

PENNSYLVANIA'S INNOVATION ECONOMY

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Carnegie Mellon University
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Systems and Public Policy

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Front Cover Image: Wireless Skyline
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Preface

This project was completed by six master's students at Carnegie Mellon University in coordination with the Pennsylvania Department of Community and Economic Development (DCED). It was born out of Governor Tom Wolf's proposals made in January 2020 to spur innovation across the state, focusing on the entrepreneurial ecosystem and the growing tech sectors. The research process for this project included a review of previously published reports, content-specific scholarship, available datasets, and conversations with experts at DCED and the innovation stakeholders on our Advisory Board.

Intended use of this document: The report and forthcoming dashboard (see list of deliverables below) serve as tools for the public, policy makers, EDO's, administrators, business organizations, and university administrators to identify the state's strengths and weaknesses in the following areas: R&D funding, business creation, risk capital, education, employment, talent retention, and transportation and broadband access. The findings in the report are intended to be a starting point for discussion amongst and further inquiry by decision makers. It does not detail every metric related to the innovation economy. The intent is for this report to be reissued on an annual basis as suggested by Governor Wolf.

This report is one of four products delivered to DCED. The other products are:

- 1) **a web dashboard** wireframe and data content, providing DCED with everything needed to display interactive graphs of PA's performance on key innovation metrics, which are also included in this report;
- 2) **a set of recommendations** regarding policy, budget, data collection, and follow-on work (some of which are included at the end of this report); and
- 3) **a user guide** to help DCED replicate this report annually and build out the dashboard on their website.

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A strong community and entrepreneurial network are crucial for an innovation economy's success. As a former businessman, I know that here in Pennsylvania, we are lucky to have both. We have a legacy of innovation and can-do spirit, and we have an opportunity to position the commonwealth as a national competitor in attracting and retaining entrepreneurs and startups, and the talent that is employed by them, through strategic funding and community support.

This annual report was made possible by the talented and forward-thinking students at Carnegie Mellon University's Heinz College of Public Policy, and it will help Pennsylvania recognize its strengths, but also identify shortcomings in innovation across the state and concentrate improvement efforts on areas with the greatest need.

This report begins by noting that "innovation is the result of a new idea becoming a product or process." This notion—that innovation is what happens when something novel becomes familiar—represents exactly what we aim to do in the commonwealth: examine our current approaches to education and workforce development, and find ways to improve them for all of our state's 12.8 million residents.

We know that today's economy is rapidly changing and investment in innovation and technology is required to support economic development. As this report notes, combatting "brain drain", providing support to entrepreneurs and start-ups, strengthening research and development, and ensuring access to high-quality education are just a few of the ways Pennsylvania can create the workforce of the future.

By tapping into the resources and connections we have at our fingertips here in the commonwealth—like the partnership we have formed with Carnegie Mellon University—we can build on our strengths and enhance our state's technology and innovation landscape. This will benefit not just our businesses, but our communities, as building a skilled workforce will lead to good-paying, family-sustaining jobs and improvements in quality of life in neighborhoods across Pennsylvania.

I would like to thank the team at Carnegie Mellon University for their work on this report, as the recommendations found within will help inspire and inform public policy for years to come.

TOM WOLF

Governor of Pennsylvania

Executive Summary

Innovation is the result of a new idea becoming a product or process at a large enough scale to change how we live. The innovation economy refers to the people, policies, companies, funding, and infrastructure that help bring these new ideas to life and, in turn, drive diversified, sustainable economic growth. Research-based industries and the creation of new companies are central to this.

Historically, Pennsylvania led the nation in innovation, as one of the first states to fund collaborations between universities and tech companies through the Ben Franklin Partnership. But it now maintains a middling ranking on well-regarded innovation indices, due to several key challenges:

- 1) The state has world class research developed in its institutions, but it is not being converted into new enterprises that are built or scaled up in-state. The state has 0.58 young high-tech firms per 1,000 residents compared to Massachusetts' 0.86.
- 2) Women and people of color are not participating in the high-wage entrepreneurial economy at the same rates as men and non-minorities. In the Philadelphia metro area 16.1% of businesses in high-wage industries are owned by non-minority individuals, while only 11.6% are minority-owned.
- 3) The state is in desperate need of talented workers, both to support our aging population and to staff companies so that they can grow here in Pennsylvania instead of elsewhere. Only three of the ten Partnerships for Regional Economic Performance (PREP) regions saw a positive net migration of working-age adults in 2019.

However, Pennsylvania also has key assets that can be leveraged to grow the innovation economy:

- 1) Pennsylvania boasts a vast network of colleges and universities where talent is developed and new technologies are invented.
- 2) Ben Franklin Technology Partners (BFTP) and PREP provide a business support network with a statewide footprint. Since BFTP was founded in 1983, at least 19 alumni companies have gone public.
- 3) Pennsylvania occupies a geographically strategic spot. Proximity to global hubs on the East Coast offers manufacturers access to ports and customers, and offers newly remote workers from these population centers a nearby place to relocate.

This report measures nearly 40 metrics related to the innovation economy, with the intention that the most important metrics will be tracked year over year, in future iterations of this report or in the [web dashboard](#) that accompanies this report, informing policy for the foreseeable future. The economic impact of the COVID-19 pandemic adds a layer of urgency to this task, as there is increased need for innovative ideas, jobs, and institutional partnerships to support the state's recovery. With the passage of the American Rescue Plan and the anticipated influx of even more federal funds, this report can help the state prioritize issues and allocate funds that foster the broader population's *inclusion* in the innovation economy, to ensure growth and prosperity statewide, across all communities.

1. Introduction to Pennsylvania's Innovation Economy

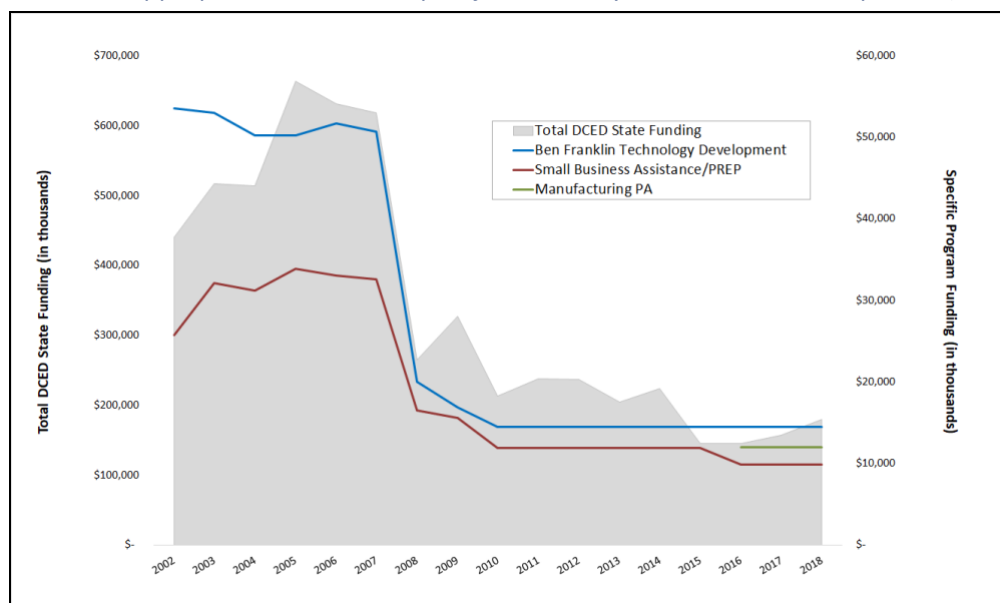
Innovation is the result of a new idea becoming a product or process at a large enough scale to change how we live.^{i,ii} The innovation economy refers to the people, policies, companies, funding, and infrastructure that help bring these new ideas to life. This report measures the status of these inputs, as well as outcomes of the innovation economy, to arrive at a picture of the state's overall strengths and weaknesses in this arena.

This is worth doing because, while innovation has always contributed to economic growth, it is now a principal driver of regional prosperity, which is not distributed evenly across the country.ⁱⁱⁱ Between 2005 and 2017, 90% of new jobs in the innovation sector (comprised of STEM and research intensive industries)¹ were generated in just five cities: Seattle, Boston, San Francisco, San Diego, and San Jose, California, while less innovative regions saw economic stagnation or decline.^{iv} Helping Pennsylvania win a greater share of these jobs will help individuals and the overall economy: the average worker in an advanced industry earns double that of the average worker in other industries,^v and, according to one estimate, every ten jobs in an advanced industry creates eight other locally-based jobs in other industries.^{vi}

Pennsylvania was a past leader in innovation. The state was one of the first to recognize the importance of collaboration between higher education institutions and industry, especially the importance of turning university research into economic activity.^{vii} In 1982, the Thornburgh administration, with bipartisan support from the legislature, proposed the creation of Ben Franklin Technology Partners (BFTP), which to this day provides investments, support, and infrastructure to technology-oriented companies and research institutions.^{viii} But the state cut funding for innovation-related programs like BFTP during the 2008 recession, and never restored them to their original levels.

¹ In this 2015 Brookings and ITIF report, the innovation sector was defined as the 13 industries whose R&D expenditures exceeded \$20,000 per worker and had a STEM-worker share of 45%. These were basic chemical manufacturing; pesticide, fertilizer, and agricultural chemical manufacturing; pharmaceutical and medicine manufacturing; computer and peripheral equipment manufacturing; communications equipment manufacturing; semiconductor and other electronic components manufacturing; navigational, measuring, electromedical, and control instruments manufacturing; aerospace product and parts manufacturing; software publishers; satellite telecommunications; data processing, hosting, and related services; other information services; and scientific research and development services.

Fig. 1 General Fund Appropriations to the Dept. of Community & Economic Development (2002-2018)



Source: PA Department of Community and Economic Development^{ix}

The state needs an economic boost to help address current and imminent challenges:

- **Pennsylvania's population is aging**, especially in rural areas.^x As of 2017, Pennsylvania had the seventh highest percentage of seniors of any U.S. state, and that percentage is rising.^{xi} As the population ages, the labor force is shrinking, causing the government to take in less revenue while spending more on healthcare, pensions, and social services.^{xii} Investing in innovation can help solve this problem by creating high-quality, family-sustaining jobs that keep young professionals in the state.
- **Closures associated with the COVID-19 pandemic caused the public, private, and nonprofit sectors to shrink, and many workers to lose their jobs.**^{xiii} Some people, disproportionately women, left the workforce entirely to serve as caregivers to family members.^{xiv} While high-wage employment has risen 5.7% since January 2020, low-wage employment has dropped 19.9% since then.²
- **A Census survey administered during the pandemic (February 17-March 15, 2021) found that, of Pennsylvania adults:**^{xv}
 - 10% reported not having enough to eat.
 - 20% reported being behind on rent.
 - 31% reported having difficulty covering usual household expenses.

However, the pandemic proved that Pennsylvania's businesses and institutions can quickly implement innovative ideas. During the height of the pandemic, Pennsylvania's institutions demonstrated their ability to solve the world's biggest problems. Faculty at the University of Pennsylvania Perelman School

² Figures as of March 2021. High-wage employment refers to those earning over \$60,000 annually; low-wage employment refers to those earnings less than \$27,000 annually.

of Medicine created a central hub to coordinate coronavirus-related research for the global science community.^{xvi} Every1Online (a partnership between universities, nonprofit organizations, and school districts) turned the University of Pittsburgh’s Cathedral of Learning into a giant antenna that provided wi-fi to schoolchildren in the area.^{xvii} Even entertainers became innovators: the Scranton Fringe Festival was held outside in the city’s downtown, with performances staged in storefront windows, and the audience listening from the street through wireless headsets.^{xviii} Innovations like these exemplify Pennsylvanians’ ability to create new solutions for new problems, and make the economy stronger than it was before.

This Report’s Structure



This report focuses on people, with the perspective that the economy should work for people, not the other way around. It begins with measures of idea creation, and how these ideas are commercialized and scaled up into businesses that provide lucrative jobs. This section, *Converting New Ideas into Jobs*, covers investments in university research, rates of new and fast-growing high-tech businesses, demographic representation among entrepreneurs in these businesses, and measures of venture capital that can help grow these businesses.

The second section, *Developing and Maintaining Talent*, focuses on the most crucial building block to the innovation process: talent. Without enough STEM workers, tech-based companies will leave the state to grow their workforces elsewhere, taking their tax revenue and indirect job creation with them. The same is true for advanced manufacturing companies which need access to trained mechanics and IT workers.^{xix} To meet this need, Pennsylvania must improve quality of and access to K-12 education, higher education, and technical training; it must attract talented workers from other states and countries, and it must retain these workers by ensuring a high quality of life in the state.

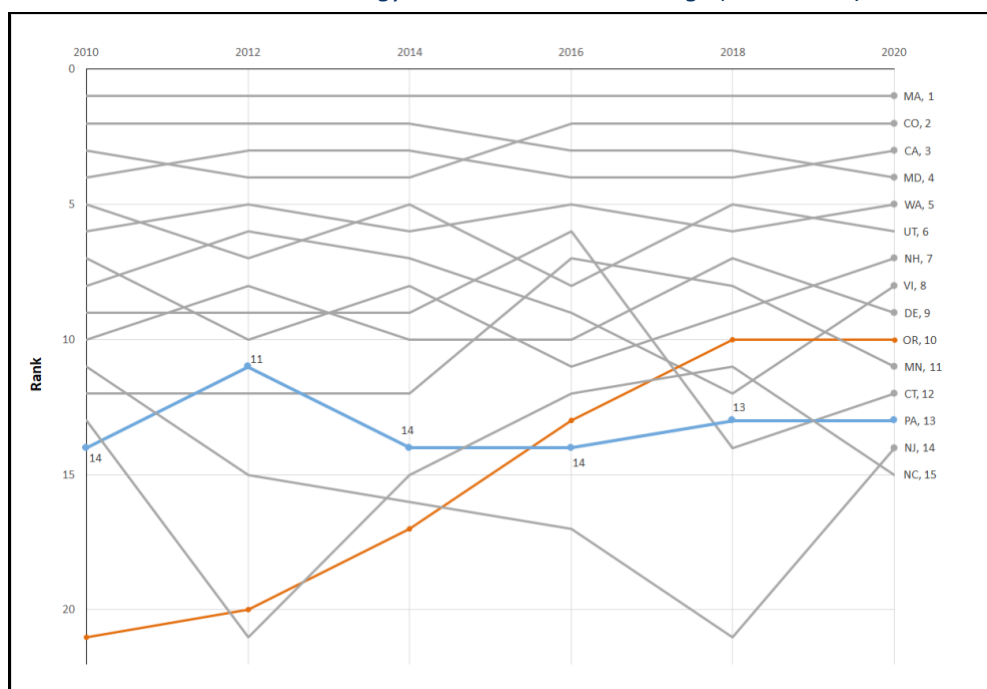
The third section, *Connecting Workers to Jobs*, focuses on connecting workers to both in-person and remote jobs, through transportation and internet access, respectively. Providing every potential worker with the opportunity to access a wide array of jobs will optimize all the other state investments that supported that individual and that employer, so they can work together to prosper.

Ranking PA's Innovation Economy

The Milken Institute State Technology and Science Index (STSI)

National rankings and indices gauge the strength of Pennsylvania's innovation economy relative to peer states, which is helpful as employers and talent often consider multiple states in which to locate. This report uses the Milken Institute STSI, published by the Information Technology and Innovation Foundation, because it is released biennially and formulates its ranking based on each state's performance in five areas related to the innovation economy. Rankings and indices offer a starting point for economic and workforce development strategies, but meaningful progress is made when Pennsylvania policymakers make decisions based on the state's specific issues and assets that factor into these rankings.

Fig. 2 The Milken Institute State Technology & Science Index Rankings (2010-2020)



Source: The Milken Institute^{xx}

Milken State Technology & Science Index Pennsylvania's Subcomponent Rankings			
Subcomponent	2016	2018	2020
Overall	14 th	14 th	13 th
R&D Inputs	9	8	7
Risk Capital & Entrepreneurial Infrastructure	24	14	10
Human Capital Investment	27	13	22
Tech & Science Workforce	14	15	17
Technology Concentration & Dynamism	14	31	30

Source: The Milken Institute^{xxi,xxii,xxiii}

Pennsylvania's highest sub-category ranking on the Index was in R&D inputs, which measures R&D funding, National Science Foundation grants and contracts, and Small Business Innovation Research (SBIR) awards. PA's lowest sub-category ranking on the Index was in Tech Concentration and Dynamism,

which measures establishments, employment, and payrolls in high-tech industries. This indicates that the state has world class research coming out of its institutions, but it is not being converted into new enterprises that are built or scaled up in-state.

Overall, Pennsylvania has held its ranking among the top third of states. However, the “winner-takes-most” dynamics of the innovation economy do not reward stagnation. As the knowledge-driven economy is increasingly dominated by a few cities and states, moving “sideways” year after year will not be enough to ensure that the Commonwealth stays competitive with other regions.^{xxiv}

Case Study: Oregon’s Rise on the STSI Index

Oregon is a strong example of a state with a rapidly growing innovation economy, as measured by the Milken STSI Index. The state’s rise from 21st place in 2010 to 10th place in 2020 is partly attributable to their development of a state Innovation Council, which publishes biennial plans that coordinate innovation efforts across the state.^{xxv} In addition, a massive targeted investment was made into the University of Oregon for a science center and towards a new Manufacturing Innovation Center that hosts projects for companies including Boeing.^{xxvi}

Converting New Ideas into Jobs for Pennsylvanians

2. Research & Development (R&D)

R&D and the Innovation Economy

R&D creates the new technologies, scientific techniques, and processes that are fundamental to innovation. Businesses and governments can use these new inventions to improve everyday lives, and businesses built on original intellectual property are more competitive and efficient, meaning they are likely to increase the tax base and provide jobs.^{xxvii} Public policy plays a major role in fostering research, and one major lever that has proven to be a good investment is the authorization of R&D dollars: a 1% increase in R&D spending will grow the entire economy by 0.61%.^{xxviii}

Major Types of R&D Investments

R&D investments in a state are typically divided into four major categories, with consistent interplay between categories. A minimum level of strength across all four is important to a well-rounded innovation economy. The categories are as follows:

Federal R&D Expenditures - Federal government agencies invest R&D dollars into academic institutions, private businesses, federally-funded research and development centers (FFRDCs), non-profit organizations, or directly into state and local government agencies.

State R&D Expenditures - In addition to distributing federal R&D funds, state governors, in conjunction with the legislature, can allocate funding to various departments. State governments also provide funds for colleges and universities to conduct R&D and for specific R&D tax incentives.

University R&D Expenditures - Academic institutions with a research focus are an important source of R&D spending. While institutions sponsor their own R&D, particularly for basic research, they also receive funding for more targeted and applied research from governments and businesses.

Industrial R&D Expenditures - Private businesses invest in R&D to make their products more competitive and their processes more efficient. While most private R&D is funded by companies reinvesting revenues, federal and state governments also contribute to industrial R&D endeavors.

Federally-Funded R&D

The federal government allocates a significant budget each year to R&D projects that support basic research, applied research, or development projects that serve their goals. These can take the form of direct grants, subsidized loans, tax breaks, and opportunities at national research facilities. These

investments are generally directed towards the PA state and its local governments, PA institutions of higher education, PA businesses, and often partnerships amongst them.^{xxxix}

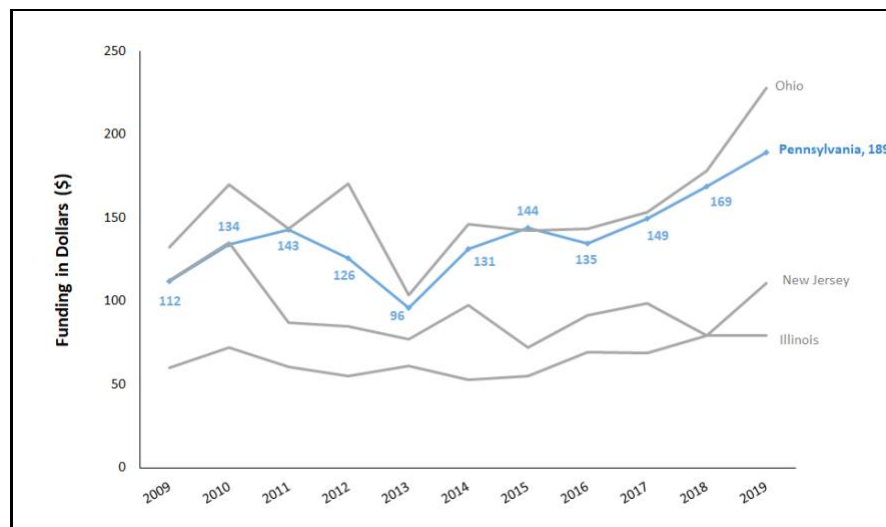
Three of the most important resources that help connect businesses to federal R&D funds are:^{xxx}

- **The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs** - Highly competitive awards meant to assist small businesses in developing innovative technologies with a high potential for commercialization.^{xxxi}
- **Grants.gov** - A database for connecting grant-seekers to R&D grant opportunities. Grants are posted for businesses, state and local governments, school districts, and more.^{xxxii}
- **Beta.sam.gov** - Similar to grants.gov, beta.sam.gov is a database for monitoring opportunities for government contracts. R&D opportunities can be found either via the search bar, or directly through the Federal Assistance portal.^{xxxiii}

SBIR and STTR Funding

As mentioned, the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs offer federal grants to small companies to conduct proof-of-concept research and develop prototypes, with the goal of commercialization. STTR grants require a partnership with a non-profit research institution. Awards are both an indicator and enabler of future business success.

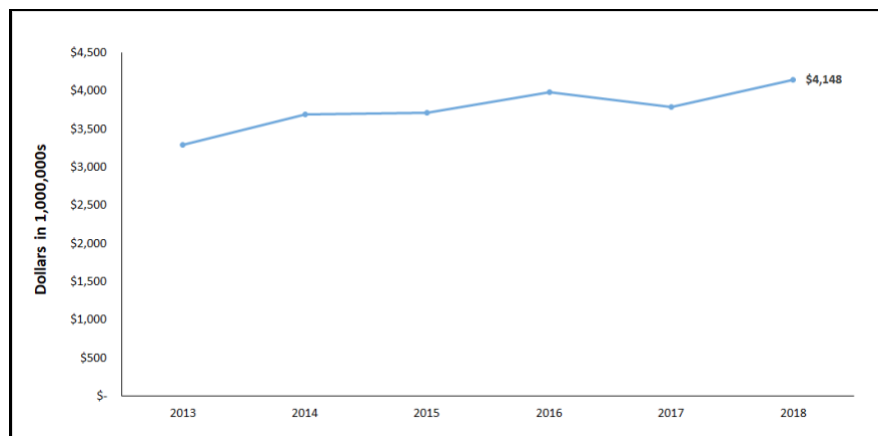
Fig. 3 SBIR and STTR Funding in PA per \$1 Million in GDP (2009-2019)



Source: SBIR/STTR Award Summary by Year (Small Business Administration) and U.S. Bureau of Economic Analysis^{xxxiv}

The level of SBIR and STTR funding in PA has been trending upward since 2013. Adjusted for state GDP, it trails peer state Ohio but performs better than New Jersey and Illinois. Among all states, PA ranks 10th for total number of awards, and ninth for the total amount of funding granted.^{xxxv}

Fig. 4 Federal R&D Obligations (Select Agencies) to PA (2013-2018)



Source: National Science Foundation^{xxxvi,3}

In 2018, almost 80% (\$3.29 billion) of federal R&D obligations to PA went to colleges and universities or industry investments. Over 75% of these funds were sourced from the U.S. Department of Defense and the U.S. Department of Health and Human Services.^{xxxvii}

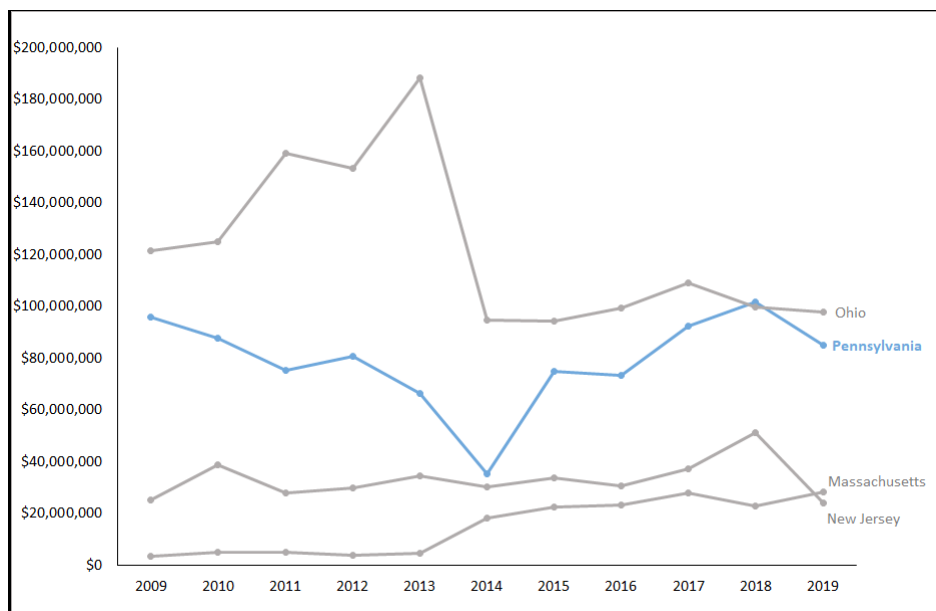
The Fourth Economy report “Advancing Pennsylvania’s Entrepreneurial and Innovation Economy” compares PA’s federal R&D inflows to other states, finding that in 2016, PA was just below the top quarter of states. While this is positive, there was a significant jump in funding between PA and Arizona, the state just above PA in the standings.^{xxxviii}

State-Funded R&D

R&D spent by the state government plays an important, targeted role in boosting the innovation ecosystem. Former Brookings Fellow and current CMU program director Scott Andes explains that, “states and regional governments are often more aware of regional economic clusters and the needs of local firms than university endowments or federal agencies.”^{xxxix} Whether it be through government-run programs performing R&D, or through targeted R&D investments at local universities, PA state government expenditures on research are well tailored to the problems of the state.

³ **Note:** In the National Science Foundation survey providing these data, only eleven agencies are required to report their R&D obligations by state. This is because these agencies make up the vast majority of federal R&D obligations (98% of total obligations for FY 2008-2018). These agencies are: The Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security, the Interior, and Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). National Science Foundation, “Survey of Federal Funds for Research and Development - About the Survey,” nsf.gov, n.d., <https://www.nsf.gov/statistics/srvyfedfunds/#sd>.

Fig. 5 State Government Expenditure on R&D (2014-2019)



Source: National Science Foundation^{xli4}

In FY2019 (the most recent year of data available), approximately 80% of R&D funds provided by the PA state government were allocated to the state's Department of Health and the Department of Community and Economic Development (DCED).^{xli}

Focusing on the latter, three DCED-funded programs conduct R&D activities reported to the NSF: the Ben Franklin Technology Development Authority, the Pennsylvania Life Sciences Greenhouse Initiative, and the Manufacturing PA Innovation Program. Of the \$29.5 million that these programs were allocated in FY2019^{xlii}, they spent \$21.6 million on R&D activities.^{xliii}

Fourth Economy's 2019 report shows that PA's state R&D spending was one of only 10 states that decreased from 2010 to 2016. While spending passed 2010 levels in 2017 and 2018, it fell again in 2019. It is also worth noting that state funding is a minority of R&D funding, relative to the other sources mentioned in this section.^{xliiv}

R&D Tax Credits

Another key way that PA supports R&D initiatives is via the **Research & Development Tax Credit**. The credit provides tax incentives for conducting applicable R&D work in the state. In 2020, businesses in the Information Sector received on average more credits than those in any other sector, at \$183,000 per business. While there is no maximum credit amount a business can apply for, the program has an overall cap of \$55 million to be awarded annually, with an \$11 million set-aside for small businesses. Every year since 1997 when the program was established, tentative awards have far surpassed the cap, which was last increased in 2011.^{xliv}

In 2020, the five largest R&D tax credit recipients were:

1. Janssen Research & Development

⁴ Note: The data point for 2008 is not available as the NSF survey was not conducted that year.

2. Comcast Holdings
3. Uber Technologies
4. GlaxoSmithKline
5. Merck Sharp & Dohme

R&D Case Study: New Jersey's R&D Tax Credit Modernization

R&D tax credits provide a strong incentive for businesses to innovate, so they invest more than they otherwise would. New Jersey has not just leaned into this incentive, but optimized it to increase usership and efficiency.

The state implemented its largest reforms in 2018, with the goal of aligning the state credit with federal tax law, simplifying administration and overhead for companies. NJ now allows companies to use the Alternative Simplified Calculation (ASC) from the federal R&D tax credit. The ASC reduces the number of years of base R&D expenditures companies must track to just three and makes it so that companies only need to perform one calculation for both federal and state credits. This is different from the PA program, which requires four years of expenditures for the calculation.

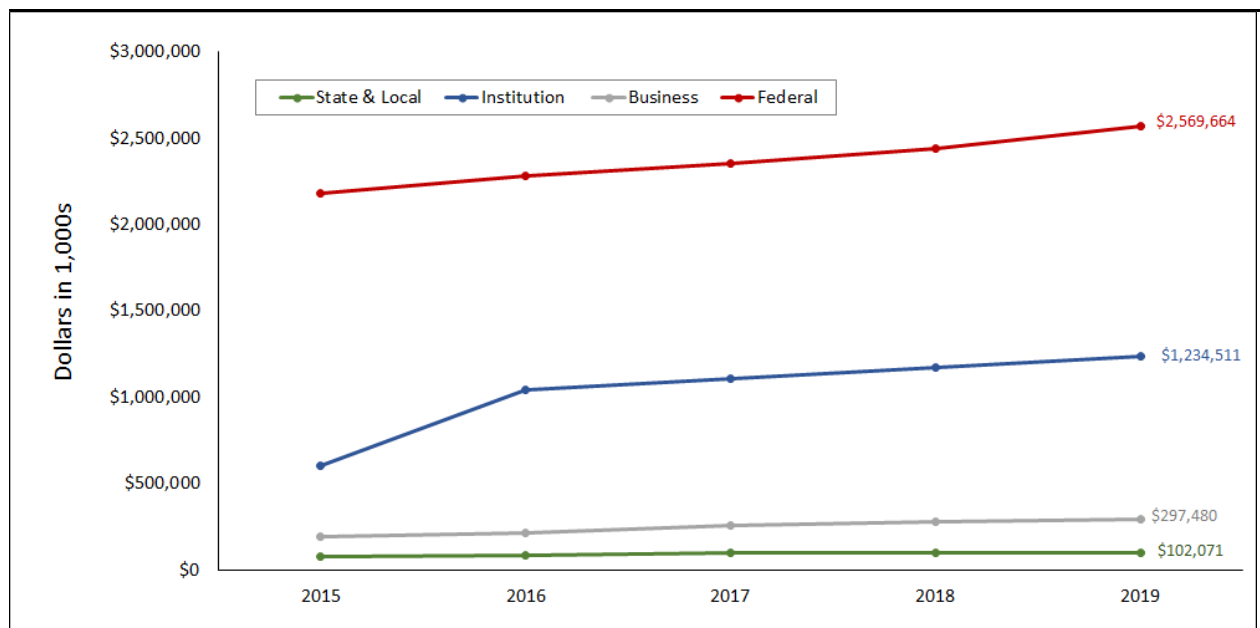
Another difference between the states' credits is that PA's has a \$55 million cap, while NJ's has no cap at all. PA should consider similar modernizations to simplify the administrative burden on companies and further incentivize industry research. ^{xlvii}

R&D Performed by Universities

R&D performed by universities is primarily broken into two categories: basic and applied. Basic research is driven by a desire to expand general knowledge, while applied research answers specific questions and is more focused on commercialization.^{xlviii} For as long as the data have been recorded, the federal government has provided the majority of university R&D funding across the U.S.^{xlviii}

PA is home to some of the strongest research universities and institutions in the country, with three universities ranking in the top 25 for tech transfer and commercialization in the nation: Carnegie Mellon University, University of Pennsylvania, and the University of Pittsburgh, and three others ranking in the top 100: Drexel University, Penn State University, and Temple University.^{xlix} When universities excel at research, they create talented individuals with hands-on experience, and spinoff companies founded on newly-created technology. They also attract research-based companies which sponsor research at the labs, or hire graduates.

Fig. 6 Funding for PA University R&D by Source (2015-2019)



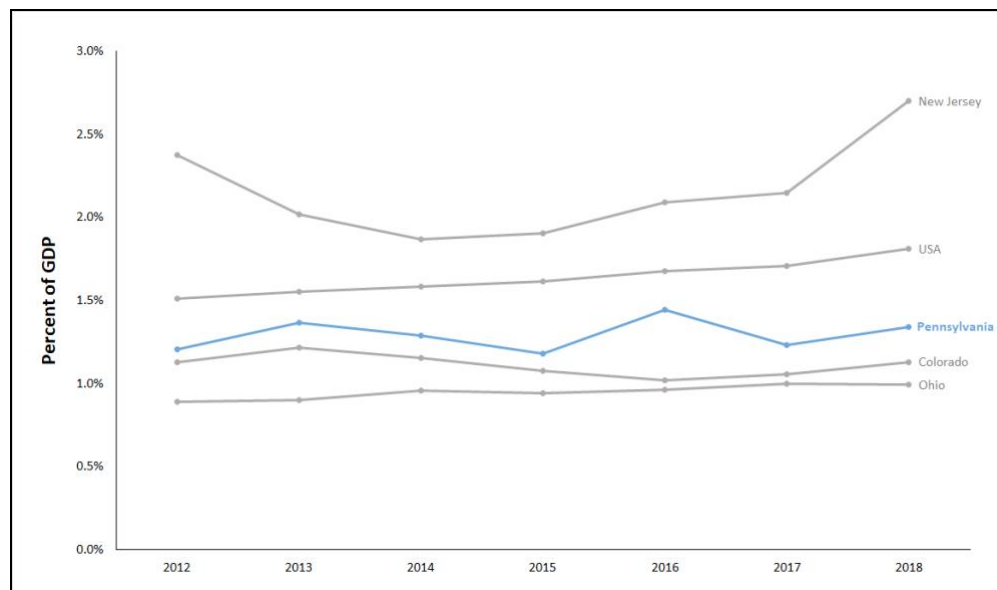
Source: National Science Foundationⁱ

According to the Fourth Economy report, PA was in the top 10 states for university R&D funding as of 2016. The majority of this funding is provided by the federal government. The next highest funding source are the institutions themselves, followed by businesses and PA government funding. All sources of funding have steadily increased over time, which bodes well for the state although it is important to note that in the longer term, funding for university R&D has sizably decreased from almost all sources since the 1990s.ⁱⁱ In the absolute sense, this form of R&D makes up the minority of PA's overall R&D spending.ⁱⁱⁱ

Industry-Funded R&D

Industry R&D is critical to the innovation economy as it trends heavily towards applied research that is more readily commercialized. In addition to creating new products and services, businesses with high R&D investments see increased productivity than their counterparts, and startups founded on patented research are more likely than their counterparts to survive and grow.^{liii} R&D spent by industry is also one of two criteria that Brookings uses to identify advanced industries, which are responsible for a disproportionate share of employment and productivity in the U.S.^{liv}

Fig. 7 Industry R&D Spending in PA as a Percentage of GDP (2012-2018)



Source: National Science Foundation^{lv}

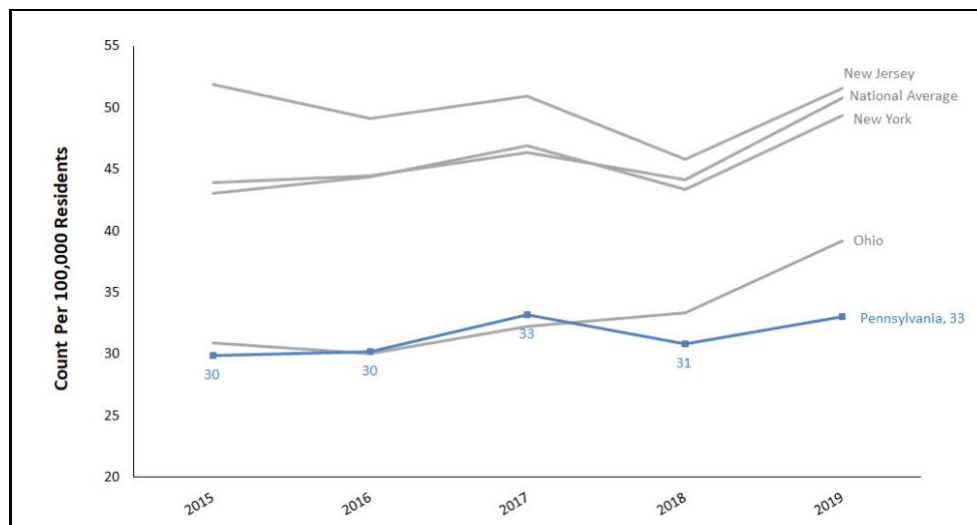
Looking at the absolute numbers, PA appears to be performing well on industry R&D: as of 2016 it constituted the majority of R&D spending in the state and PA remains above average on this form of funding compared to all states.^{lvi} However, when looking at industry R&D funding as a percentage of state GDP, PA's rate remains stagnant and trails states like New Jersey and the national average, both of which have a steadily increasing rate. It is worth noting that the national average is pulled upward by the top performers, specifically California who, in 2018, performed 34% of all industry R&D in the country. PA's competitors, such as Ohio, Indiana, and Rhode Island, are pursuing a diverse array of policies dedicated to enhancing businesses R&D. Pennsylvania must match the intention behind these efforts if it wishes to improve its position.^{lvii}

Utility Patents

Patents are a cornerstone of the innovation economy, incentivizing individuals and companies to invest in R&D by providing patent holders with a guarantee that they will have exclusive access to commercially benefit from their work. Utility patents, otherwise known as patents for invention,⁵ are a proxy for how well investments in R&D translate to useful product outputs. One reason to focus on patents is that they are a predictor of business success, particularly for startups. Startups with a patent in their first year are 60 times more likely to achieve IPO or high-value acquisition than those without a patent in their first year.^{lviii}

⁵ Patents for invention, as opposed to patents for things like design.

Fig. 8 Utility Patents per 100,000 Residents (2015-2019)



Source: U.S. Trademark Office^{lix, lx, lxi}

The above graph breaks down the number of utility patents awarded for every 100,000 residents in a particular state. PA's performance on utility patents relative to its population lags in comparison to peer states and the nation as a whole. This indicates that while PA has strong R&D dollar investments in several areas, particularly in universities and by industry, it is not converting those investments into commercialized products and processes. This gap has only been widening in the past couple of years.

Pennsylvania's R&D Strengths and Weaknesses

Strengths:

- Strong base assets, including top-ranked research universities and well established programs by DCED (such as the R&D tax credit), on which the state can build.
- Solid R&D investments in universities, both from internal endowments and external funding sources such as state and federal governments.
- Steadily increasing R&D expenditure in the state from federal agencies, a stable source of funding that constitutes a large percentage of PA's overall R&D dollars.
- Upward-trending SBIR/STTR awards as a percentage of GDP, suggesting strong potential for future commercialization of products in the state.

Weaknesses:

- PA has struggled to invest in R&D in such a way that leads to practical invention, as demonstrated by the lackluster utility patents earned relative to its population. Stagnant state government R&D investment, and industry R&D investment relative to GDP might contribute to this.
- Strong assets in the state are being held back by a lack of funding, such as the R&D tax credit being underutilized relative to peer states with a capless credit.

3. Entrepreneurship and High-Growth Firms

Entrepreneurship and the Innovation Economy

A Kauffman Foundation study on U.S. companies between 1988 and 2012 found that **startups are responsible for almost all net job growth in the U.S.**^{lxiii} This job growth is sustainable: when a cohort of firms founded in a given year reaches age five, their employment is on average 80% of the initial value.^{lxiii} That's because high growth at the surviving firms makes up for those firms that did not survive. By contrast, **older companies (over 11 years old) destroyed more jobs than they created** in all but eight of the study years.

This exemplifies why the state needs to prioritize supports for startups, particularly startups that use novel business ideas or technology. In contrast to new companies that use well-understood business ideas to compete in local markets, these innovative startups have the potential to pursue competitive advantage in global markets and achieve high rates of growth.^{lxiv} While both types create jobs and offer needed goods and services, these high-growth firms (defined as those with 20% or greater compound annual revenue over 3-years) are responsible for a significantly outsized contribution to economic growth and job creation.^{lxv}

Research and development plays a strong role in high-potential entrepreneurship because new discoveries made in labs are opportunities to bring new products to market and solve problems that no one else is solving. Strengthening Pennsylvania's innovation economy will require translating our university research into new startups, and, crucially, keeping those startups in Pennsylvania. Venture capital is a key piece of this puzzle, and is discussed in the subsequent section.

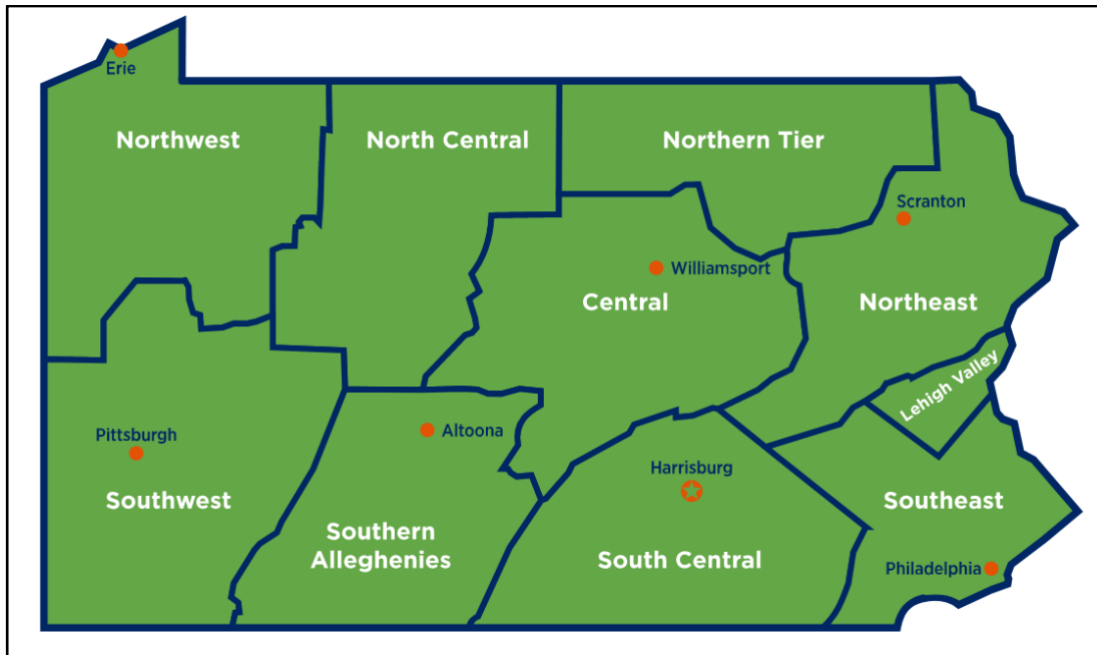
DCED's Funded Partners that Support Entrepreneurship

The Department of Community and Economic Development oversees several programs to help all types of entrepreneurs:

- **Ben Franklin Technology Development Authority (BFTDA)** - The BFTDA is a state technology development entity dedicated to bolstering innovation, the entrepreneurial environment, and the PA workforce through embracing technological change. The Authority utilizes thought leaders and provides funding to improve technology strategy and the state's economic competitiveness.
- **Ben Franklin Technology Partners:** A program within BFTDA, this program provides early-stage tech firms and manufacturers with grants, investments, business consultation, and access to a network of innovation experts. In 2020, BFTP assisted 1,697 technology-based companies across Pennsylvania and helped 101 new companies form.^{lxvi} BFTP also provided crucial grants to vulnerable early-stage companies that may not have otherwise survived the COVID-19 pandemic.
- **Pennsylvania Life Sciences Greenhouse Initiative** - The three Life Sciences Greenhouses provide grants and expertise to universities and companies conducting biomedical, clinical, and health services research. These funds are specifically designed to encourage high-quality job growth and commercialization of new technologies. The program was created in 2001 out of the Tobacco Settlement Act. It has funded 253 companies and projects and 86 new technologies, 45 of which have exited.^{lxvii}

- **BFTDA Venture Investment Program:** This program invests venture capital into portfolios comprised of 22%-33% Pennsylvania-based firms. The program aims to support Pennsylvania companies and to earn a high return on investment. According to its managers, 4.57 companies are created for every \$1 million invested. This program was created by the one-time sale of insurance premium tax credits in 2015.^{lxviii}
- **Manufacturing PA Innovation Program** - Manufacturing PA assists and offers grants to small and medium-sized manufacturers and does so through a variety of partners responsible for job training and workforce development. These partners include the Industrial Resource Centers (IRCs), colleges and universities, and nonprofit organizations.
- **PA Business One-Stop-Shop:** Business One-Stop-Shop is generally the first point of contact and central resource for any founder looking to plan, register, operate, or grow a business.
- **Innovation Partnership:** This program helps early-stage tech firms submit applications for federal funding awards, including travel and training grants related to the submission process.
- **PA Infrastructure Technology Alliance:** The Alliance provides grants to labs at Lehigh University and Carnegie Mellon University for salaries, research materials, and operational costs that help spin-off technology companies emerge, scale, and increase operational efficiency.
- **Partnership for Regional Economic Performance (PREP):** Started in 2012, PREP is a network of business assistance partners who help any business start, grow, and prosper. PREP provides grants to incentivize coordination between regions in economic development efforts. By integrating existing networks from efforts like the Industrial Development Organizations (IDOs) and the Small Business Development Centers (SBDCs), PREP creates a comprehensive economic development strategy across the state. See a map of these regions below.

Map of PA Partnership for Regional Economic Performance (PREP) Regions

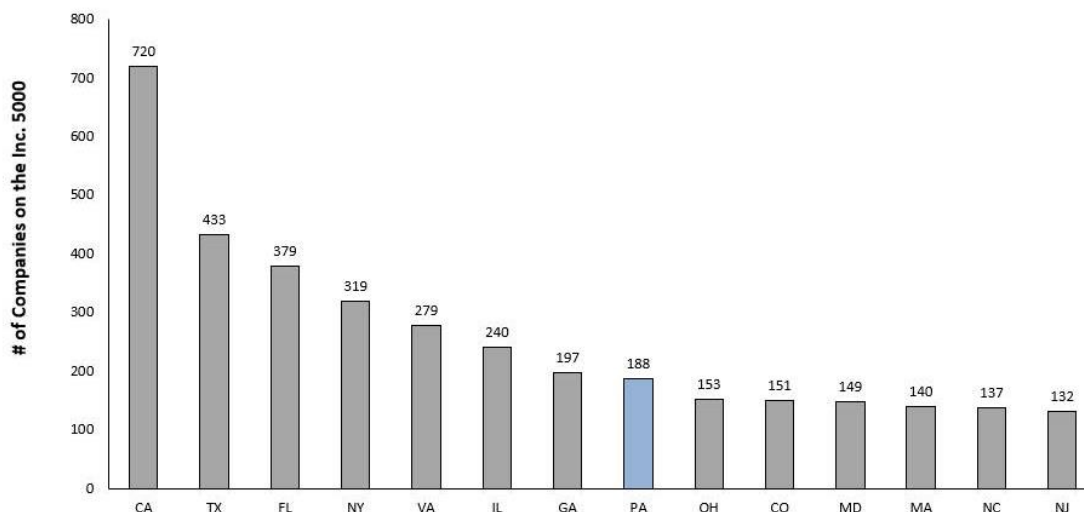


Source: PA Department of Community and Economic Development^{lxix}

High-Growth Firms

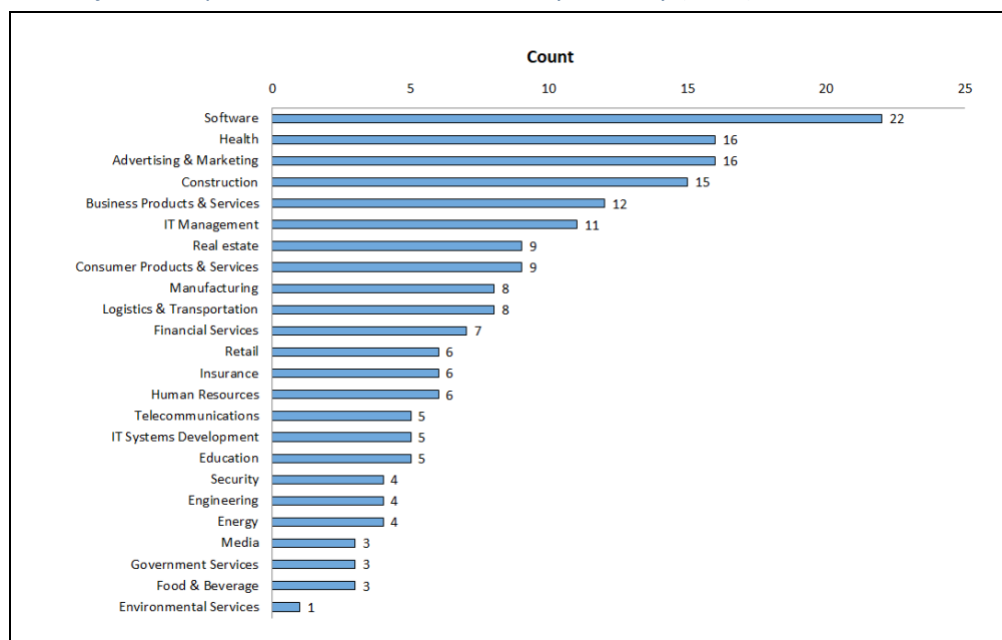
When businesses grow, they typically provide more jobs, pay more taxes, and require more suppliers and services for an overall positive impact on the economy. The Inc. 5000 tracks the 5,000 fastest-growing U.S. companies (as measured by revenue) on an annual basis. Of those companies on the 2020 list, 188 were headquartered in PA, making it the eighth-best performing state by this measure.

Fig. 9 Number of Companies on the Inc. 5000 List, by State (2020)



Source: Inc. 5000^{lxx}

Fig. 10 Number of PA Companies on the Inc. 5000 List, by Industry (2020)



Source: Inc. 5000^{lxxi}

The software, advertising, and health industries saw the most Pennsylvania-based companies to make the list. However, the very top-performing companies on the list were in fact not representative of these industries. The top-performing companies were:

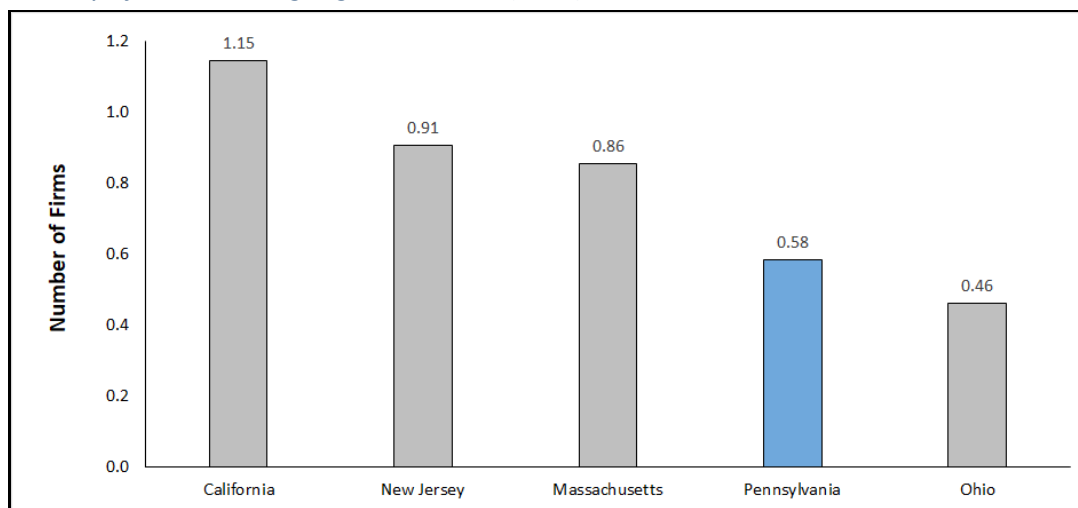
1. Catalyst Experiential, Newtown Square (Real Estate)
2. Netizen Corp., Allentown (Security)
3. Infinia Search, Kennett Square (Human Resources)
4. Signallamp, Scranton (Health)
5. Fishing Online, New Brighton (Retail)

Participation in Innovative Entrepreneurship

New and Young High-Tech Firms per 1,000 People

The more people who found high-tech companies, the more seeds of economic growth are planted in the Commonwealth. The chart below shows the number of new high-tech firms⁶ per 1,000 residents in PA, as compared to other states—a proxy for density of high-potential entrepreneurship. As of the most recent year that data are available (2018), PA lags key competitor states, with its density of 0.58, which is derived from 7,461 new and young high-tech companies in the state. The vast majority of these companies are in the Philadelphia area, followed by the Pittsburgh area, indicating the need to boost support for entrepreneurship beyond these clusters.

Fig. 11 Density of New & Young High-Tech Firms (2018)



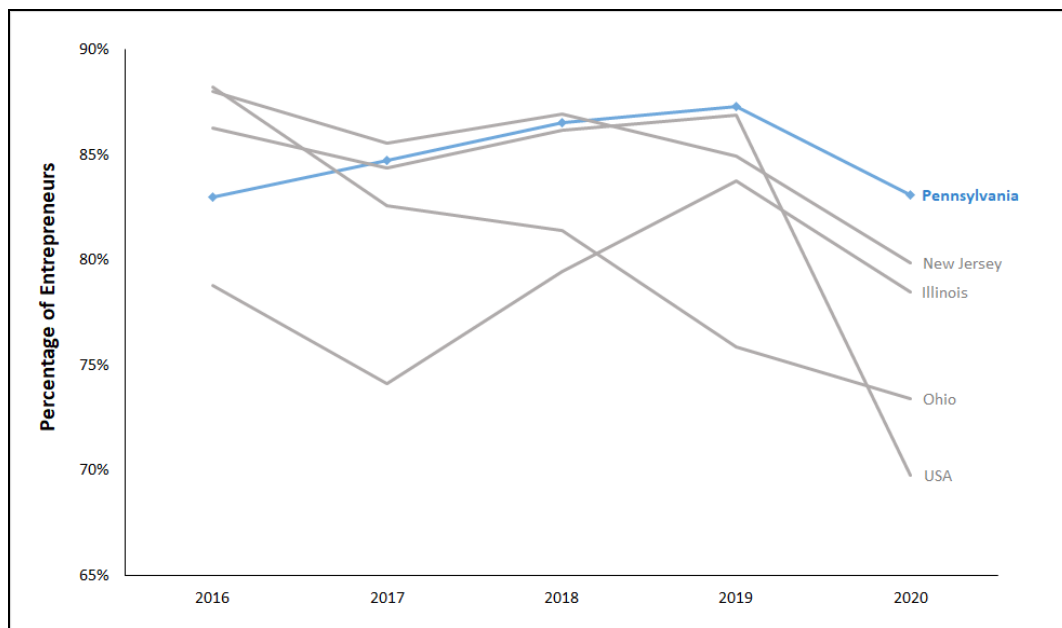
Source: U.S. Census Business Dynamics Statistics Survey^{lxvii}

Opportunity Share of New Entrepreneurs

It is important to study a founder's motivation for starting a new company because it is another factor correlated with high growth. Those who start a new business because they see a new market opportunity are more likely to create high-quality, high-growth firms than those who start a new business for needed income.^{lxviii} Opportunity share measures the share of all entrepreneurs who started a business by choice. That applies if they were both employed and not searching for a new job at the time of first establishment.

⁶ New firms are defined as an entirely new business, as opposed to a new arm or franchise of an existing business. High tech-firms are identified as those with NAICS industry labels of "Information" and "Professional, Scientific, and Technical Services."

Fig. 12 Share of New Entrepreneurs who Created a Business by Choice instead of Necessity (2016-2020)



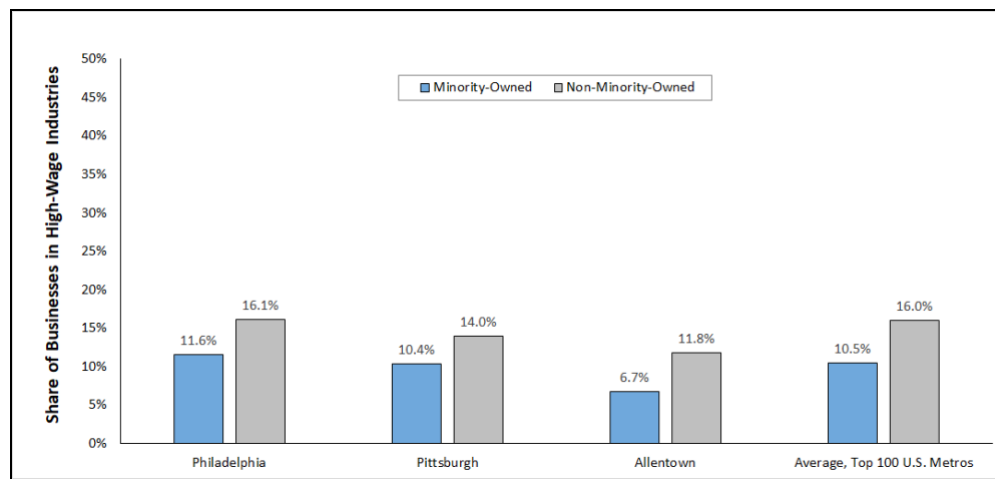
Source: Kauffman Foundation^{lxxiv}

As is implied by the chart (and bolstered by research), overall economic conditions impact the reason for and quality of new business creation.^{lxxv} Prior to 2020, the share of Pennsylvania entrepreneurs who started a business by choice had been steadily increasing, surpassing peer states and in line with the national average. But the state's rate dropped from 87.3% in 2019 to 83.1% in 2020, when the COVID-19 pandemic hit, though this drop was not as dramatic as the U.S. overall. Improving the Commonwealth's overall economy can get us back on track to raise the share entrepreneurs who start a business by choice.

Demographic Representation among Entrepreneurs

Cost-prohibitive education, limited access to established professional networks, discrimination in lending, and underrepresentation in venture capital firms^{lxxvi} are some of the reasons why minority-owned businesses fare worse than non-minority-owned peer businesses. Minority business owners make on average \$1.5 million less in annual sales than non-minority business owners in Philadelphia, \$1.6 million less in Allentown, and \$1.8 million less in Pittsburgh.^{lxxvii} Another reason for this is that minority business owners are less likely to run businesses in high-paying sectors, as shown in the chart below.

Fig. 13 Share of Businesses in High-Wage Industries, by Owner Race/Ethnicity (2018)



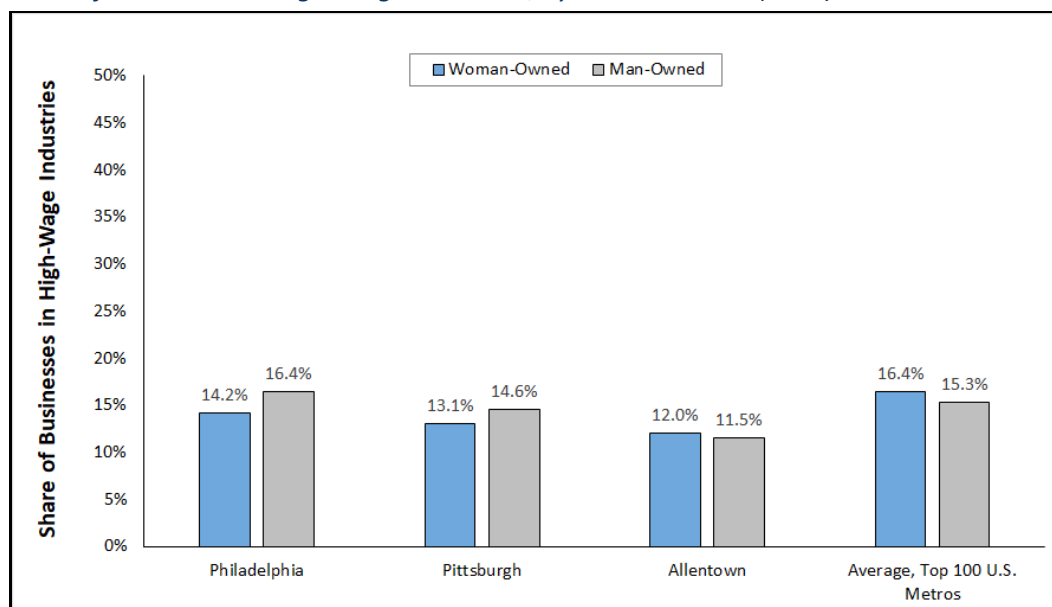
Source: 2018 Annual Business Survey via Nowak Metro Finance Lab^{xxviii}

Note: Data from the Professional, Scientific, and Technical Services sector are used as a proxy for high-wage industries, as this sector ranks third in terms of average wages in the U.S. but has better data availability by sector and race/ethnicity of the owner than the two higher paying sectors: Information, and Finance.

The most important information gleaned from the chart is the percentage point difference between the rates of minorities' participation in high-wage industries (the blue bars) and the rates of non-minorities' participation in high-wage industries (gray bars). While all three PA metro areas shown see a sizable disparity in the share of minority- versus non-minority owned businesses in high-wage industries, their disparities are smaller than the average of the top U.S. metros.

Philadelphia and Pittsburgh's women are also underrepresented in high-wage industries, as shown in the chart below. However, in Allentown, women are more likely to run businesses in high-wage industries, which mirrors the trend in the top 100 U.S. metros and shows that progress can be made in other metro areas.

Fig. 14 Share of Businesses in High-Wage Industries, by Owner Gender (2018)



Source: 2018 Annual Business Survey via Nowak Metro Finance Lab^{lxxxix}

Note: See Note on previous chart

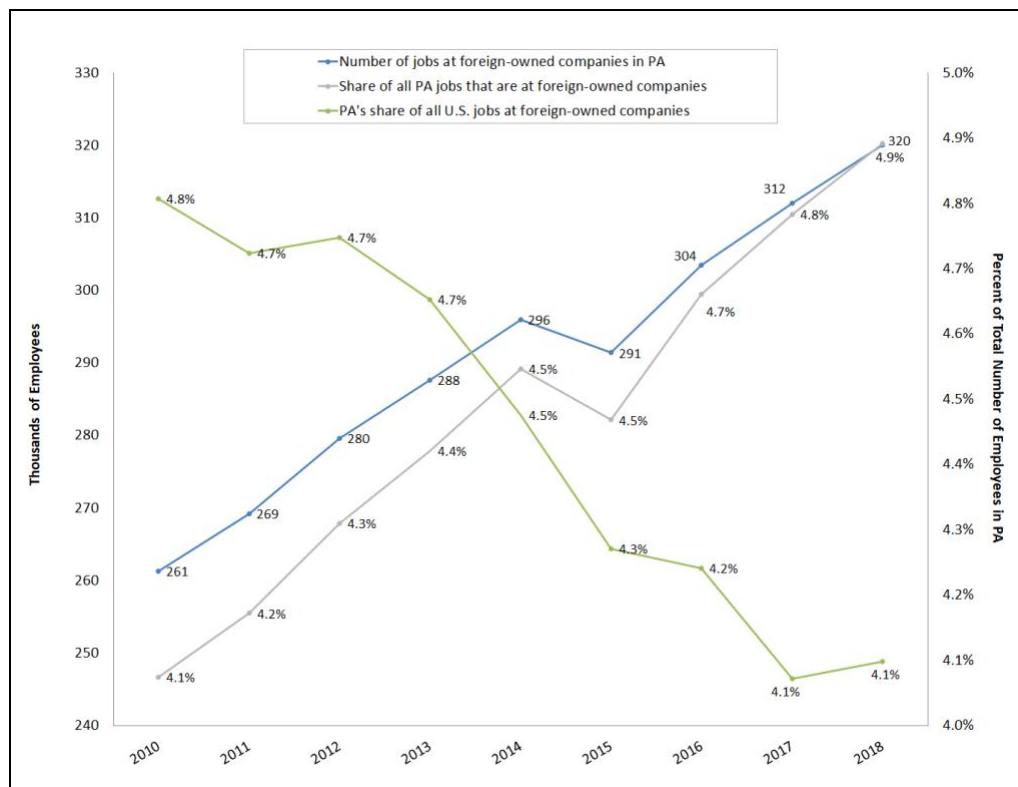
Without equitable representation among entrepreneurs, only a slice of the population is tasked with innovating on behalf of the entire population, which means issues will inevitably go unsolved or approached incorrectly. With the passage of American Rescue Plan and expected increases in federal funds to invest in Socially and Economically Distressed Individuals (SEDIs), the state is well positioned to start new business training programs and specialized investment funds to support women- and minority-owned businesses.

The Importance of Foreign Owned Companies to Employment

Foreign-owned companies also play an important role in U.S. economic growth and prosperity by creating highly-compensated jobs, bringing in innovative ideas, and boosting exports.^{lxxx} Typically, foreign-owned companies belong to high-tech, research-based industries.^{lxxxi} The presence of foreign-owned companies in a region may also attract other foreign firms, both within and outside of the same industry, ultimately creating more jobs for Pennsylvanians.^{lxxxii}

Among the reasons that foreign-owned companies choose Pennsylvania are access to its universities and research hospitals, access to large population centers and ports on the east coast, and connections to industrial suppliers and customers in the state.

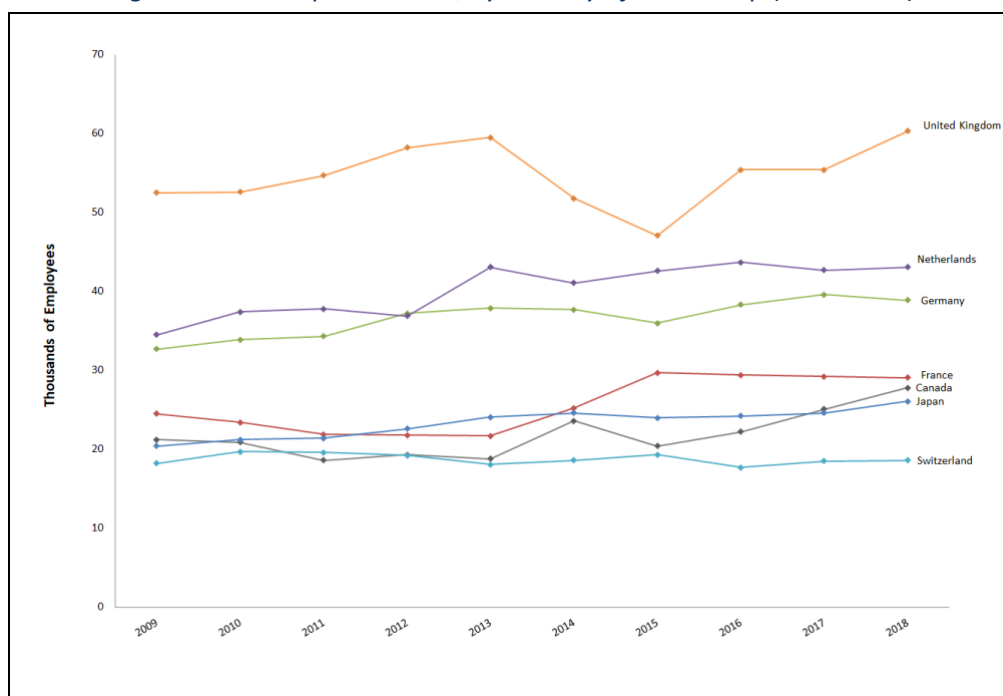
Fig. 15 Jobs at Foreign-Owned Companies in PA (2010-2018)



Source: U.S. Bureau of Economic Analysis - Foreign Direct Investment^{lxxxiii}

From 2010 to 2018, the raw number of workers at foreign-owned companies⁷ in PA increased steadily, as did the share of the *state's* workforce employed at these firms. However, PA appears to be losing ground to other states: as PA's share of the *U.S.* workforce employed by foreign-owned companies is decreasing.⁸

Fig. 16 Jobs at Foreign-Owned Companies in PA, by Country of Ownership (2009-2018)



Source: U.S. Bureau of Economic Analysis - Foreign Direct Investment^{lxxxiv}

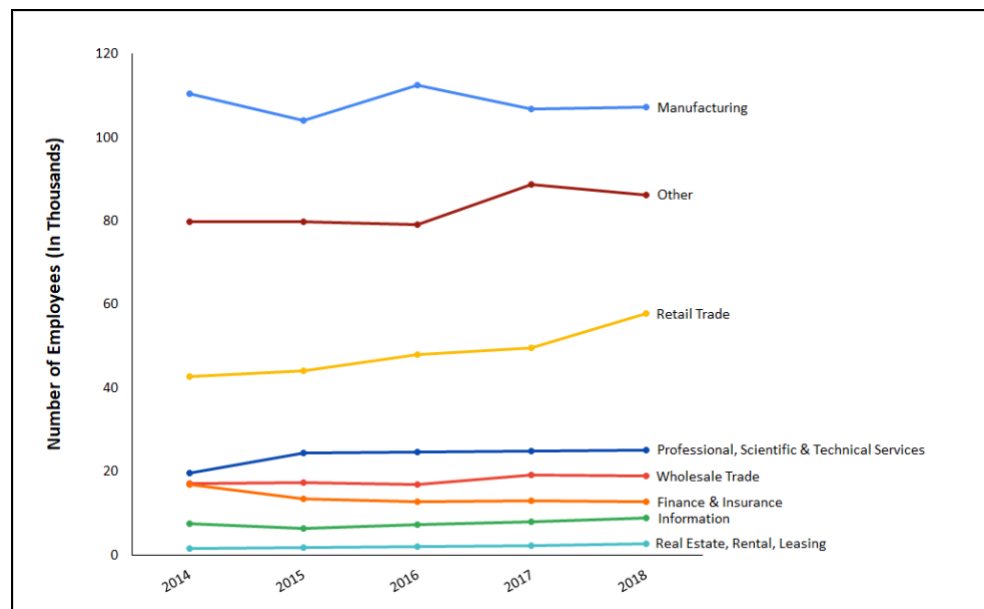
As shown in the graph above, companies from the United Kingdom have been the largest source of job opportunities at foreign-owned companies in PA from 2009 to 2018, followed by Germany and the Netherlands.

Finally, the graph below shows the number of jobs at foreign-owned companies in PA, by industry, from 2014 to 2018. The manufacturing industry makes up the largest portion of employment at foreign-owned companies, followed by wholesale trade and retail trade.

⁷ Foreign-own companies are defined by the U.S. Bureau of Economic Analysis as those for which the combined ownership of all foreign parents exceeds 50%.

⁸ Data on the number of foreign-owned companies in each PA county is available on DCED's website.

Fig. 17 Jobs at Foreign-Owned Companies in PA, by Industry (2014-2018)



Source: U.S. Bureau of Economic Analysis - Foreign Direct Investment^{xxxxv}

The following are examples of specific foreign-owned companies in PA:

- SAP, Germany (Cloud-based business software)
- IKEA, Sweden (Furniture)
- Saint Gobain, France (Manufacturing)
- Ebara, Japan (Manufacturing)
- Wuxi, China (Pharmaceuticals and Medical Devices)
- Ahold Delhaize, Netherlands (Supermarkets)
- Mitsubishi Electric, Japan (Electronics)
- Almac, UK (Pharmaceuticals)

Pennsylvania's Entrepreneurship Strengths & Weaknesses

Strengths

- PA's entrepreneurial economy is resilient. COVID-19 has not led to a significant increase in the rate of entrepreneurs creating businesses out of necessity, versus by choice, as compared to the national rate.
- As measured by the Inc. 5000, PA is home to a higher number of highest growth firms relative to states with competitive economies.
- Foreign-owned companies are contributing to employment growth in PA.

Weaknesses

- Pennsylvania could improve its density of high-tech firm creation to keep up with key competitor states.
- Entrepreneurial activity in the state is unequally distributed—it is highly concentrated in Philadelphia and Pittsburgh.

- Foreign-owned companies are not creating jobs in Pennsylvania at the same rate as is occurring nationally.
- In PA's three largest cities, minorities are not running businesses in high-wage industries at the same rates as non-minorities. And in PA's two largest cities, women are not running businesses in high-wage industries at the same rate as men.

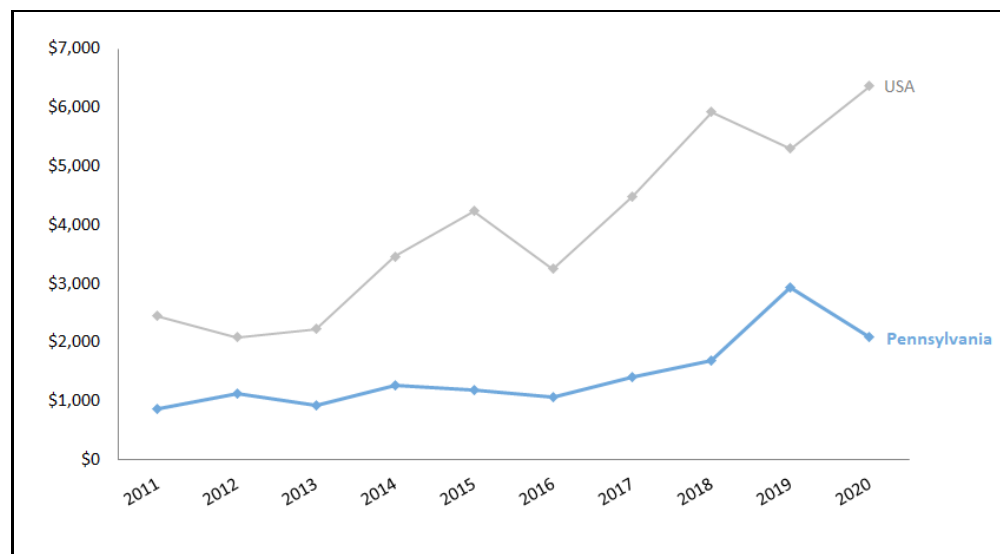
4. Risk Capital

Risk Capital and the Innovation Economy

New technologies and startups can only make an impact on society with capital that enables them to commercialize and scale, in turn creating new jobs and bringing innovative products and services to more people.^{lxxxvi} Two state-run programs that provide risk capital to Pennsylvania companies are Ben Franklin Technology Partners, and the Venture Investment Program, which are both detailed in the Entrepreneurship and High-Growth Firms section.

The following graph measures the magnitude of venture capital (VC) invested in companies in the Commonwealth compared to the amount invested in all companies in the U.S., adjusting for the size of their respective economies. Positive trends in this metric indicate new products and services, job creation and revenue growth.

Fig. 18 Venture Capital Dollars per \$1 Million GDP (2011-2020)



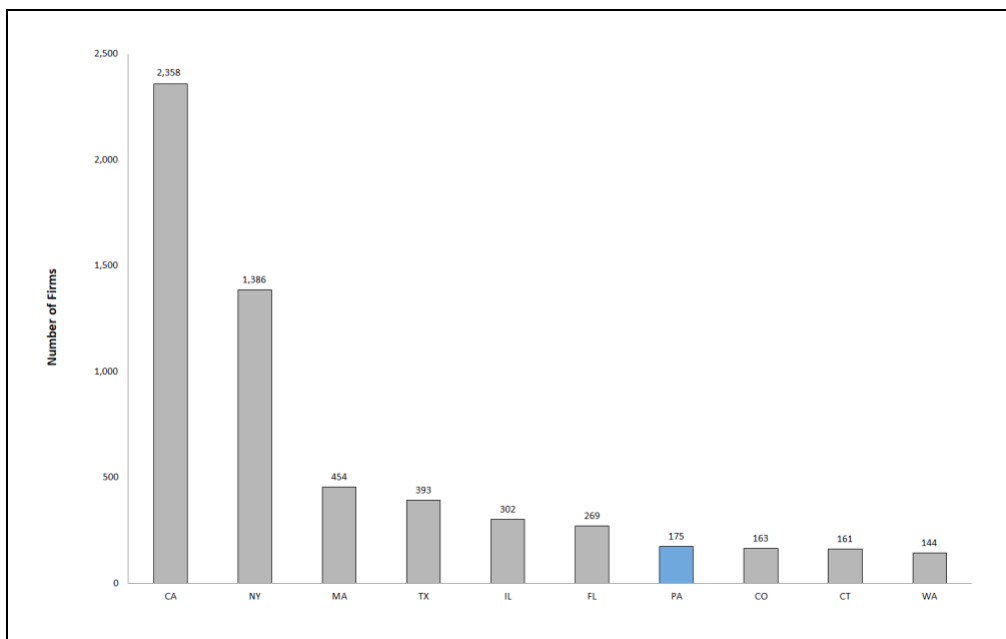
Source: PwC/CB Insights MoneyTree™ Report^{lxxxvii}

Not adjusting for GDP, the total amount of Pennsylvania VC deals rose from \$534 million in 2011 to \$2.37 billion in 2019 before dropping to \$1.63 billion in 2020. The state clearly lags the U.S., even adjusting for size of their economies, but it should be noted that the U.S. figure is significantly boosted by outliers California and New York.

Venture Capital Firms in Pennsylvania

It is also important to look at the other side of VC deals—investors. A strong presence of venture capital firms within the state not only fuels businesses at every stage of their growth, but decreases the likelihood that firms will relocate to hubs like Silicon Valley to access capital, taking their existing and future jobs with them. The following graphs measure the number of VC firms in PA and the number of investments made by top VC firms in PA.

Fig. 19 Venture Capital Firms – Top Ten States (as of March 2021)



Source: Crunchbase^{lxxxviii}

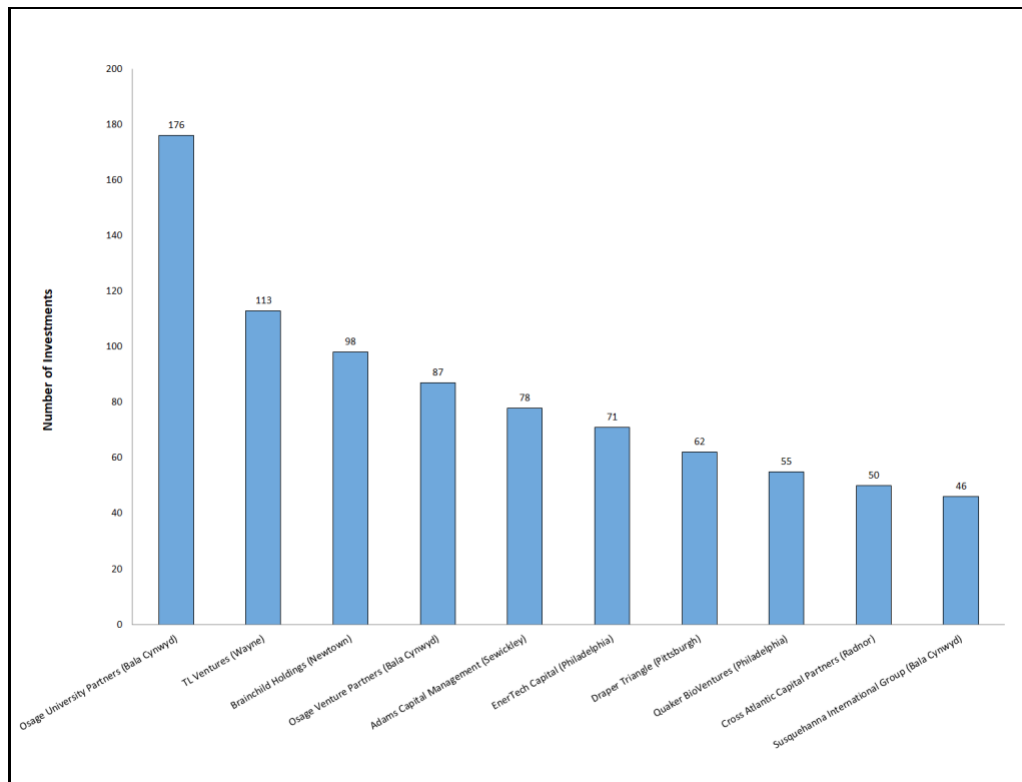
Note: Some of the firms in Crunchbase's dataset have since closed.

As of March 2021, PA ranks seventh among all states by number of venture capital firms, with 175 firms. While California and New York are famed for their finance clusters, even a state like Illinois which has a comparable population to Pennsylvania has many more firms, meaning there is progress to be made. These disparities in VC density are very likely to be a cause of the outflow of businesses from PA.⁹

The graph below shows the top 10 VC firms in PA by number of investments. The top-ranking VC firm is Osage University Partners, which has made 176 investments in total.

⁹ For a separate but concurrent project conducted through the Carnegie Mellon Block Center for Technology and Society, one of the authors conducted interviews with alumni entrepreneurs from Carnegie Mellon University, many of whom keep a research office for their company in Pittsburgh but have leadership and sales based out of the Bay Area for this reason. Several of these founders said that the bulk of their planned employment growth would occur outside of Pittsburgh.

Fig. 20 Pennsylvania Venture Capital Firms – Top Ten Firms by Number of Investments (as of March 2021)



Source: Crunchbase^{xxxix,10}

Note: These ten firms are still active, to the writers' discernment.

Eight of these firms are located in the Philadelphia area; two are located in the Pittsburgh area. Of the full list of VC firms in the state, just a handful are located outside of these two metros, including 1855 Capital, based in State College, and Factory LLC, based in Bethlehem. Future analyses might look into which of these firms prioritize investing in Pennsylvania-based companies.

Initial Public Offerings (IPOs)

Access to capital is important for innovative businesses at each stage of their growth cycle, including when they are ready to scale up widely. By going public through IPO, companies get faster access to capital, expanded publicity, and the ability to attract better employees by offering equity participation. In 2020, several big IPOs launched in Pennsylvania, three of which are listed here:

- **Vertex** - Business and income tax software services
- **Shift4 Payments** - Payment processing solutions for the food & beverage industry
- **Bentley Systems** - Software and consulting services for the construction and infrastructure sectors

¹⁰ Note: As this data is automatically aggregated from Crunchbase, it may have errors.

Measuring the total number of IPOs in the state on an annual basis would show how many companies here are achieving high growth, at least as measured by financing, though to the writers' knowledge this information is not formally collected by the government.

Ben Franklin Technology Partners Companies that have IPO'd

Since Ben Franklin Technology Partners was founded in 1983, at least 19 companies have gone public, which are listed below along with their industry and the year of IPO.^{11,12} When BFTP invests in early-stage companies that eventually go public, they make a large return that goes back to state coffers and can be reinvested in other PA companies.

Innovation Works

- II-VI Corporation - Optical electronics (1987)
- ANSYS - Engineering software (1996)
- FORE Systems - Computer networking (1994)
- FreeMarkets - Online auctions for businesses (1999)
- Medrad - Medical devices (1992)

BFTP Central/North

- NOVA Measuring Instruments - Semiconductor equipment (2000)
- Turtle Beach - Audio equipment (Year Unknown)

BFTP Northeast

- Orasure - Medical Diagnostics (2000)
- IQE - Semiconductor equipment (1999)

BFTP Southeast

- Onconova - Biopharmaceutical (2013)
- Relmada Therapeutics - Biotechnology (Year Unknown)
- Accolade - Healthcare (2020)
- Annovis Bio - Pharmaceutical (2020)
- Bionano Genomics - Medical Devices and diagnostics (2021)
- NuPathe - Pharmaceutical (2010)
- CDNow - Dot-com (1998)
- Cephalon - Biopharmaceutical (2007)
- Centocor - Biotechnology (1982)
- Immunicon - Biotechnology (2004)

SBA Small Business Investment Companies (SBIC) Funding

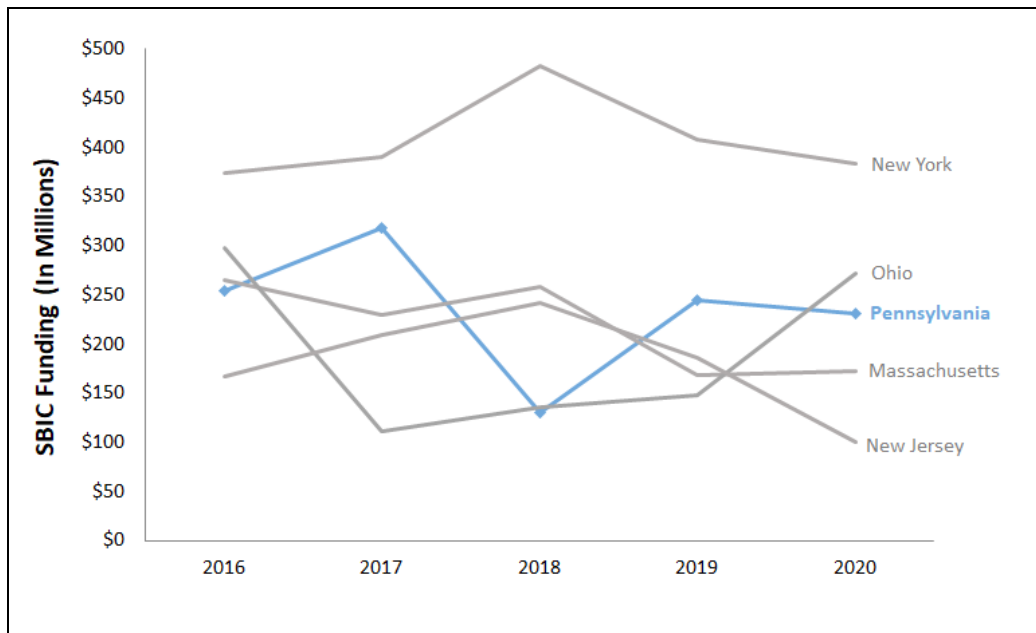
The Federal government also distributes funds to be used as investments. The Small Business Administration's (SBA) runs the Small Business Investment Companies (SBIC) program, which gives licenses and issues debt to venture capitalists and private equity funds to invest in small businesses. Apple, Intel, and FedEx all received SBIC investments in their early years.^{xc}

Sixteen of the country's 302 licensed SBIC funds are located in Pennsylvania. Only one of these sixteen—Tecum Capital—is located outside the Philadelphia area, though West Virginia's Mountain State Capital maintains an office in Pittsburgh and invests in many Pittsburgh-based startups. In 2020, \$231 million in SBIC financing was distributed to 53 Pennsylvania small businesses.

¹¹ This data is not formally collected but was sourced through communication with BFTP's regional leaders.

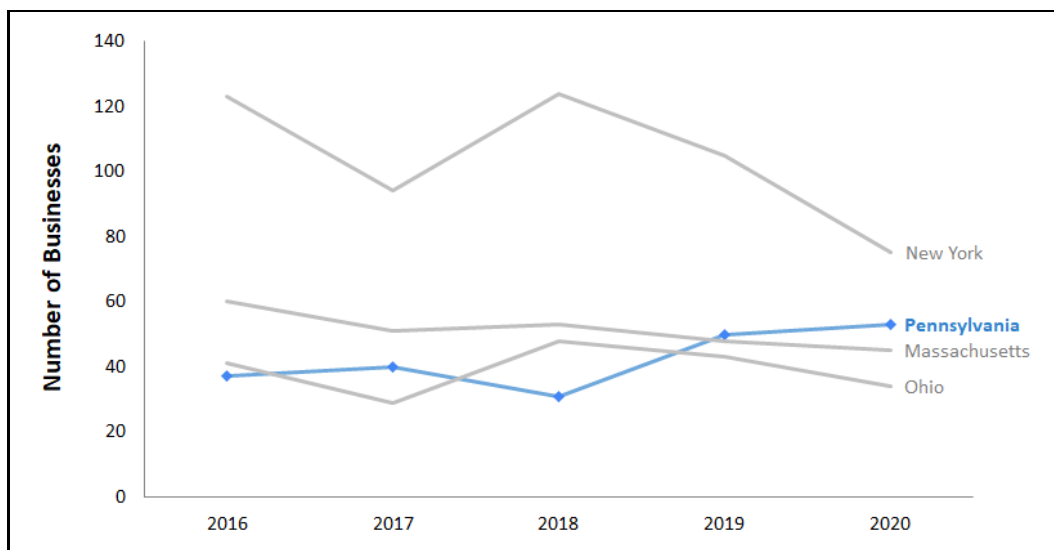
¹² Some of these companies were since acquired by other firms after their IPO.

Fig. 21 Amount of SBIC Funding (2016-2020)



Source: U.S. Small Business Administration^{xci}

Fig. 22 Number of Businesses Receiving SBIC Funds (2016-2020)



Source: U.S. Small Business Administration^{xcii}

Pennsylvania's Risk Capital Strengths and Weaknesses

Strengths:

- Venture capital dollars to Pennsylvania companies more than quadrupled between 2011 and 2019.
- Pennsylvania fares well compared to other states on the number of businesses receiving SBIC funding.
- Most IPO's in the Philadelphia region are in biotechnology and pharmaceuticals.

Weaknesses:

- Pennsylvania is losing ground to the U.S. as a whole on the total number of venture capital dollars to companies, even adjusting for size of GDP.
- Pennsylvania trails peer states on total number of VC firms located here.
- Very few of PA's VC firms are located outside of Philadelphia and Pittsburgh.

Developing and Maintaining a Talented Workforce

5. Education & Workforce Development

Education and the Innovation Economy

Education, like innovation, “is a cumulative process,” which means investing in basic skills provides opportunities for students to access “higher-level knowledge.”^{xciii} Education prepares individuals for rigorous post-secondary opportunities, fosters the skills needed for the workforce, and allows people to gain self-knowledge and become good citizens.^{xciv} High-quality K-12 schools also attract outside workers with school-age children or plans for them. Thus investments in education are a necessary complement to investments in business development so individuals have the tools to grow and staff organizations.

Supporting “Schools that Teach” is one of the Wolf Administration’s primary goals for Pennsylvania. This includes ensuring that graduates from Pennsylvania’s high schools are career ready as well as improving access, affordability, and completion of post-secondary education and training.^{xcv} Education spending is fundamental to this, and in 2018, Pennsylvania ranked #8 for per-pupil spending on pre-K-12 education.^{xcvi}

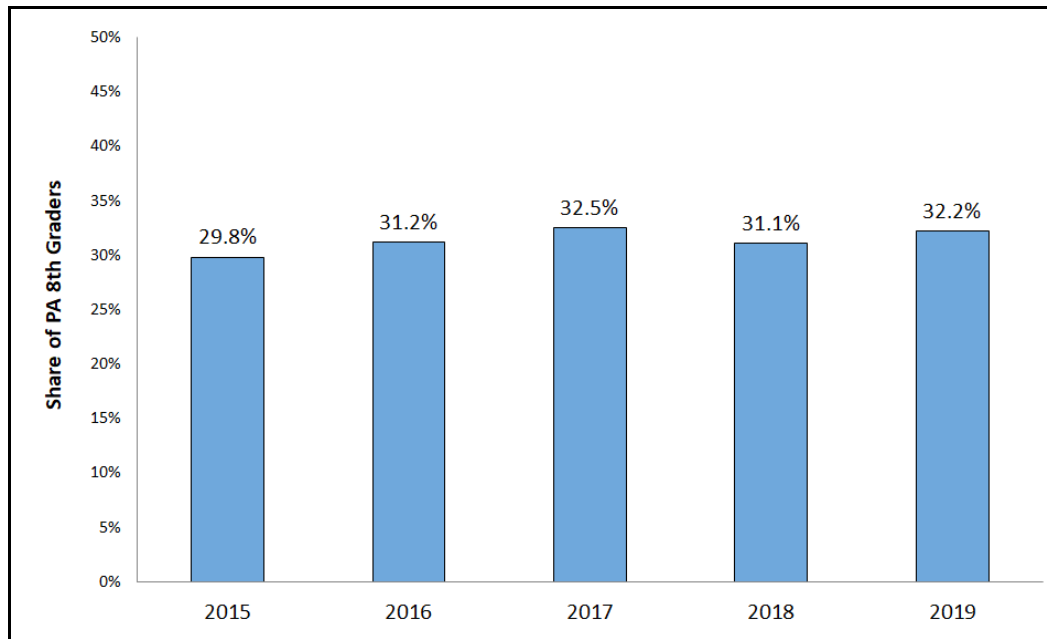
Every one of the state’s 1.7 million public school students were affected by the COVID-19 pandemic in the 2020-2021 school year. School districts are grappling with students’ academic regression and lack of wi-fi, budget strains largely attributable to cyber charter school tuition payments, and reduced staffing levels. These issues are captured in the Pennsylvania School Board Association’s 2021 State of Education report.^{xcvii}

K-12 Measures

Eighth Grade Math Scores

While comprehensive assessment of student and school progress is necessary, test results are one way to measure the value of investments in K-12 education. Proficient scores open doors to more advanced classes and a college preparatory high school curriculum, and are correlated with higher college enrollment and graduation rates.^{xcviii, xcix} This also means that investment in K-12 education is an opportunity to identify and respond to inequities in education at an early level so that the state’s college graduates, talented workers, and entrepreneurs include everyone regardless of race, class, gender, or geography.

Fig. 23 Share of 8th Grade Students in PA Scoring at or above “Proficient” on Statewide Math Tests (2015-2019)



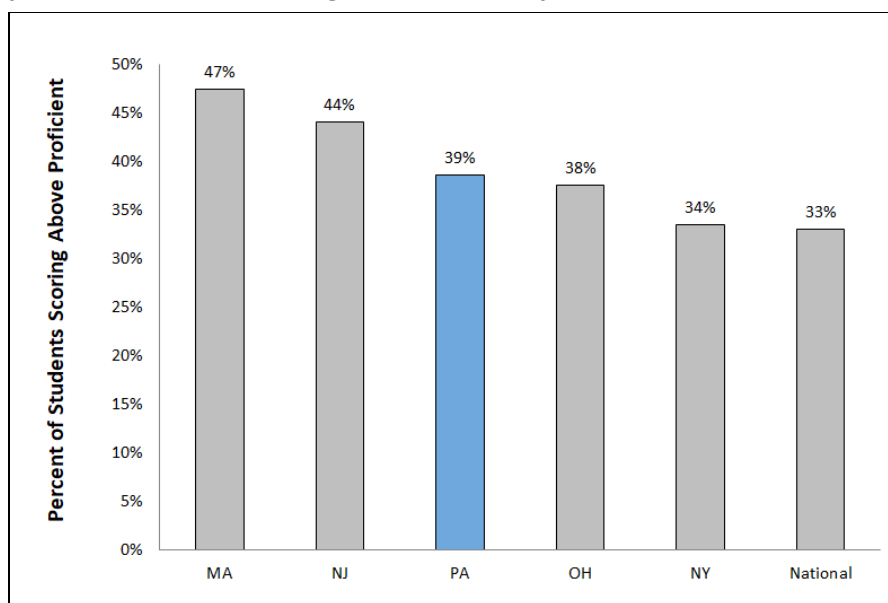
Source: PSSA Results, PA Department of Education^c

Pennsylvania’s performance on eighth grade statewide math tests has remained fairly stable since 2017, with about a third of students receiving scores qualifying as “proficient” or “advanced”. This data captures statewide numbers; the Future Ready PA Index breaks performance down by school and district, allowing resources to be focused where they can make the biggest impact.¹³

While test scores are a useful measurement of school performance, they are difficult to compare across different states. The National Assessment of Educational Progress (NAEP) responds to this issue by creating a standardized assessment for performance across states.

¹³ Pennsylvania uses the Future Ready PA Index to track school progress. It was designed to help schools promote multiple pathways to career success by measuring not just test scores but academic growth measures, attendance, and four-year graduation rates.

Fig. 24 Share of 8th Grade Students Scoring at or above “Proficient” based on National Standards (2019)



Source: National Assessment of Educational Progress (NAEP) State Profiles^{ci,14}

In 2019, Pennsylvania beat the national average, but came in behind peer states Massachusetts and New Jersey. The prior year, these states spent \$663 and \$3,626 more per student, respectively, than Pennsylvania did.^{cii}

Postsecondary Measures

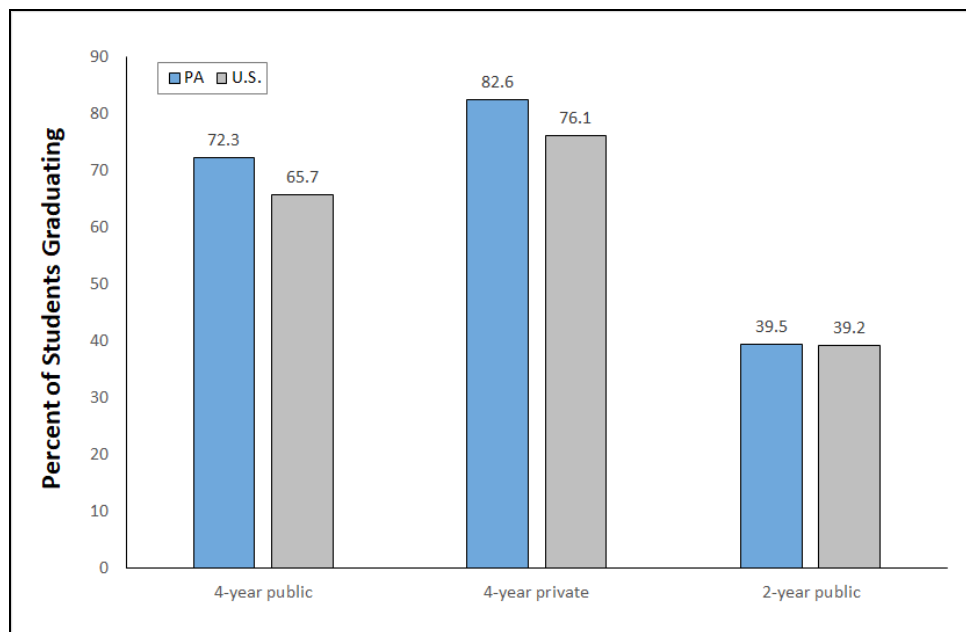
Six Year Degree Completion Rate (Broken Down by Race/SES)

Increasing the number of Pennsylvanians who earn a bachelor’s degree will improve outcomes for individuals and the communities they live in. Median lifetime earnings for individuals with a bachelor’s degree are twice that of individuals with a high school diploma.^{ciii} With greater earnings, college and advanced degree graduates spend more, which supports local economies.^{civ} Additionally, post-secondary education is a path to developing Pennsylvania’s workforce, which is necessary to provide the talent that businesses need to grow and further create jobs.

The six year degree completion rate refers to the percent of students who receive a bachelor’s degree within six years or less from the time they entered college. In a National Student Clearinghouse study of students who entered public universities in Pennsylvania in 2012, 72.6% students^{cv} graduated within six years. This was above the national rate of 65.5%.^{cvi} This data is shown in the graph below.

¹⁴ Note: The NAEP’s designation of proficient or above is different from a state level designation of proficient or above.

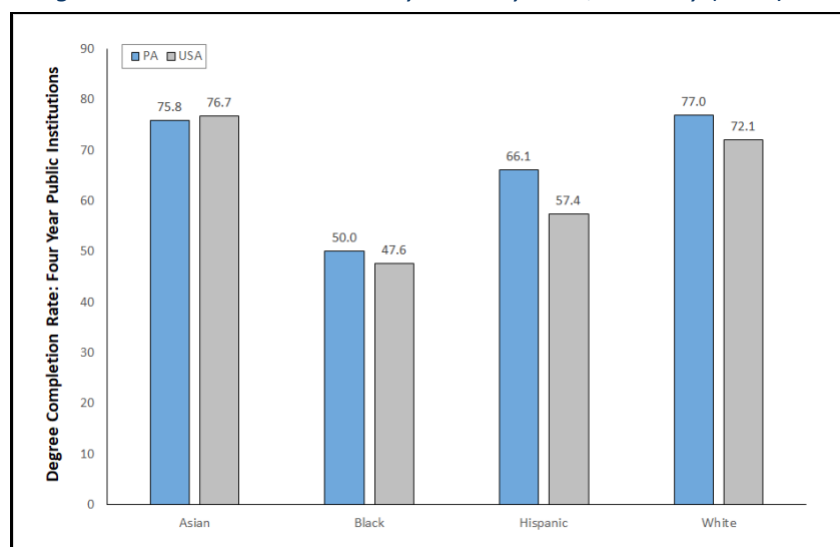
Fig. 25 Six Year College Graduation Rates, Pennsylvania vs. U.S. Average (2019)



Source: National Student Clearinghouse Research Center^{cvi}

Because of the positive impact education has on financial stability, increased education can also influence quality of life. While Pennsylvania's completion rates at two- and four-year institutions are above the national average, the report notes **there is a significant racial gap in completion rates**. This means it is imperative to examine the inequalities (racial, geographic) in post-secondary education completion in Pennsylvania in order to prepare all Pennsylvania's and foster an innovation economy that benefits from representation of the entire population.

Fig. 26 Six Year College Graduation Rates in Pennsylvania by Race/Ethnicity (2019)



Source: National Student Clearinghouse Research Center^{cvi}

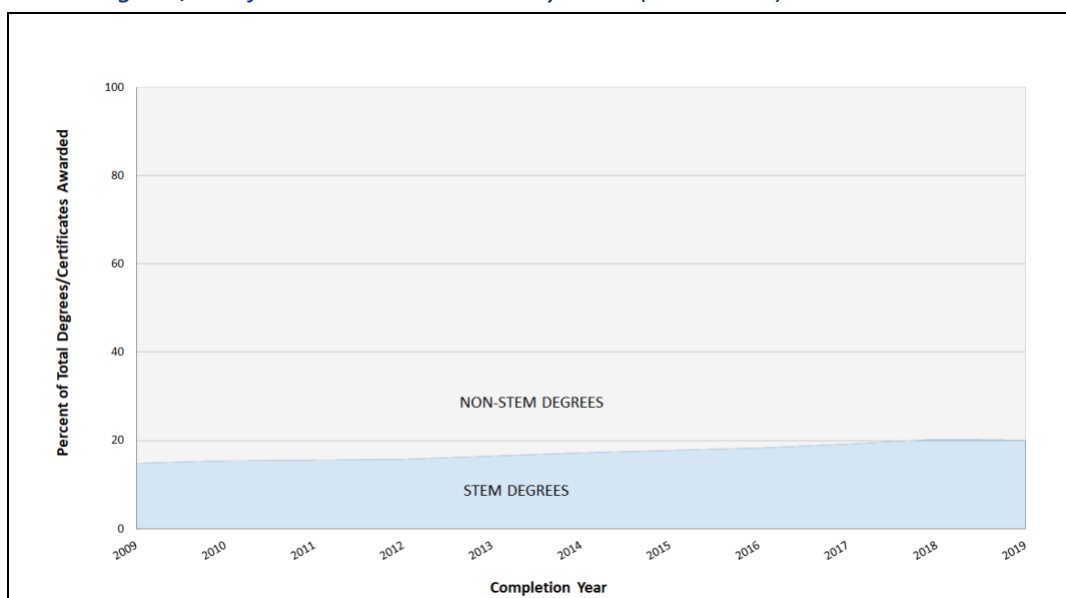
While outcomes for Black, Hispanic, and white students are slightly higher in Pennsylvania than nationally, the gap between the share of white students who complete a four-year degree at a public

university in six years and Black students who do so is nearly 27 percentage points. Hispanic and Asian students also trail on this measure, showing the need to better prepare these students for college and support them while they are in college.

Degrees Awarded in STEM Fields

Societal progress relies on a diversity of skills, but STEM education is especially important because “technology-enabled innovation is the major spur to productivity” and productivity drives economic growth.^{cix} But anecdotal conversations with business and government leadership in PA indicated many STEM-oriented job positions remain unfilled because companies cannot find workers with the desired qualifications.^{cx} Tracking the number of STEM degrees awarded each year helps measure supply for hard-to-fill jobs, which will keep research-based businesses in the state. A higher share of STEM graduates will also improve Pennsylvania’s public and private entities’ ability to attract federal grants and other research funding.”^{cxii}

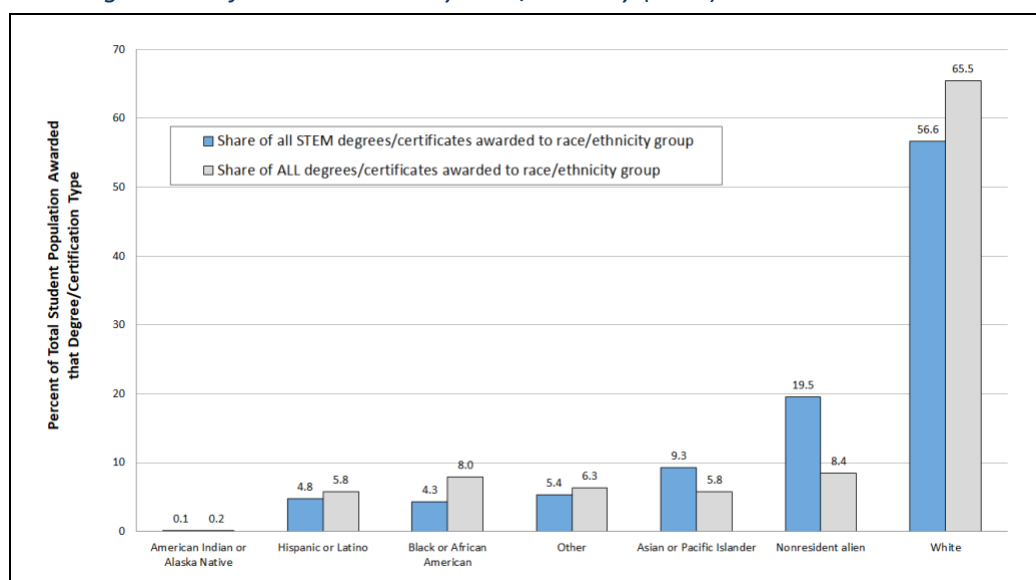
Fig. 27 STEM Degrees/Certificates Awarded in Pennsylvania (2009-2019)



Source: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS)^{cxii, 15}

¹⁵ Note: Degrees include Associates, Bachelors, Masters and PhDs.

Fig. 28 STEM Degrees Certificates Awarded by Race/Ethnicity (2019)



Source: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS)^{cxiii, 16}

In Pennsylvania, the share of all degrees awarded that are in STEM fields has increased slightly from 15% in 2009 to 20% in 2019. However, this share has grown at a similar rate in many other states, meaning Pennsylvania is “about average” on this measure.^{cxiv}

For all racial/ethnic groups, with the exception of Asian or Pacific Islander, there are gaps between the share of all STEM degrees awarded to them compared to the share of all degrees awarded to them. From an equity perspective, this statistic is particularly dire when considering the gap between white and minority students completing any degree. If Pennsylvania’s innovation economy is to serve diverse stakeholders, first all students must have the supports to achieve academic success. International students share a disproportionate amount of STEM degrees awarded.

Simply earning a STEM degree in Pennsylvania does not mean a graduate will remain in the state. For example, Pittsburgh-based universities award a large share of STEM degrees in the state, yet as of 2016, Pittsburgh is one of the worst-performing cities when it comes to retaining college graduates.^{cxv} One way to solve this is to open doors for international students to stay in in the state, as they make up a disproportionate share of STEM degree recipients.

The number of STEM degree recipients who choose to live in Pennsylvania after graduation would be a more insightful measure of the innovation economy, however, at the time of writing simply the number of degrees conferred is the more publicly available statistic.

Cost of Postsecondary Credentials in Pennsylvania

Rising costs and insufficient financial aid are significant barriers for many individuals who wish to pursue a postsecondary credential.^{cxvi} Those who take on debt to complete a degree are more constrained

¹⁶ Note: Degrees include Associates, Bachelors, Masters and PhDs.

regarding the career opportunities they can pursue, and their appetites for entrepreneurialism are reduced.^{cxvii}

According to a recent report from the Center on Budget and Policy Priorities, Pennsylvania ranks 45th in the nation for per-student spending on higher education.^{cxviii} Since 2008, the state government's spending on higher education has decreased by over 33%. PA's public schools have turned to students to fill this funding gap, raising tuition about 20% since 2008.^{cxix} By 2018, PA's net price at a 4-year public institution was 34% of the median income of all Pennsylvania families, which put the state second to last in the country. For Black families, the figure was 56% and for Hispanic families, 48%. And on a nationwide level, Black graduates hold almost twice the amount of debt as their white counterparts four years after graduation.^{cxx}

The Federal Pell Grant program has long been “the cornerstone” of higher education financial aid for low-and-moderate income families. However, the spending power of Pell Grants now cover a shrinking amount of college costs, currently just 29%.^{cxxi} Additionally, Pennsylvania has seen a decrease in the amount of aid awarded, primarily due to a decrease in aid applications being submitted.^{cxxii} For the 2019-2020 school year PA students received \$845.7 million in federal aid, compared to \$873 million during the 2018-2019 school year.^{cxxiii} This demonstrates the need for additional funding sources at the state and local level. In Pennsylvania, almost 80% of State System students receive some form of financial aid, which includes grants/scholarships, loans, and work-study jobs.^{cxxiv}

Fostering Supports to Upskill Workers

Including everyone in the innovation economy does not mean that every Pennsylvanian needs to pursue a higher degree in a STEM field. A truly robust innovation economy will be able to meet people where they are and help them secure good jobs — those that pay at least middle-class wages and provide health benefits. A 2018 Brookings study identified which industries provide a disproportionate share of these good jobs for sub-baccalaureate workers, in which maintenance, construction, production, and transportation stood out.^{cxxv} In 2016, over a third of computer network architects and support specialists did not have a bachelor's degree, and these jobs were common in midwestern metros that are not classic tech hubs.^{cxxvi}

Growing this part of the workforce will require workforce development training and other, less direct support such as increased access to child care and public transportation — which are discussed later in this report.

Tracking Outcomes for Workforce Training Programs

Workforce training programs connect un- or under-employed individuals with job opportunities and help fill critical labor gaps. Providing these worker-job connections is especially critical during the COVID and post-COVID era in which many Pennsylvanians find themselves out of work due to business closures and other pandemic-related policies. The Department of Community and Economic Development (DCED) and the Department of Labor and Industry (L&I) currently track the number of State-sponsored and industry-sponsored training sessions provided.^{cxxvii,cxxviii} However they do not comprehensively measure the quality of these programs, which could be done by tracking participants' employment outcomes and their reported experiences of the program itself. This would help clarify whether Pennsylvania's efforts to train the workforce are efficient and effective.

A separate team of graduate students from Carnegie Mellon University's Heinz College recently conducted a capstone project tracking the outcomes of Pennsylvanians who participated in the Manchester Bidwell Training Center programs. Using social services data from the Allegheny Department of Human Services (DHS) and quarterly earnings and unemployment insurance from the Department of Labor and Industry, the team found that graduates of the program earn at least \$12,000 more per year on average compared to DHS Self-Sufficiency Program participants. The analysis was performed using Propensity Score Matching, regression models, and Hazard models.^{cxxix} The project is a strong example of how the state could design methods for tracking and measuring the success of state-led and sponsored workforce development programs.

Pennsylvania's Education Strengths & Weaknesses

Strengths:

- PA has a high ranking among all states on investments in K-12 education.
- Students' math proficiency scores are above the national average.
- College completion rates are above the national average.
- There is a robust network of public and private universities in-state.

Weaknesses:

- There are significant gaps in college completion outcomes for students based on race, ethnicity, class, and geography.
- Pennsylvania spending per-student for higher education is low compared to high innovation states.
- There is a decreasing number of financial aid applications completed annually.
- Pennsylvania's share of STEM degrees for all degrees awarded is about average, while strong innovation states are increasing the number of students graduating with STEM degrees.

6. Workforce Attraction & Retention

The Workforce and the Innovation Economy

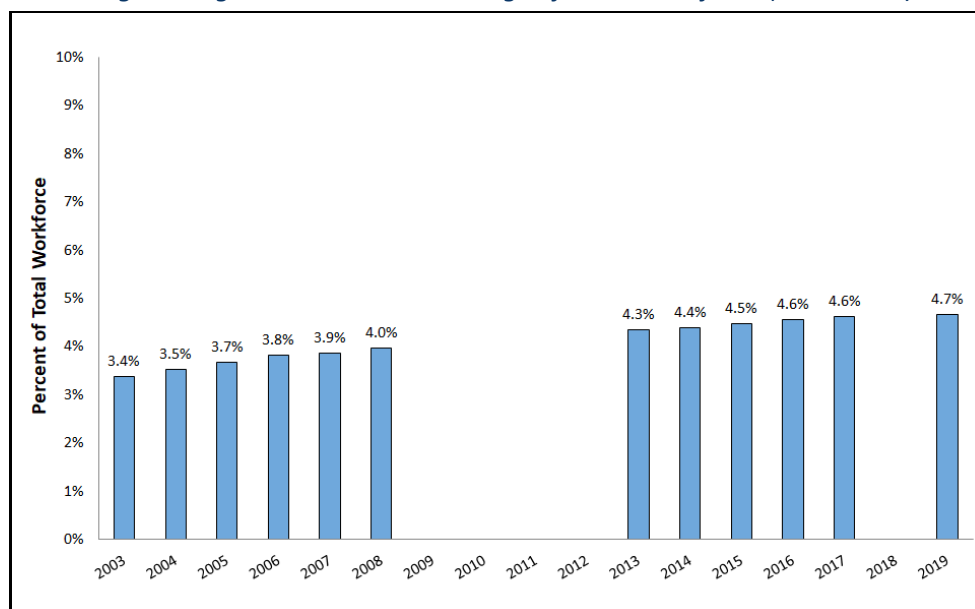
Pennsylvania's labor force participation rate never recovered to its pre-2008 recession level of 65.3%, reaching 63.5% in early 2020, just before the COVID-19 pandemic hit.^{cxxx} Yet an active and skilled workforce is needed to support the state's aging population, which grew at a rate over 20 times the total state population between 2010 and 2017.^{cxxxi} These issues can be addressed by ensuring that young people see a future in Pennsylvania, one where they can purchase homes, start families, seek out interesting opportunities, and stay connected to the world. This must entail an openness to cultural diversity: consider that 48% of Generation Z Americans (born 1997-2002) are non-white, and 15.9% identify as LGBT.^{cxxxii, cxxxiii}

The Importance of High-Skilled Workers

As the global knowledge-based economy grows more interconnected, Pennsylvania's future success is directly tied to its ability to foster a workforce with strong skills in science, technology, engineering, and math. According to the National Science Board, science and engineering (S&E) workers contribute to innovative growth "because of their high skill level, their creative ideas, and their ability not only to advance basic scientific knowledge but also to transform advances in fundamental knowledge into tangible and useful products and services."^{cxxxiv} Thus, the percent of total workforce made up by S&E workers can help the state gauge how well its workforce is adapting and contributing to a growing innovation economy.

According to Bureau of Labor Statistics data processed by the National Science Foundation, the share of S&E workers in Pennsylvania's total workforce has slightly increased from 3.4% in 2003 to 4.7% in 2019, placing it in the second quartile of U.S. states on this metric in 2019. States in the first quartile have workforces made up of 5.2%-10.7% S&E workers; Maryland, Washington, Virginia, and Colorado lead on this metric.^{cxxxv}

Fig. 29 Science & Engineering Workers as a Percentage of Total Workforce (2003-2019)

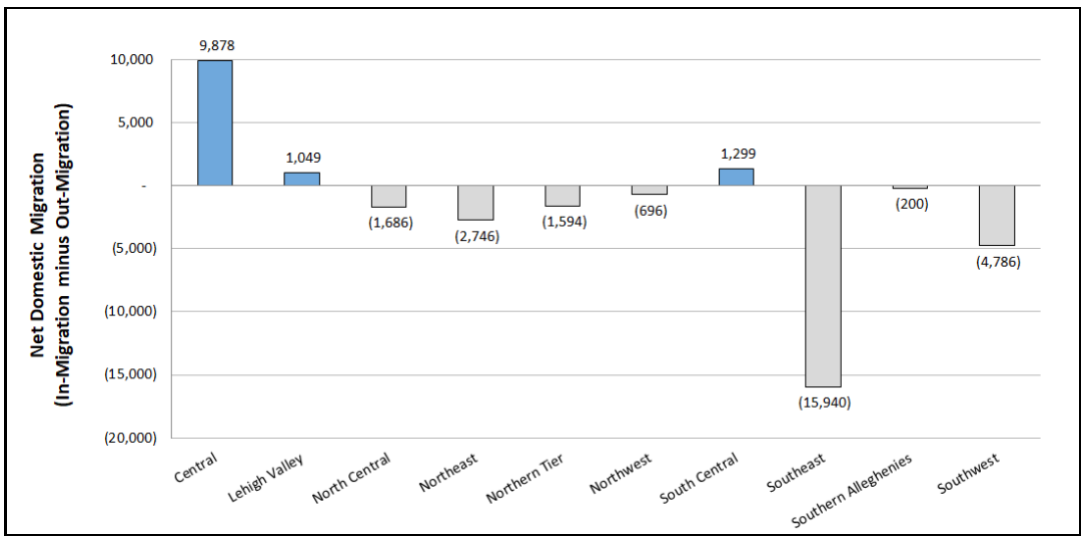


Retaining and Attracting Talent

In addition to educating and upskilling workers, Pennsylvania needs new strategies to retain our college students and attract outside talent into the state. Attracting new working-age adults to a region enables growing companies to stay, and attracts outside companies to set up shop in state. Outsiders bring new skills and ideas, help connect the region to the national and global economy, and may drive up local wages.^{cxvii} A high level of in-migration also indicates a region’s attractiveness regarding amenities, school quality, social and environmental safety, and a variety of high-quality jobs.

The following graph shows the number of working-age newcomers to each PREP Region (originating from other PREP Regions or outside the state) minus the number of leavers (to other PREP Regions or states). In 2019, only three PREP regions saw a positive net migration of working age adults. This highlights the need to build more opportunities for young people while they still live in these areas as high schoolers or college students. This could be done through internships and apprenticeships with local employers, or mentorship programs to better integrate them with the local community.

Fig. 30 Net Domestic Migration of Working Age Adults (18-65) (2019)

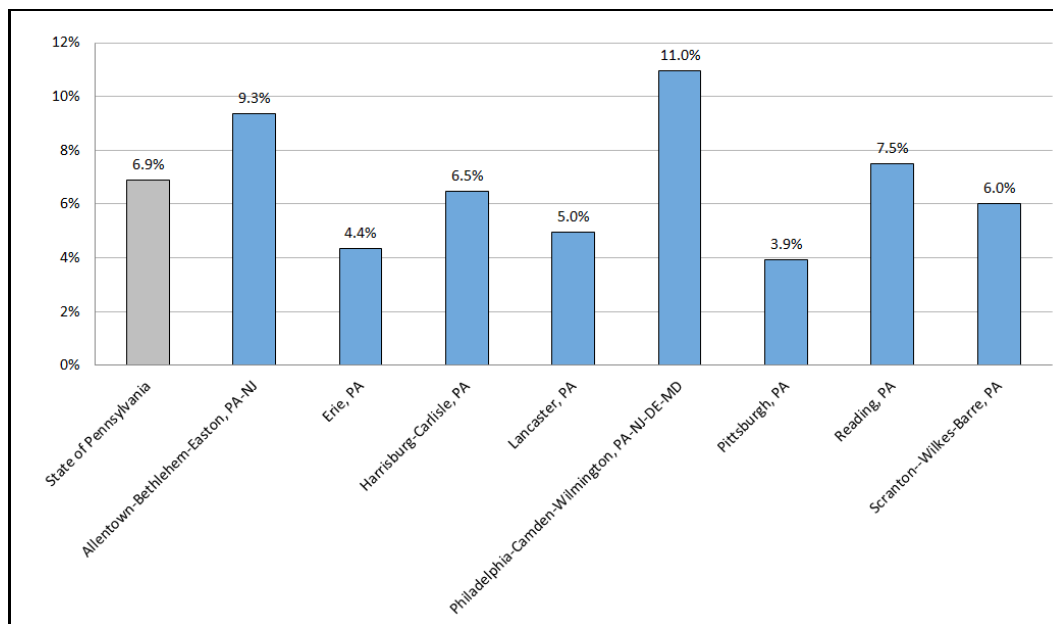


Source: U.S. Census 2019 5-Year ACS^{cxviii} ^{cxix}

Retaining and Attracting Foreign Born Talent

Foreign born Pennsylvanians, over half of whom are naturalized citizens, play a key role in growing the economy. They make up 7% of the state’s population, but 10% of the entrepreneurs. Forty-one percent of them have a bachelor’s or advanced degree compared to 31% of native-born Pennsylvanians, and they are over-represented as workers and founders in science and technology industries.^{cxl} The top countries of origin for Pennsylvania’s foreign-born residents are India, Dominican Republic, China, Mexico, and Vietnam.^{cxli} Many of these immigrants were educated in Pennsylvania’s enviable universities, and employers play a crucial role in providing them visas so that they can stay here and contribute to the economy.

Fig. 31 Share of Population that is Foreign Born by Metro Area (2019)



Source: U.S. Census 2019 5-Year ACS^{cxlii}

Philadelphia, Allentown, and Reading are the PA metros with the highest share of immigrants among their population. The state's overall foreign-born population (7% of the total population) compares to competitor states as follows: 4.6% in Ohio, 22.4% in New Jersey, and 13.6% across the entire United States.^{cxliii}

Case Study: The Welcoming Pittsburgh Roadmap

Mayor Bill Peduto's Welcoming Pittsburgh Roadmap is an initiative started in 2014. After conducting outreach to both immigrants and U.S.-born Pittsburghers, it led to 37 community-led recommendations to make immigrants feel more included in the community and economy—one built by immigrants, including industrialist Andrew Carnegie. The effort led to a new online directory of international businesses, expanded language access to public services, and partnerships with the Pittsburgh Financial Empowerment Center and the University of Pittsburgh Institute for Entrepreneurial Excellence. Crucially, the Roadmap's progress was trackable and publicly available.^{cxliv}

Attracting Remote Talent

The post-pandemic growth in remote work represents one of the biggest new economic opportunities for small cities. Because remote workers can work anywhere, regardless of employer's location, they represent a huge new pool of potential talent—one that earns above-average wages and that generates less traffic and emissions than commuters. About 16 million people in the U.S. moved during the first six months of the pandemic, an increase of 600,000 over the same timeframe in 2019.^{cxlv} The gig worker platform Upwork claims between 14 to 23 million Americans are considering moving as a result of the new remote work opportunity.^{cxlvi}

In 2018, the cities (population over 50,000) that numbered in the top fifteen nationwide by at-home workforce as a share of total workforce or in the top fifteen by growth in at-home workforce as a share of total workforce (2013-2018) were far and away in the southern and western United States. Most of these cities are known for their natural beauty (Bend, OR, Asheville, NC, St. George, UT) and/or have access to a large metro (Winchester, VA, Prescott, AZ, Mount Vernon, WA).^{cxlvii}

Following these principles, eastern Pennsylvania's proximity to both coastal metropolises and to stunning natural areas is a huge asset. In fact, before the pandemic, Allentown stood out as the only U.S. city where high-income workers had, on average, longer commutes than low-income workers, because of its access to these global hubs.^{cxlviii} The top PA metro by at-home workforce as a share of total workforce was East Stroudsburg, and the top PA metro by growth in at-home workforce was Scranton-Wilkes Barre-Hazleton.^{cxlix} Both are near the Poconos and are between 90 minutes and two hours away from New York City and Philadelphia.

Many municipalities and states are offering incentive programs to attract or retain talented workers. The following offers a small sampling of these incentives, which must be strategically designed for high return on investment.

Sampling of Other State Workforce Incentives

- **Fellowships for top in-state graduates**
 - Connecticut Governor's Innovation Fellowship^{cl}
 - Year started: 2020
 - Description: \$5,000 Fellowship prize and work in a STEM or tech-related job at a top-performing company in Stamford. Gain access to mentorship and a cohort of other fellows.
 - Eligibility: Only graduates of CT high schools or colleges are eligible.
- **Student loan forgiveness based on occupation**
 - Utah's Talent Development Incentive Loan Program^{cli}
 - Year started: 2019
 - Description: Every other year, the Governor's Office of Economic Development selects five college degrees to be those eligible for this program, based on their preparation for high-demand occupations.
 - Eligibility: Students must work at a qualifying job in Utah and work there for the same number of years as they received the loan.
- **Home Buying Assistance for in-state graduates**
 - New York's Graduate-to-Homeownership Program^{clii}
 - Year started: 2017
 - Description: Program provides a subsidized low-interest mortgage, down payment assistance loan worth the greater of 3% of home price or \$3,000; loan total can be up to \$15,000.
 - Eligibility: Homes must be located in one of the eight upstate college towns.

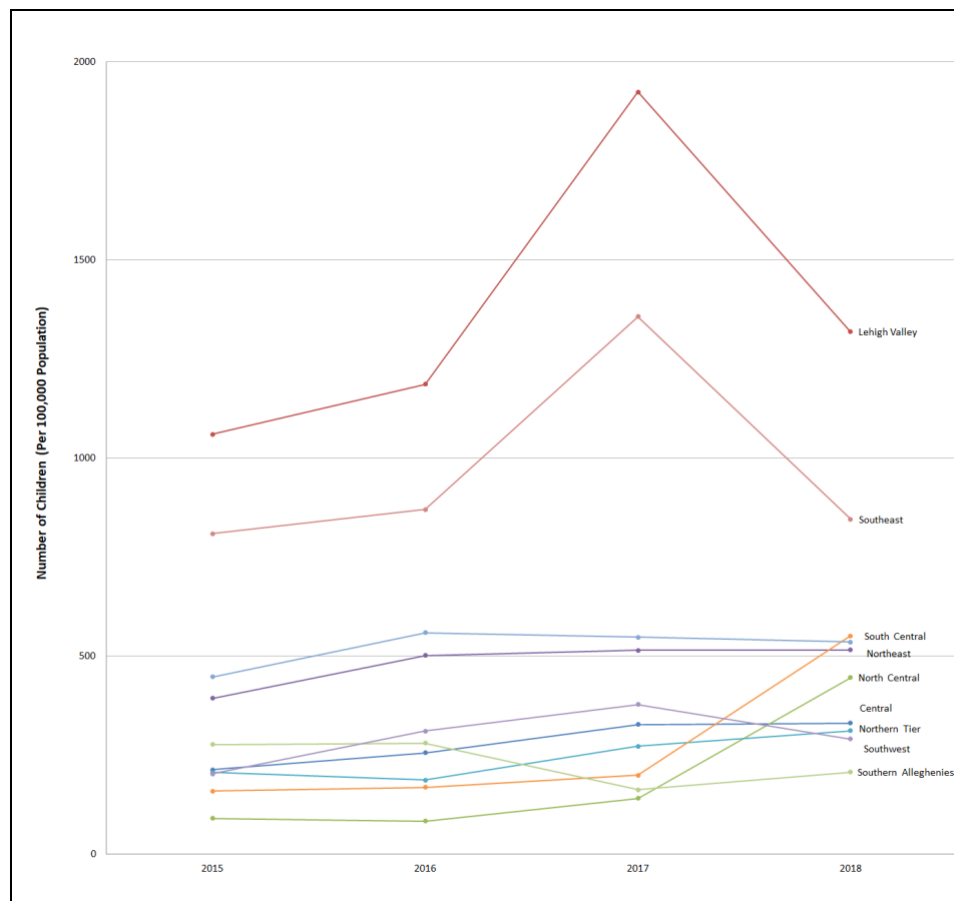
Child Care Access

Finally, the state must prioritize child care access if it hopes to grow and attract a strong workforce that supports an innovation economy. Child care access impacts today's economy by freeing parents to pursue education or work opportunities, and tomorrow's economy by placing children in a setting that promotes healthy development and school readiness.^{cliii} Research has shown that increased child care access reduces barriers to entering the workforce and supports both state and local economic growth.^{cliv}

Unsurprisingly, lack of access to quality, licensed child care has a disproportionate impact on women and low-income parents. Women are more likely to take on unpaid caregiving responsibilities than men, and low-income families overburdened by childcare often struggle to participate in the workforce training programs that help connect them to the innovation economy.^{clv,clvi}

The figure below shows the number of children (per 100,000 population) on the Child Care Works Program waitlist. Managed by county-level Early Learning Resource Centers, the program helps low-income families pay their child care fees.^{clvii} No PREP region reduced the number of children on the waiting list size since 2015, and the South and North Central regions both saw the number of children on their waitlists rise from 2017 to 2018. A total of 78,515 children were on the waitlist in 2018.

Fig. 32 Number of Children on the Child Care Works Program Waitlist (2015-2018)



Source: Pennsylvania DHS, Office of Child Development and Early Learning, Child Care Works Program^{clviii}

Childcare quality is as much of a concern as childcare quantity within Pennsylvania. Low wages for childcare providers negatively impact both turnover rates, and therefore the quality of care at centers throughout the state. In February of 2021, Governor Wolf announced an increase in the base pay of all providers participating in the Child Care Works program.^{clix} The base pay increase is a step in the right direction when it comes to increasing equitable access to quality child care and, ultimately, the innovation economy.

The First Annual Report (2020) from the Keystone Economic Development and Workforce Command Center details barriers preventing some workers from accessing jobs, including education and child care.^{clx}

Pennsylvania's Workforce Strengths and Weaknesses

Strengths

- The number of science and education workers in the state is rising slightly, though not enough to meet demand.
- Pennsylvania's immigrants are helping sustain new business creation in the state.
- Eastern Pennsylvania is located near east coast metro areas from which it can attract new remote workers.

Weaknesses

- Not all parents in the state who need child care have access to it, which impacts their ability to work to their full potential.
- Pennsylvania could retain more of the skilled graduates coming out of its universities, especially to level out working-age population declines in some regions.
- Pennsylvania's rate of science and engineering workers among all workers is middling compared to all other states.

Connecting Pennsylvania's Workers with Employment Opportunities

7. Transportation & Broadband Infrastructure

Transportation and the Innovation Economy

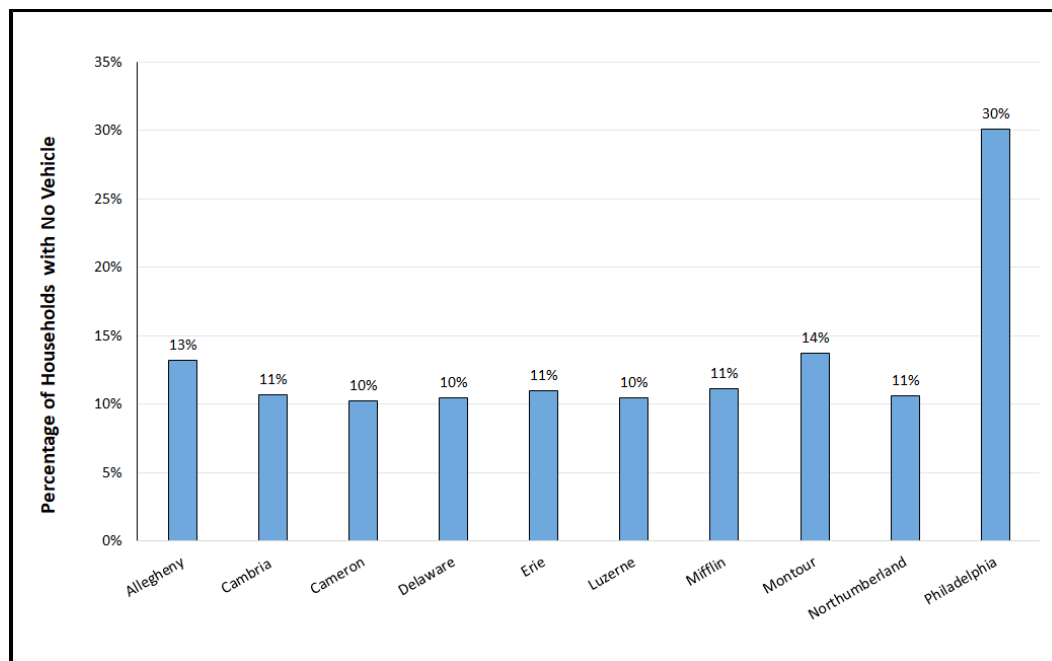
Transportation is foundational to equitable economic development, connecting workers to jobs, enabling businesses to reach more customers, and improving quality of life for all income groups. While the knowledge economy traditionally benefits the urban core of cities like Pittsburgh and Philadelphia, it can have harmful effects on communities that lack these means to optimally contribute to and benefit from it. This is a top concern for suburban and rural communities throughout Pennsylvania, many of which were built around manufacturing hubs that have since shuttered.

The Need to Connect Workers to Jobs

With companies in the growing service industries almost exclusively locating in cities,^{clxi} there is an increasing spatial mismatch between workers and jobs. And even as the COVID-19 pandemic has spurred an acceptance of remote work, only about 40% of all jobs can be done remotely, with lower rates among jobs that require less education.^{clxii, clxiii, clxiv} In other words, living near work matters most to less educated workers, who earn on average less money, yet (at the countrywide level) poverty is growing fastest in suburban counties which are far from central job hubs.^{clxv}

With over half a million carless households in Pennsylvania (11% of all households), transit or other transportation solutions are crucial to help people both find jobs (e.g., attend in-person interviews) and keep their jobs.^{clxvi} This is needed in rural counties just as much as in urban counties, as shown in the following graph. A map showing what transit service options are available in each county can be found on the Pennsylvania Department of Transportation's website.^{clxvii}

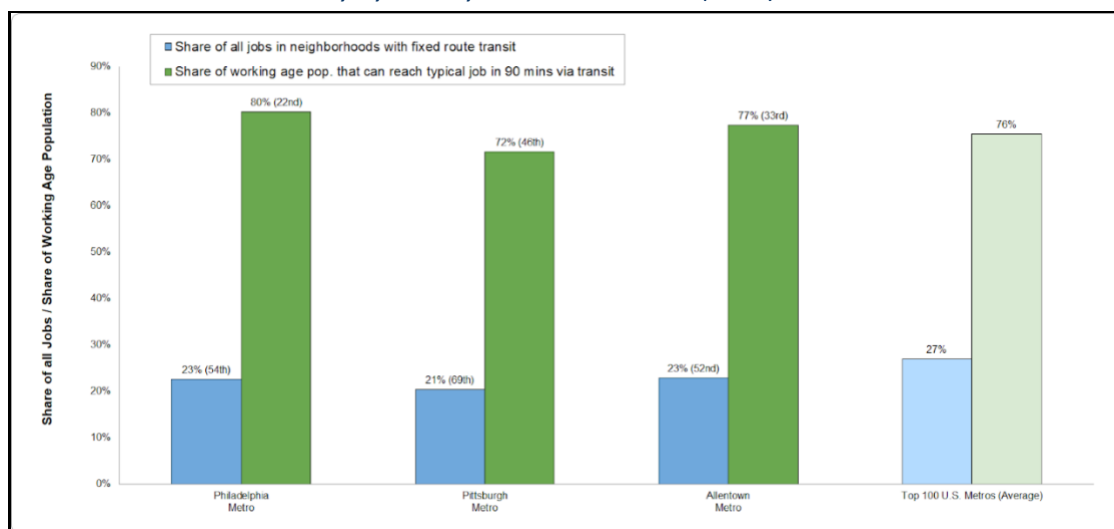
Fig. 33 Counties with Highest Share of Households with No Vehicle (2019)



Source: U.S. Census 2019 5-Year ACS Survey^{clxviii}

The subsequent chart provides a more in-depth look at job-worker connectivity using 2010 data on the 100 largest metro areas. (The data have not since been updated.) It makes clear that eleven years ago, many of PA's workers lived in areas where they could not realistically reach jobs via transit. The blue bars show the share of all jobs that are in neighborhoods with fixed route transit service. Philadelphia, Pittsburgh, and Allentown all ranked in the bottom half of the 100 largest metro areas on this metric. The green bars show the share of the working age population that can reach the typical job in 90 minutes via transit. While Philadelphia, Pittsburgh, and Allentown all ranked in the top half of top metros on this metric, hundreds of thousands of workers in these areas alone are still too far from jobs, representing a missed opportunity to grow the economy.^{clxix}

Fig. 34 Labor and Job Connectivity by Pennsylvania Metro Area (2010)



Source: Brookings^{clxx}

Note: The study defines a job as being in a neighborhood with fixed route transit if there is a transit stop within $\frac{3}{4}$ mile of the geographical center of the job location census tract.

The Economic Impact of Transit-Oriented Development and Pedestrian Infrastructure

Economic Gains for Businesses

Research shows that workers and firms in the same or complementary industries are more productive when they locate near each other. These industry clusters tend to attract more suppliers, customers, and skilled employees, who benefit from easier communication and transport costs with one another.^{clxxi} To enhance the economic impact of co-location, targeted investments to develop industry clusters should be paired with pedestrian-friendly planning. Walkable areas have been shown to increase retail sales at main street businesses.^{clxxii} They also produce higher real estate values than suburban comparators: 2019 study comparing the top 30 U.S. metros found that office and commercial uses in walkable areas were valued about 75% higher than non-walkable properties.^{clxxiii} Every county has at least one anchor community where improvements to pedestrian infrastructure would be sensible. DCED's Multimodal Transportation Fund is one program that helps communities improve streetscapes in areas served by public transit.

Economic Gains for People

Development centered around transit stops helps to create jobs that are accessible to a higher share of the population, spurring economic mobility. A study that builds on the *Opportunity Index* data finds that children from walkable areas see higher economic mobility as measured by earnings in adulthood. (This holds true when controlling for other neighborhood characteristics that affect income mobility.)^{clxxiv} And people who are from walkable neighborhoods feel a greater sense of belonging to their community, implying that they are more likely to build their careers there.^{clxxv} Finally, encouraging main street activity and enhancing streetscape amenities, like tree canopy, increases people's perceptions of safety in the area, regardless of the actual crime rate.^{clxxvi, clxxvii} This in turn increases their likelihood to engage with neighbors and businesses, and thus stay in the area.^{clxxviii} However, this type of urban development can lead to displacement of existing residents without provisions in place to protect them. One example of such a provision is a requirement that all housing developments include 30% affordable units.^{clxxix}

Internet Access the Innovation Economy

Just as transit is needed to connect workers to jobs, internet access is fundamental to job access in the new economy, and opens doors to an exponentially larger number of jobs than are available locally. As the COVID-19 pandemic pushed people to move even more activities online, including schooling and business activities, it has become clear that the real task for policy makers is to ensure *universal* access to broadband within the state.

Defining Broadband and Broadband Coverage

The term broadband refers to the type of high-speed internet access that is always on and faster than traditional dial-up.^{clxxx} The overall broadband coverage level is measured using the ratio of the population with access (not subscriptions) to fixed internet speeds of 25 megabits per second (Mbps) for downloads and 3 Mbps for uploads. These are consistent with the speed thresholds that the Federal Communication Commission's (FCC) uses to define broadband.

Types of High-Speed Transmission Technologies that Provide Broadband:^{clxxxi}

Asymmetric Digital Subscriber Line (ADSL): ADSL uses phone lines, which run through most households, to deliver internet services. As a result, it is widely available around PA and the U.S., especially in rural areas where cable and fiber connections are sometimes unavailable. However, ADSL has lower stability compared to cable and fiber because it changes based on the distance between the household or business and the nearest telephone company facility.^{clxxxii} Moreover, the speed range advertised for ADSL plans is typically 3 Mbps to 115 Mbps, while cable connections can reach approximately 1000 Mbps, and fiber connections can reach double this speed.^{clxxxiii} It typically provides faster speed in the downstream direction than the upstream direction. As a result, ADSL might not satisfy the speed and stability needs of users with higher bandwidth requirements, like businesses.

Cable Modem: This technology provides internet access using the same cables that deliver image and sound to TV sets. Cable performs better than ADSL in terms of stability, and speeds for cable family plans are comparable to that of the ADSL. However, for business use, cable internet could serve a wider range of customers as it provides an upper bound for speed of 1,000 Mbps. Despite these advantages over ADSL, cable internet coverage in rural areas does not compare to DSL internet, as there is not widespread construction of cable networks in rural areas.

Fiber: Fiber optic technology converts data-laden electrical signals into light and sends the light through glass fibers the size of a hair. Fiber's transmission speed far exceeds that of DSL and cable, reaching 2,000 Mbps, and it is a top choice for a stable connection. Similar to cable, the coverage rate for fiber is relatively low because of the incompleteness of fiber network construction.

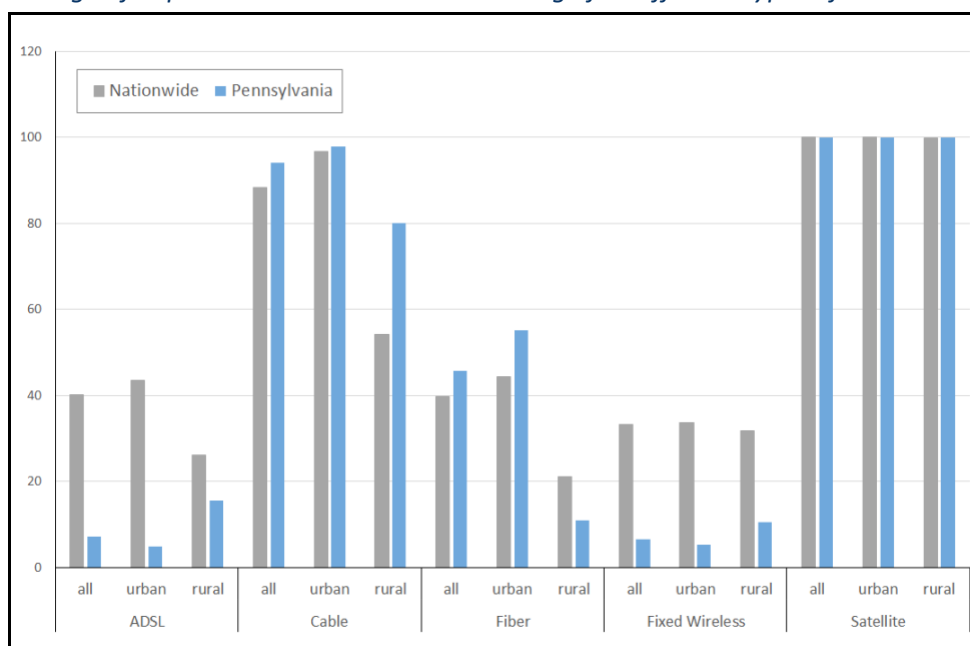
Satellite: Access to broadband can be provided by satellites orbiting the earth, often useful when serving remote and sparsely populated areas. Typically, satellite users can expect speeds of about 500 kilobits per second (Kbps) (download)/80 Kbps (upload), which is even slower than the ADSL internet. However, satellite connections often have a strict data cap and a high level of latency,^{clxxxiv} which would cause its failure to serve functions like video calls. Moreover, extreme weather conditions can compromise its speed and stability.

Fixed Wireless: Like satellite, this type of connection can serve rural areas well, by using radio waves, although it is not widely available or widely accepted by customers at present. This technology has a higher data cap and improved latency over satellite, and comparable speeds to DSL. However, it has the potential to carry faster speeds with technology that is being continuously developed.

Broadband Coverage in PA

A region's broadband coverage reflects its ability to attract remote workers and well-connected firms.^{clxxxv} The following data on broadband coverage are derived from FCC maps. However, these maps in all likelihood overstate broadband coverage, especially in rural areas.^{clxxxvi} The FCC is in the process of updating them.^{clxxxvii} Until the maps are updated, a true picture of broadband access, quality, and availability in the state will need to be based on a different data source in combination with FCC data. Microsoft's recently released data on where users are accessing cloud services at broadband speed (available on Github) is a potential option.^{clxxxviii} And the case study at the end of this section describes North Carolina's quick and cheap method to improve on the FCC's existing map, by adding several other currently available metrics, with the intention that no one metric is overemphasized.

Fig. 35 Percentage of Population with Broadband Coverage for Different Types of Connections (2019)



Source: Federal Communications Commission Broadband Map^{clxxxix}

Note: FCC data is not guaranteed to be accurate.^{cxc}

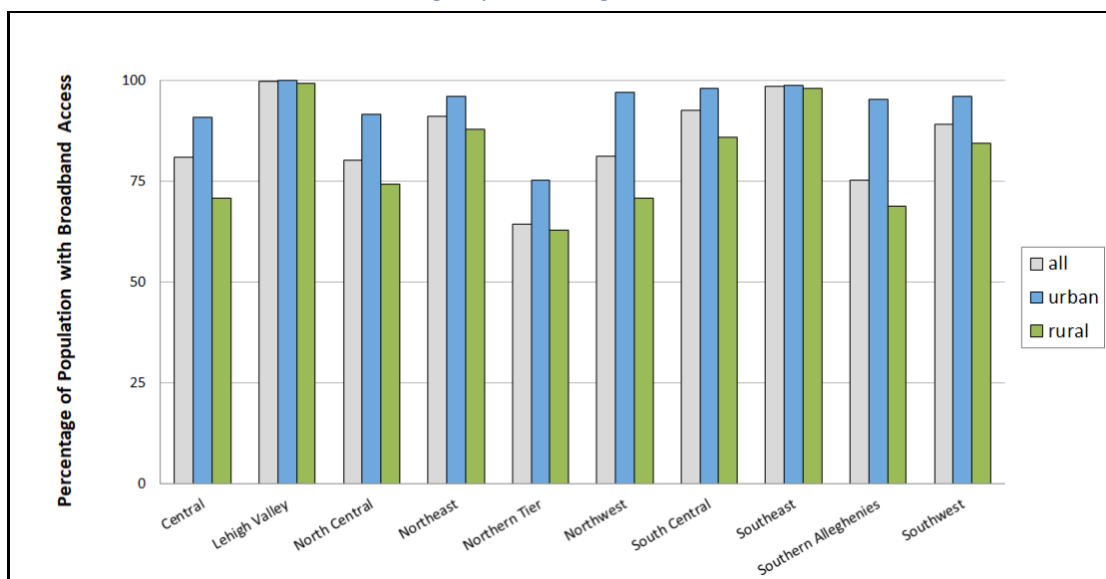
The graph shows the percentage of the population who have potential access (not a subscription) to broadband internet for the five types of connections: ADSL, Cable, Fiber, Fixed Wireless, and Satellite. Using the broadest definition of broadband (based on the download and upload speed), Pennsylvania has 100% percent broadband coverage due to satellite. However, considering the aforementioned pros and cons of each technology regarding speed, stability, data caps, and latency, it is more appropriate to use cable and fiber to define coverage.

Using this definition, the overall and urban-area coverage rate in PA both exceed 90%, which is slightly above the national average. The percentage of PA's rural population with broadband coverage is higher than the national average, but still only 80%, which is significantly lower than that of PA's urban area.^{cxc}

In terms of fiber internet, which is a more scalable and "future proof" technology, PA's overall coverage rate is a low 45.6%.^{cxcii} It is just above 10% in rural areas specifically, which is lower than the national

average for rural fiber coverage of 21%.^{cxci} This indicates the unevenness and incompleteness of the construction for fiber-optic cable networks within PA.

Fig. 36 Broadband: Cable or Fiber Coverage by PREP Region (2019)

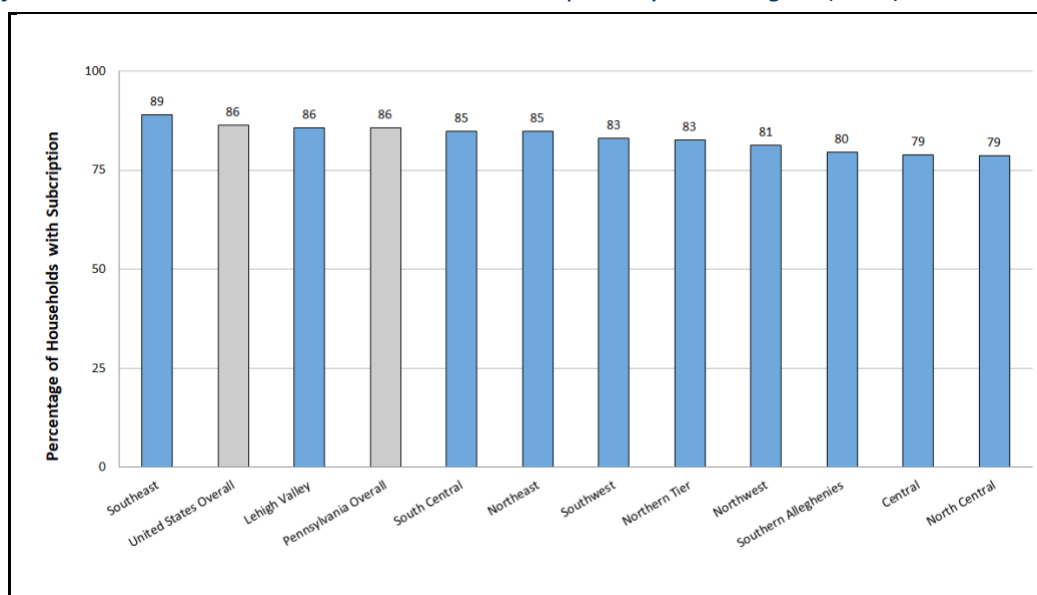


Source: Federal Communications Commission Broadband Map^{cxci}

Note: FCC data is not guaranteed to be accurate.^{cxv}

This graph shows the percentage of population with coverage of cable/fiber internet across PREP Regions. The Lehigh Valley and Southeast regions have the highest coverage rate of cable/fiber internet, regardless of urban or rural area. In other regions of PA, the difference between the coverage rate of rural and urban areas are more significant. The cable/fiber internet coverage rate in the Northern Tier is the lowest.

Fig. 37 Percent of Households with a Broadband Internet Subscription by PREP Region (2019)



Source: U.S. Census 2019 5-Year ACS Survey^{cxvi}

As shown in the chart, 14% of Pennsylvania households do not have a broadband subscription, the same as the U.S. average. Even in the dense and urban Southeast PREP region, 11% of households are without one, showing that while this problem is exacerbated in rural areas, it remains a problem in cities.

Creating the North Carolina Broadband Indices

Released in February 2020, North Carolina's interactive map incorporates over a dozen metrics showing broadband availability, quality, and adoption potential (like poverty level and share of households with no computer devices). The data is granular to the county and census tract level, and all derived from public datasets including FCC and census data.^{cxcvii} Knowing that FCC data is faulty, the map creators aimed to avoid overemphasizing any single factor in characterizing broadband access. The map reportedly took about five weeks and cost \$9,000 for a contracted PhD researcher at Purdue University to build.^{cxcviii}

Pennsylvania's Transportation & Broadband Infrastructure Strengths and Weaknesses

Strengths

- Philadelphia, Pittsburgh, and Allentown all rank above average in comparison to the top 100 metro areas on share of all jobs that are in neighborhoods with transit stops, though updated data is needed.
- Pennsylvania's urban areas have high broadband coverage (though not necessarily access) according to FCC maps.

Weaknesses

- Hundreds of thousands of workers in the top three metro areas alone cannot reach the typical job by public transit, though updated data is needed.
- Pennsylvania is merely average compared to the nation on the share of households with a broadband internet subscription, and 14% of PA households do not have a subscription.
- Rural areas are in dire need of better broadband internet access, and progress is needed in urban areas, too.

8. Conclusion

This report has provided a high-level, comprehensive view of the Commonwealth's innovation economy that compiles the most important metrics in this arena into one document. The [web-based dashboard](#) released with this report provides an even more user-friendly tool to assess the innovation economy's strengths and weaknesses. This is a first step: by measuring the innovation economy, decision makers are then empowered to properly manage it. Further, as these metrics are updated over time, in the dashboard and future iterations of this report, the data will serve as the basis for a sharper understanding of which programs are working and which are not.

The findings in this report align with the state's 13th place ranking on the Milken Institute's State Science and Technology Index. Positioning Pennsylvania as a top competitor on startup activity and a high-skilled workforce will require partnerships that optimize its top assets—its research universities, statewide business support networks, and geographic proximity to east coast ports and population centers, among others. Peer states are making bold and strategic investments that Pennsylvania can rival, if there is the political will to do so. For example, Ohio's economic development corporation recently partnered with the Cleveland Clinic, and other university and health sector partners to commit a combined \$565 million for a new a Cleveland Innovation District focused on pathogen and virus research, which will create thousands of direct and indirect jobs.^{cxcix}

With the state about to receive an influx of federal funding dollars, there is more opportunity than ever for Pennsylvania's leaders to make meaningful change that expands access to and the overall performance of the innovation economy. To this end, the accompanying recommendations offer options for improving policies, programs, and data collection.

Appendix

A. Table of Key Metrics Figures

Metric	Figure	Year of Data	Source
Ranking on the Milken State Technology and Science Index	13th	2020	The Milken Institute State Technology & Science Index
Research & Development			
SBIR and STTR Funding per \$1 Million State GDP	\$189	2019	Small Business Administration and U.S. Bureau of Economic Analysis
State Government Expenditure on R&D		2019	National Science Foundation
Industry R&D as a % of State GDP	1.34%	2018	National Science Foundation
Utility Patents per 100,000 Residents	33	2019	US Patent and Trademark Office
Entrepreneurship & High Growth Firms			
Number of Businesses on the Inc. 5000	188	2020	INC. 5000, <i>Introducing the 5,000 Fastest-Growing Companies in America</i>
Number of High-Tech Firms ≤ 5 Years Old	7,461	2018	U.S. Census Business Dynamics Statistics Survey
Share of New Entrepreneurs who Created a Business by Choice instead of Necessity	83.1%	2020	Kauffman Foundation
Number of Jobs at Foreign-Owned Businesses in PA	320,000	2018	U.S. Bureau of Economic Analysis - Foreign Direct Investment
Percent of all Jobs at Foreign-Owned Businesses in the U.S. that are in PA	4.1%	2018	U.S. Bureau of Economic Analysis - Foreign Direct Investment
Risk Capital			
Venture Capital Dollars per \$1 Million State GDP	\$2,090	2020	PwC/CB Insights MoneyTree™ Report

Number of Venture Capital Firms in PA	175	2020	Crunchbase
Amount of SBIC Funding to Businesses	\$231,000,000	2020	U.S. Small Business Administration
Number of Businesses Receiving SBIC Funding	53	2020	U.S. Small Business Administration
Education			
Share of 8 th Grade Students Scoring “Proficient” or “Advanced” on Statewide Math Tests	32.2%	2019	PA Department of Education
Six-Year College Graduation Rate, 4-Year Public Universities	72.6%	2019	National Student Clearinghouse Research Center
Six-Year College Graduation Rate, 2-Year Public Colleges	39.5%	2019	National Student Clearinghouse Research Center
STEM Degrees awarded as a Share of Total Degrees awarded	20%	2019	U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS)
Workforce			
Science and Engineering Workers as a Share of Total Workforce	4.7%	2019	National Science Board, Science and Engineering State Indicators, State Indicator S-32
Share of Population that is Foreign-Born	6.9%	2019	U.S. Census Bureau
Total Number of Children on the Child Care Works Program Waitlist	78,515	2018	Pennsylvania Department of Human Services
Transportation			
Share of Households with No Vehicle Available	11%	2019	U.S. Census Bureau
Broadband			
Percentage of Population with Broadband Coverage	94.7%	2019	Federal Communication Commission

Percent of Households with a Broadband Internet Subscription	86%	2019	U.S. Census Bureau
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