller in scope and financial commitment than other spatially oriented innovation initiatives, which means it will likely have a correspondingly smaller impact for selected communities. However, it nonetheless has several important advantages in the Pennsylvania context. First, its low price and bipartisan history means it can be an easy model for Pennsylvania to leverage in the near-term. Furthermore, such a program can serve as an important signaling mechanism that the state is committed to its smaller communities. Leveraged in the right way, this could lead to additional follow-on investment in communities that participate in the program. Finally, this initiative has created a series of publicly available free products that other communities in the state can leverage. For example, communities can take advantage of the InnovateNC Community Innovation Asset Map, a turnkey tool for helping communities assess the quality and inclusiveness of their innovation ecosystems.¹¹⁰

Connecticut Innovation Places

State: Connecticut

Summary: Grant program to fund infrastructure and programs aimed at attracting talent and increasing knowledge sharing that leads to innovation in four Connecticut communities.

Year created: 2016

Budget and funding mechanism: \$30 million over five years funded through state bonds issued to support the CTNext Fund¹¹¹

Relative size of state economy: 34.6 percent of Pennsylvania

While Connecticut is a small state, it nonetheless faces issues related to divergence among different places in the state. In response, CTNext, a public-private network of entrepreneurs, mentors, and service providers aimed at supporting Connecticut startups, created the Connecticut Innovation Places program in 2016, with the goal of improving both the physical infrastructure and networking capacity of places around the state.

The program is the first of several planned CTNext initiatives aimed at helping places in the state become magnets for talent, better support entrepreneurship in higher education, and focus on growth-stage companies.

In 2016, the program kicked off by providing grants to communities to help them conduct strategic planning, assess community capabilities and needs, and develop plans for becoming an "Innovation Place." The program provided up to \$50,000 to selected communities to establish their plans.

In 2017, four communities were selected from a pool of 12 applicants across the state: New Haven, Hartford/East Harford, Stamford, and Thames River. The program will distribute the remainder of the \$30 million allocation to the four winning communities over a period of five years.¹¹² This funding will augment other private and public investments and will fund infrastructure and programs aimed at attracting talent and increasing knowledge sharing that leads to innovation. Some of the ways that communities can use the grant money include:

- Attracting and directing support to startup business and anchor institutions
- Developing business incubators, co-working spaces, and accelerators
- Events, community building, and marketing/outreach
- Open space improvement, housing development, bicycle paths, broadband, and other infrastructure improvements

In addition to support from grants, state agencies have been encouraged to favor applications from Innovation Places for additional financial and technical assistance on projects.¹¹³

Rhode Island Industry Cluster Grants

State: Rhode Island

Summary: Financial support for planning and organizing industry clusters in the state, as well as strengthening developed clusters in areas such as R&D, tech transfer and workforce development.

Year created: 2015

Budget and funding mechanism: \$1.35 million allocated since 2015, funded through direct state appropriations

Relative size of state economy: 7.8 percent of Pennsylvania

The Industry Cluster Grant program was designed to encourage companies, non-profits, trade associations, and other major stakeholders to work together to build out industry clusters in key sectors across the state. Due to the inherently spatial nature of clusters, as well as their impact on local supply chains, bolstering their development can lead to broader economic growth in surrounding communities.¹¹⁴

The program issues two types of grants:

- **Technical assistance (planning) grants** provide up to \$250,000 for communities to undertake feasibility studies and organizational development efforts that would benefit a key sector.
- **Implementation grants** provide up to \$500,000 to launch a program to improve a key industry sector's effectiveness in areas of innovation, such as R&D, tech transfer, workforce development, or marketing.¹¹⁵

The state created the Industry Cluster Grant program with an initial appropriation of \$750,000 in its FY2016 budget. In the program's first year demand significantly outpaced supply, as the state received 26 applications seeking over \$5.7 million in funding.¹¹⁶ However, state allocations for the program have waned, and the program has only received \$600,000 in additional appropriations over the past three fiscal years.¹¹⁷

Grants have been awarded to organizations in a variety of clusters across the state, including urban food and agriculture, educational technology, advanced manufacturing, and virtual/augmented reality.¹¹⁸

TEDCO Rural Business Innovation Initiative

State: Maryland

Summary: Leverages regional mentors in communities across the state to provide technical and business assistance to small and early stage technology-based companies in rural areas.

Year created: 1998

Budget and funding mechanism: \$500,000 in direct state funding per year, with additional funding from TEDCO itself; state funding comes in the form of appropriations from the General Assembly¹¹⁹

Relative size of state economy: 52.5 percent of Pennsylvania

As previously mentioned, the Maryland Technology Development Corporation (TEDCO) is a publicly chartered corporation that supports innovation and technology-based economic development in the state. It helps anchor Maryland's innovation ecosystem by providing financial support and expertise for entrepreneurs and companies across the state.¹²⁰

TEDCO's Rural Business Innovation Initiative (RBI²) aims to support startups and small businesses in rural Maryland by providing mentorship and funding, and connecting them with the broader statewide innovation ecosystem.

RBI² leverages a network of four regional mentors across the state to provide a variety of services for rural entrepreneurs and firms. These services include business model and strategy development, competitive analysis, funding opportunities and introductions, financial analysis, intellectual property support, prototype development, and manufacturing problem solving, among others. All services are offered at no cost to companies.¹²¹

RBI² also provides funding to pre-seed investment opportunities for rural companies, as well as for projects to help advance small rural businesses. Companies that receive initial investments also receive ongoing mentoring and funding to commercialize their product or advance their project.¹²²

To qualify for RBI², firms must operate in one of 19 designated rural counties, have fewer than 16 employees and annual revenues \$1 million or less, and must be involved in developing new technologies or products, or utilizing technology to create or expand their business.

The program has been well received by rural businesses and elected officials. In FY2018, RBI² mentors supported 124 companies, and RBI² provided pre-seed investments of \$25,000 to five companies.¹²³

Massachusetts Broadband Institute

State: Massachusetts

Summary: Works to extend high-speed internet access to homes, businesses, schools, libraries, medical facilities, government offices, and other public places across Massachusetts.

Year created: 2008

Budget and funding mechanism: \$135 million; funded through three rounds of capital bonds: one in 2008 for \$40 billion, one in 2014 for \$50 billion, and one in 2018 for \$45 billion¹²⁴

Relative size of state economy: 72.2 percent of Pennsylvania

The Massachusetts Broadband Institute (MBI) focuses on expanding broadband access throughout Massachusetts. In particular, it aims to solve two challenges to connectivity:

- Expanding broadband service in communities where an incumbent provider offers broadband service with limited coverage
- Bringing broadband coverage to entirely unserved communities that lack any high-speed internet access¹²⁵

MBI operates three major programs. The first two programs focus on “last mile” infrastructure, or the local network closest to end-users. The Last Mile Program co-invests in broadband solutions for the 45 Massachusetts towns that have lacked broadband service. The program provides grants to both private broadband service providers, as well as directly to municipalities. The Broadband Extension Program for partially-served towns helps further extend broadband access in communities with existing residential cable franchises that do not cover substantial areas of the town.¹²⁶

The third program focuses on building up so-called “middle mile” infrastructure in Massachusetts, which connects “last mile” networks to major telecommunications carriers and the broader internet. The MassBroadband 123 Network Operations program constructed a 1,200-mile open access fiber-optic middle mile network to deliver high-speed internet access to over 1,100 facilities across 120 communities in central and western Massachusetts. The network covers more than one-third of the geographic area of Massachusetts, accounting for over 400,000 households and one million residents.¹²⁷

In FY2017, MBI provided over \$16.6 million in direct grants for the construction of municipally owned broadband networks in 18 underserved communities, and provided an additional \$5.2 million in grants to private companies to provide service to six additional municipalities.¹²⁸

Return on investment: Since its creation, MBI has worked with 46 of the 54 municipalities across Massachusetts that had been designated as either unserved or underserved. In addition to the construction of the MassBroadband 123 Network, MBI has identified active broadband solutions for over 87 percent of underserved premises in central and western Massachusetts.

Illinois Innovation Network

State: Illinois

Summary: Envisioned as a \$1.2 billion statewide network of research universities, businesses, and public sector partners focused on the development of solutions in computing and big data, advanced materials, food and agriculture, and biosciences and health.

Year created: 2017

Budget and funding mechanism: \$500 million allocated over several years from the “Build Illinois” bond fund, which funds state and local infrastructure, economic development, and other projects¹²⁹

Relative size of state economy: 108.9 percent of Pennsylvania

The Illinois Innovation network is an emerging network of research and innovation hubs across Illinois, operating under the leadership of the University of Illinois system. The network has been envisioned as a \$1.2 billion initiative connecting research universities, businesses, and public sector partners across the state.

In June 2018 the state legislature approved \$500 million from the Build Illinois bond fund to be used “over a number of years” to fund the Illinois Innovation Network.¹³⁰ The program is intended to be a public-private partnership, with public money catalyzing private investment. However, to date, it is not clear how much private support has materialized.¹³¹

The network will be helmed from a proposed institute, the Discovery Partners Institute (DPI), to be built on donated land in Chicago’s South Loop. Hubs throughout the state are to be anchored by local universities.

When completed, the DPI will be home to more than 100 researchers and thousands of students focusing on R&D in key sectors. The DPI will also have partnerships with global universities. The first agreement was recently signed with Tel Aviv University.

In addition to its Chicago headquarters, the network will have hubs in communities of all sizes throughout the state. To date, the network has launched or announced plans for its first four hubs in Springfield, Urbana-Champaign, DeKalb, and Peoria. Each hub will have a unique focus aligned with existing strengths.

In August of 2018, the network absorbed the existing Innovate Springfield, a business incubator and social innovator, as its first hub.¹³² The hub is slated to receive \$1.5 million dollars over the next three years, coming from the U of I system, the city, and other partners. That same month, the University of Illinois announced two big projects for its Urbana-Champaign campus, in concert with the network: a new data science center and expansion of its research park.¹³³ In October, Northern Illinois University (NIU) announced plans for a \$23 million business-development incubator and innovation center focusing on food, water, and the environment, to serve as the next hub of the Illinois Innovation Network. It will be financed in part through the state’s \$500 million appropriation.¹³⁴ In December, the network announced plans to add a fourth hub in Peoria, focused on finding solutions to problems facing underserved populations.¹³⁵

5. Takeaways

In many ways, the coming decades are likely to mirror the most recent ones—which, based on current trends, is not an entirely good thing for Pennsylvania. The increasingly knowledge-based and global nature of the U.S. economy means that the challenges the state faces in innovation and economic performance will not abate on their own. Indeed, solving these challenges will require concerted state effort.

Fortunately, Pennsylvania has a well-developed and proven technology-based economic development ecosystem that can lead these efforts if adequately resourced. For example, the Ben Franklin Technology Development Authority and Ben Franklin Technology Partners could be well-positioned to incorporate new initiatives, and could likewise serve as a central node for coordinating innovation strategy across the state. Indeed, over time they have served in several critical strategic planning roles for the Pennsylvania innovation economy.¹³⁶

That Pennsylvania can likely carry out any of these programs with relatively little retooling is a significant asset for the state. Addressing these challenges, then, is less a question of economic capacity than political will.

Enhancing Pennsylvania's performance will require investments to address each of the major challenges outlined in this report. However, the natural first step would be to create an evidence-based plan that further categorizes the strengths that Pennsylvania possesses, provides additional nuance and detail about the challenges it faces, and makes concrete policy recommendations for how to meet them. This is also an area of low-hanging fruit, as a relatively small investment into the strategic planning process can yield significant statewide benefits in terms of clear policy recommendations tailored to Pennsylvania's unique economic environment.



In the short run, local policymakers could consider introducing some of these programs on the municipal level and then scale them across the state in the future. In particular, the following programs could be suited for municipal action:

- Innovation Vouchers (particularly in municipalities with a strong university presence)
- R&D Center grants
- Advanced Industry Accelerator grants
- Capital Catalyst and Seed Accelerator
- Industry Cluster Grants

However, it is likely that the places in the state that already have the strongest innovation ecosystems—Philadelphia, Pittsburgh, and State College—are also those that have the most capacity to implement these programs without state support. As a result, municipal action in lieu of strong state action could end up exacerbating existing regional inequalities. Therefore, state leadership on these efforts is optimal, with buy-in from municipal and private sector stakeholders across the commonwealth.

In this regard, the importance of effective statewide innovation strategy development becomes even more acute. Here, efforts conducted by other states can serve as a guide. While each state's plan is different, among the components included in multiple leading state innovation strategies are:

- Key metrics and indicators tracking the state innovation economy, ideally over time
- An assessment of state competitive advantages and challenges
- A review of major sectors, industries, and growth areas in the state innovation economy
- A benchmarking of competitor states
- Recommendations for forward-looking programs and initiatives to bolster the state innovation economy

To bolster this effort, policymakers should convene stakeholders from across the state to address different regions' unique needs, as well as to enhance coordination across regions. Furthermore, policymakers must identify the state's core assets and unique strengths in which it should invest, including through independent evaluations of the return on investment from existing programs.

Two other areas that will be necessary to evaluate will be options for funding initiatives and levers for implementing them. These vary widely across the country, but the programs reviewed in this analysis provide some direction as to the ideas for carrying these out.

For example, competitor states have used a variety of different funding provisions for implementing their own (non-tax credit) initiatives. Among these are:

- General revenue appropriations
- Public bonds
- Special obligation private bonds
- Set-asides from growth in future corporate income tax revenue in specific sectors
- Sale of the state liquor enterprise/a set-aside of current state liquor revenue
- Return on equity investment in seeded startups
- Private capital investment or leveraging public-private partnerships
- An auction of insurance premium tax credits (i.e. re-running Innovate in PA)

Additionally, the state could consider leveraging potential emerging sources of revenue moving forward. These could include:

- Revenue from newly-legalized sports betting
- Tax revenue from medical marijuana or recreational marijuana if legalized
- Carving out a portion of online sales tax revenue

Likewise, competitor states use a variety of policy levers for implementing their innovation initiatives, including:

- Direct grants (Rhode Island Innovation Vouchers, JobsOhio R&D Center Grant, Colorado Advanced Industries Accelerator, Connecticut Innovation Places, Rhode Island Industry Cluster Grants, Massachusetts Broadband Institute, Maryland TEDCO)
- Grants to intermediaries (Wisconsin Capital Catalyst and Seed Accelerator, Rhode Island Industry Cluster Grants, Massachusetts Broadband Institute, Illinois Innovation Network, Maryland Venture Fund)
- Tax credits (New Jersey R&D Tax Credit, Tennessee Angel Tax Credit)
- Equity funding (GRA Venture Fund, Maryland

- Venture Fund)
- In-kind support (InnovateNC, TEDCO Rural Business Innovation Initiative)

Finally, it is important to keep in mind that additional transformative investments will be necessary to create the context for any state innovation efforts to succeed. Among the most acute is the need for significant state workforce investments. Without a workforce equipped with the skills for emerging 21st century jobs, the economic opportunities that a successful innovation policy will create will flow to other states. Unfortunately, like with innovation policy, Pennsylvania has been going sideways on human capital investment. For example, since the end of the Great Recession, Pennsylvania has seen the fourth largest decline in higher education appropriations per student.¹³⁷ Policymakers will need to change the trajectory of human capital investment in the state, or risk being unable to capture many of the broader economic benefits of innovation.

Pennsylvania is at a critical moment. Major shifts in the national and global economy have altered the terrain for regions and affected

the livelihoods of many Pennsylvanians. Meanwhile, residual economic stress from the Great Recession has combined with longer-running national trends to exacerbate political and economic divides in the state. While these challenges are by no means unique to Pennsylvania, other states have recognized the obstacles they face and have made corresponding investments to mitigate or reverse them. In this increasingly competitive context, continuing to stand still will only increase Pennsylvania's challenges.

However, another path exists. By working to bridge existing political gaps and form a new consensus about inclusive innovation-oriented economic development, Pennsylvania can regain its competitive standing. This will require not only proactive investments, but also a recognition that every region in the state—rural, urban, and everywhere in-between—has a shared interest in mutual success. By doing so, Pennsylvania can forge a new path forward based on shared and inclusive development and along the way help improve the standard of living for citizens in every region of the state.

Appendix: Process and Methodology

The initial charge for this project was to scan Pennsylvania’s chief competitor states to create a benchmark of their ongoing innovation efforts.

Ultimately, 18 states were selected to scan for policies promoting innovation and technology-based economic development.

The analysis began with an initial literature review to develop a typology of the various policy and other supports that states can leverage to promote innovation. While this typology was not directly used in this report (as it ultimately focused on identifying programs that could address Pennsylvania’s specific challenges) it remains a useful framing device for categorizing innovation supports in general.

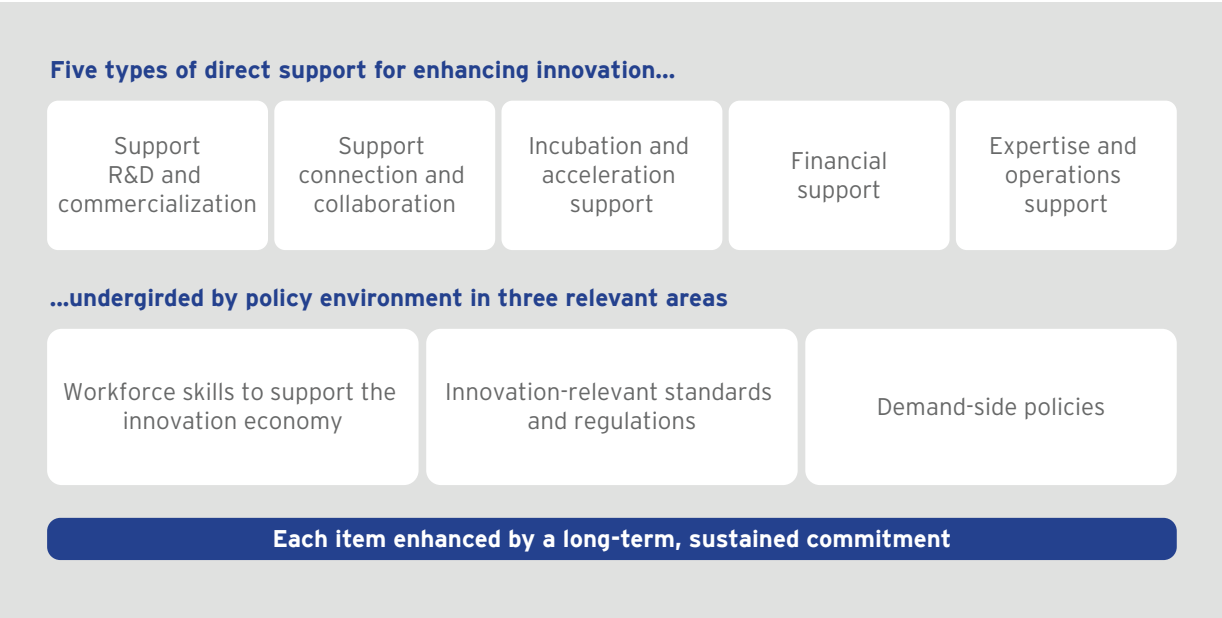
These states were selected through a combination of quantitative and qualitative measures. First Brookings assessed two major innovation benchmarks, the Information Technology and Innovation Foundation’s State New Economy Index and the Milken Institute’s State Technology and Science Index, to develop an initial list of states. This initial list was based on which states consistent ranked closest to Pennsylvania across the two rankings. From there, the list was refined through a series of interviews with policymakers and practitioners in Pennsylvania. This process yielded a list of 13 competitor states: Connecticut, Georgia, Illinois, Indiana, Michigan, New Jersey, North Carolina, Ohio, Rhode Island, Tennessee, Texas, Utah, and Wisconsin. Likewise, five states were

Brookings then set out to define the universe of states to prioritize when scanning for innovation policies. Given the charge, that consisted of two groups of states: “competitor” states that share significant economic characteristics and interests with Pennsylvania, and “national leaders” that are considered best-in-class in innovation.

FIGURE 17

A variety of supports are needed for an effective innovation ecosystem

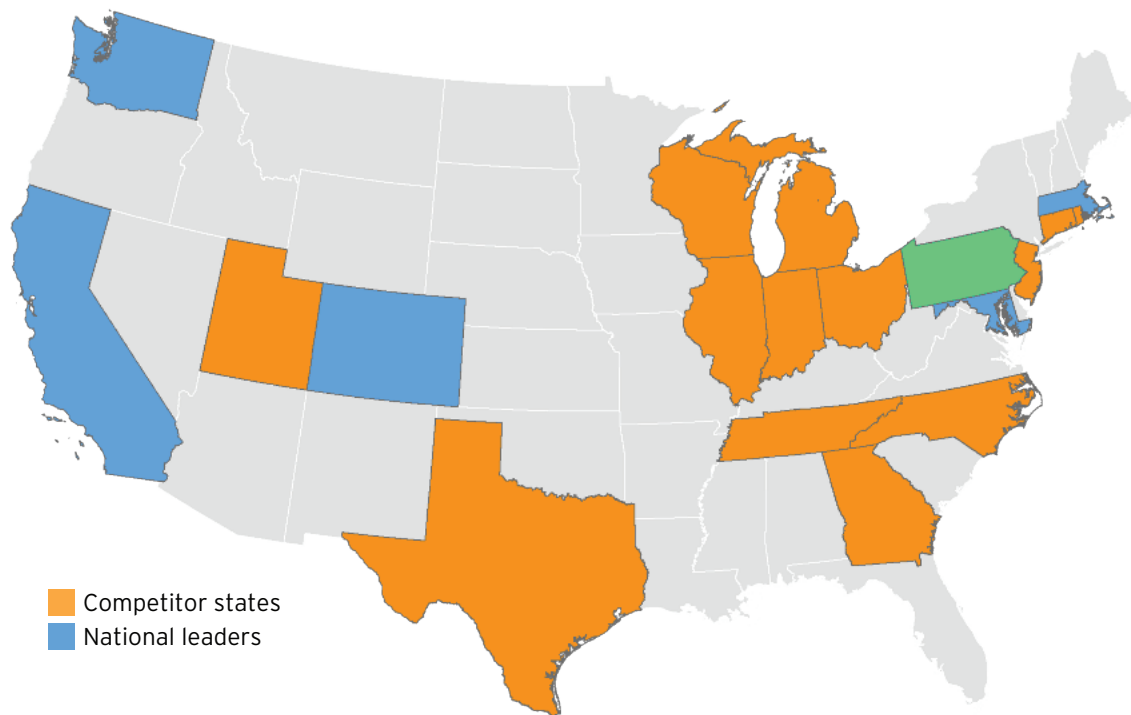
Typology of innovation supports



Source: The Brookings Institution

FIGURE 18

Competitor states and national leaders



Source: The Brookings Institution

designated as national leaders due to their consistently strong standing in major innovation benchmarking efforts: California, Colorado, Maryland, Massachusetts, and Washington.

Once the list of states to scan was finalized, Brookings set out to develop a baseline of Pennsylvania's current innovation situation and challenges. While this was not in the original charge, over the course of the project it became clear that having a sense of Pennsylvania's baseline would be useful to focus efforts toward the most relevant competitor state efforts. To do so, Brookings conducted around 20 interviews with experts in technology-based economic development in general, and Pennsylvania's innovation economy specifically. Brookings also conducted its own research and analysis, benchmarking Pennsylvania against the nation as a whole, leading states, and competitor states, on a variety of measures important to innovation and economic success. Based on the interviews

and analysis, Brookings distilled Pennsylvania's challenges into the four items identified in previous sections.

With the state baseline and challenges in hand, Brookings proceeded to conduct an initial state-by-state analysis of innovation and technology-based economic development programs deployed by the 13 competitor states and five national leaders. The scan was conducted through both Brookings in-house research, as well as additional interviews with experts in technology-based economic development.

From there, Brookings assembled an initial set of programs that could be leveraged to solve each of the challenges identified. Once this initial analysis was completed, Brookings met in Pittsburgh with a variety of stakeholders in Pennsylvania's technology-based economic development community. During these meetings, Brookings vetted its initial hypotheses and

recommendations, and received intensive feedback to incorporate into a second round of scanning.

Brookings then proceeded to conduct a second, more tailored scan to respond to the feedback

received, which yielded several additional relevant programs. The project team then compiled these revised findings into a draft report, which was circulated among a stakeholder group for feedback. That feedback led to a final round of revisions.

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