MARYLAND TECH COUNCIL
**BUSINESS CONTINUITY TASK FORCE**

MARYLAND TECH COUNCIL

# Access to Capital and Related Entrepreneurial Ecosystem Performance and Barriers Assessment

The Jacob *france* Institute
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# EXECUTIVE SUMMARY AND KEY FINDINGS

The Jacob France Institute (JFI) of the Merrick School of Business at the University of Baltimore was retained by the Maryland Tech Council (MTC) to assess the financial/access to capital and other related barriers facing the growth and development of the entrepreneurial life sciences and technology companies served by MTC and its Business Continuity Task Force (BCTF). The key findings of this analysis are as follows:

## Innovation Ecosystem Definition

There are multiple and competing definitions of an innovation ecosystem applied to multiple and different levels of geographies. There is no broad-based system to define, describe and measure an innovation ecosystem at the state level. ***The JFI developed a framework to describe and measure key elements of Maryland's innovation ecosystem in three areas: 1) innovation inputs, or the generation of new ideas, processes and products; 2) the entrepreneurial ecosystem assets that support the translation of these innovations into economic activity; and 3) innovation ecosystem outcomes, in the form of new companies and jobs.***

## Innovation Ecosystem Inputs

- Maryland has the fifth-most intensive economy for research and development (R&D) in the nation, behind our aspirational peers of California and Massachusetts but well ahead of our regional peers;
  - As home to major federal research labs, such as the National Institutes of Health, and major research universities, with two of the nation's top twenty research universities, Johns Hopkins (#1) and University of Maryland (#17), ***academic and federal research drive our innovation ecosystem***. Maryland ranks first nationally in academic and federally-performed R&D as a share of GDP;
- Despite Maryland's strong academic research position, Maryland and its key research institutions are average performers compared to the nation and most regional and aspirational peers in translating these university innovations to the private sector through university commercialization activities;
- While the rates of commercialization of academic research are average, Maryland's performance in Small Business Innovation Research (SBIR) awards, which provide federal support to small businesses for innovative research and commercialization activities, is quite strong. Maryland is ranked fifth nationally on the number of SBIR deals and third in the value of SBIR funding per $1 billion in State GDP; and
- Despite Maryland's strong national position in R&D activity, the State lags both the nation and peer states in per capita patents issued to Maryland assignees. One reason that Maryland's overall level of patenting activity may be low is the State's lower levels of industrial R&D, with most patents issued to companies. Six of the top twenty Maryland patent assignees are universities or federal agencies. Together they account for about one-fourth of patents issued in Maryland. Patenting activity is highly concentrated in the life sciences (pharmaceuticals, biotechnology, medical technology), information technology methods, and electronics sectors (digital communication, telecommunications and computer technology) areas that drive Maryland's technology base.

## Entrepreneurial Ecosystem Assets

- Maryland lags our aspirational and regional peers in both overall and per capita venture capital investment. In 2022, Maryland was ranked 19th in total and 20th nationally in per capita venture capital investment. That investment is highly concentrated in the core Life Sciences and Information Technology (IT) clusters;
- Maryland maintains one of the most highly-educated workforces in the nation. With high concentrations of workers in critical business, management and STEM fields; and
- Maryland is competitive in real estate costs and availability, with a substantial base of business incubators, accelerators and innovation/entrepreneurship resources serving its technology businesses.

## Innovation Ecosystem Outcomes

- Maryland lags the nation in terms of entrepreneurial outcomes as measured by the number of firms and share of employment in both young (less than 5 years old) and small firms (1-19 employees). With 30% of total firms less than 5 years old and 9% of employment in young firms and 83% of firms having 1-19 employees and 16% of employment in small firms but is generally competitive with most regional and aspirational peers;
- There is no database of innovation driven enterprises, so the JFI analyzed the level of establishment growth in the three targeted high technology clusters. While Maryland lagged the nation and all comparison states in the overall rate of establishment formation, the State outperformed the nation and most peers in Life Sciences and Electronics establishment growth but underperformed in IT establishment growth;
- Maryland's three target technology industry clusters are strong and growing. Maryland's Life Sciences cluster is highly-specialized and growing more rapidly than the nation, but lagging behind key peers. Maryland's IT cluster is highly specialized but lags the nation and most peers in growth. Maryland's Electronics cluster is not specialized but is growing more rapidly than the nation and most key peers; and
- ***Maryland's overall innovation ecosystem is ranked as strong in national rankings of technological capacity***. Maryland is ranked fourth nationally by both the ITIF State New Economy Index and Milken Institute's State Science and Technology Index, scoring below national leaders (CA and MA) but better than our regional peers.

## Summary and Conclusion

- While Maryland is an internationally recognized technology hub in the three technology clusters (life sciences, information technology, and electronics) that drive our innovation economy; growth in these clusters has lagged the competition in our core Life Sciences and IT Clusters. Maryland's entrepreneurial performance in terms of young and small businesses has been average. As a result of slower cluster and entrepreneurial growth, the Maryland economy has lagged in both long-term growth and its recovery from the Covid-recession;
- Maryland is a leading State in the generation of innovation through research and development; but is lagging in the translation of the innovations developed at our leading academic and federal research institutions into economic activity and jobs;
- Maryland's entrepreneurial assets are one cause of this poor performance. Expanded access to venture capital is needed to invest in growth companies and targeted and coordinated efforts are needed to support innovation-based economic development; and
- The best means to renew economic growth in Maryland is through investments in venture capital access, human capital development and targeted translational resources to expand the commercialization of Maryland's innovation ecosystem resources into new companies, products and services that create businesses and jobs for Marylanders.

# CONTENTS

# INTRODUCTION

The Maryland Tech Council (MTC) requested that the Jacob France Institute of the University of Baltimore (JFI) assess the financial/access to capital and other related barriers facing the growth and development of entrepreneurial life sciences and technology companies in Maryland. The mission and vision of the MTC are as follows:

| | |
|---|---|
| **MTC Mission** | At the Maryland Tech Council, we believe in saving lives, securing our nation and improving the quality of life through innovation.<br>We support our member companies who are driving innovation through advocacy, education, workforce development, cost savings and connecting entrepreneurial minds. |
| **MTC Vision** | The vision for the Maryland Tech Council is to propel Maryland to become the number one innovation economy for life sciences and technology in the country. |

The goal of this assessment is to support the MTC's Business Continuity Task Force (BCTF) in its mission to help companies maximize their resilience, plan for an optimal recovery, execute the recovery plan and reimagine what the future may look like – ensuring these businesses will have the greatest opportunity to survive the pandemic and thrive afterwards.[1] The JFI's approach to this assessment of Maryland's innovation ecosystem consisted of the following four key steps:

1. The JFI ***reviewed the literature*** on defining and quantifying innovation ecosystems and existing studies on Maryland, most importantly the Maryland Technology Development Corporation (TEDCO) Equitech Study;
2. Based on the review of the innovation ecosystem literature, we identified and conducted a ***quantitative analysis*** of Maryland's performance and, where feasible the State's national position in key measures of ecosystem strength, including:
    a. The *inputs* to the innovation process (most importantly academic and federal research and development activities, academic technology commercialization efforts, federal SBIR activities, federal procurement and patenting);
    b. The *assets supporting* the innovation process (most importantly access to capital, but also including such factors as access to human capital, real estate cost and availability, and translational assets such as incubators or accelerators; and
    c. The *outcomes of the innovation process*, in the form of national rankings of entrepreneurial and innovation ecosystem vitality, the performance of key target technology clusters, and young and small business activity;
3. In order to provide context to the quantitative analysis, we conducted a ***qualitative analysis*** consisting of a focus group with five BCTF members and 21 interviews with stakeholders operating within Maryland's innovation ecosystem; and
4. The JFI prepared this ***report summarizing the findings*** of the literature review, quantitative analysis and qualitative analysis, including high level recommendations on key policy issues based on the review of national literature and, more importantly, the feedback received by the stakeholders interviewed, all of whom have substantial experience working within the Maryland innovation ecosystem.

The end result of this process is this report assessing the strength, performance and key capital and related barriers to Maryland's innovation ecosystem performance to help guide MTC's and BCTF's efforts in the future.

# SETTING THE CONTEXT – ECONOMIC GROWTH IN MARYLAND

***Maryland has a strong economy, but lags the nation in terms of population, economic and employment growth.*** Maryland has the 16th largest economy in the nation and is ranked 17th in per capita GDP; however, the State has lagged in GDP growth since 2010, with 13.3% growth in real GDP, placing the State 38th nationally in terms of GDP growth.[2] With a population of 6.16 million, Maryland is the 19th largest State in terms of population but was ranked 23rd in terms of population growth since 2010.[3] With 2.1 million private sector jobs, Maryland is ranked 22nd nationally in terms of private sector employment but, between 2010 and 2021, private sector employment in Maryland only grew by 7%, with the State ranked 37th in private sector employment growth.[4] ***Renewing economic, employment and population growth in Maryland is a vitally important issue. Expanding the State's entrepreneurial and innovation economy is the best way to promote growth in Maryland***.

The U.S. Bureau of the Census' Business Dynamics Statistics (BDS) Program provides data on annual measures of business dynamics. The JFI analyzed BDS data on employment in high technology firms (Figure 1), young firms (less than 5 years old – Figure 2) and small firms (firms with less than 20 employees – Figure 3) comparing Maryland to the nation and selected peer states in terms of indexed employment in each of these classifications of firms. As shown in these three charts, Maryland has lagged the nation and most peer states in terms of employment growth in high technology, young and small firms. The charts demonstrate the need to rejuvenate Maryland's entrepreneurial and innovation ecosystem as a critical means to renew economic, employment and population growth in Maryland. This is why the MTC commissioned this study of Maryland's entrepreneurial and innovation ecosystem.

Figure 1: High Tech Employment Performance

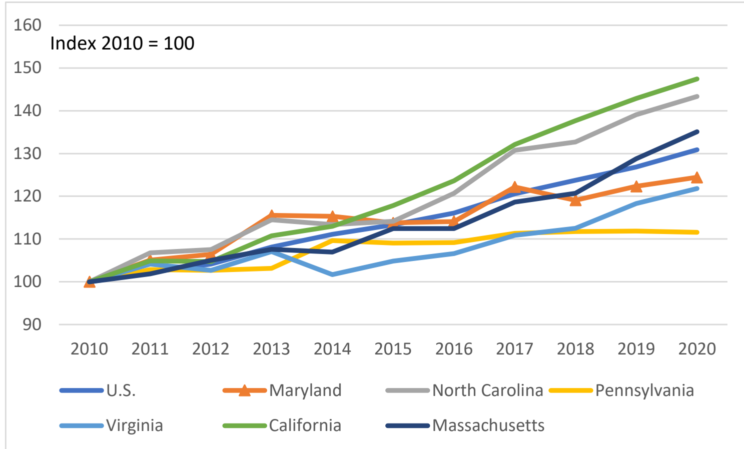



Figure 2: Employment in Firms Less than 5 Years Old

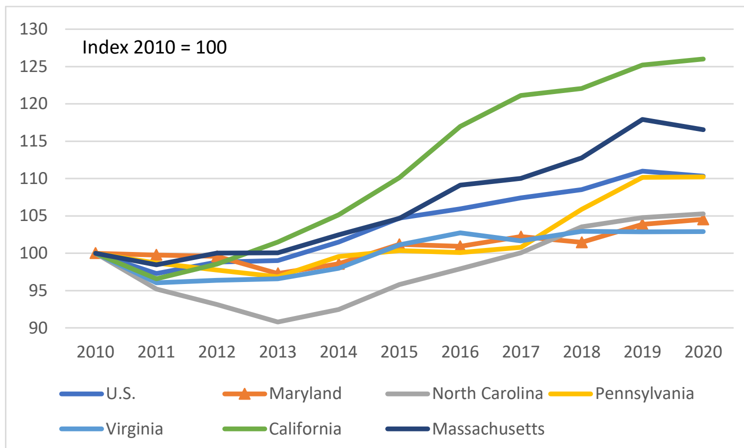
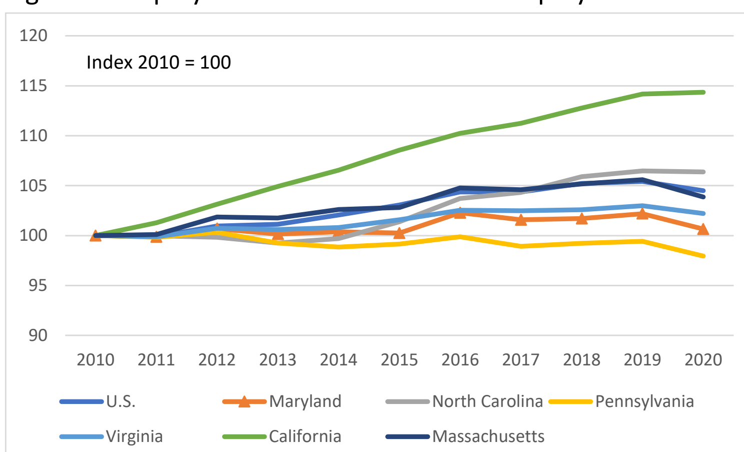



Figure 3: Employment in Firms With 1-19 Employees



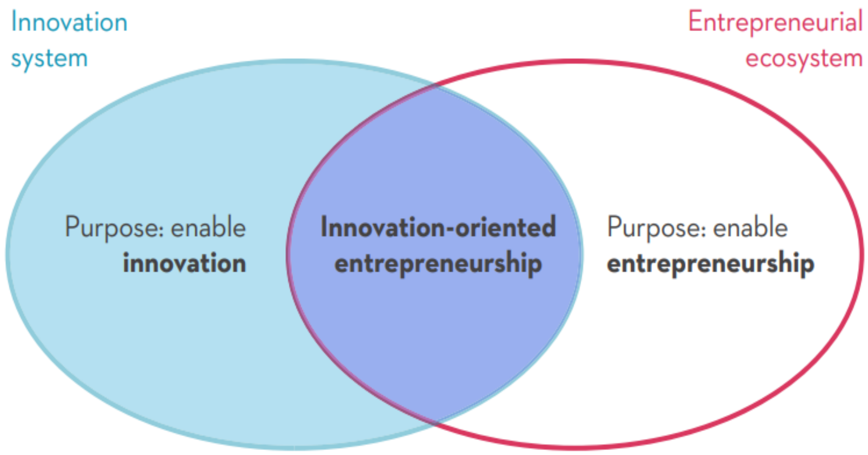
## DEFINING AND MEASURING AN INNOVATION ECOSYSTEM

There are multiple definitions of what an ***innovation ecosystem*** is, with some of the most robust models developed to describe innovation ecosystems at a national/county level. The World Economic Forum's 2020 *Global Competitiveness Report Special Edition 2020: How Countries are Performing on the Road to Recovery* report defines an innovation ecosystem as follows:

> Innovation ecosystems are a complex process that span the generation of ideas, their translation into products, and the commercialization of these products to a large scale. The success of this progression depends on multiple factors, such as a business culture that rewards entrepreneurship, risk-taking and a will to embrace change, a set of regulations and administrative norms that incentivize this attitude, a strong knowledge-generation sector (universities, research centres and laboratories), and collaboration between these knowledge centres and commercial businesses. Innovation can be successfully steered towards applications particularly valuable to society (e.g., green energy).[5]

The Massachusetts Institute of Technology[6] has developed both definitions and criteria for measuring innovation ecosystems. The MIT D-Lab describes an innovation ecosystem as the integration of *innovation systems* that exist to produce innovation and support processes of innovation and *entrepreneurial ecosystems*, or the place-based factors that contribute to its ability to produce and sustain successful entrepreneurship. MIT's D-Lab defines innovation ecosystems as place-based communities of interacting actors engaged in producing innovation and supporting processes of innovation, along with the infrastructure, resources, and enabling environment that allow them to create, adopt, and spread more effective ways of doing things.[7]

**Figure 4: MIT D-Lab Innovation Ecosystem Model**

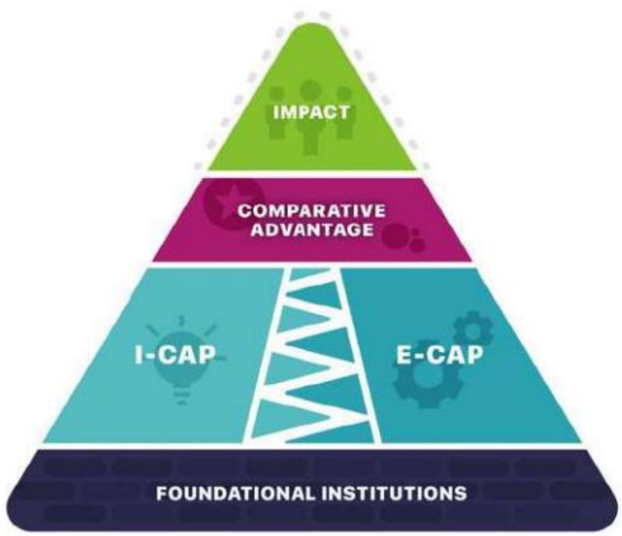



The MIT innovation initiative has a framework, including key metrics to describe innovation ecosystems at the national level, consisting of four core elements. The MIT innovation initiative defines "'innovation-driven entrepreneurship ecosystems' ('iEcosystems')" as geographically bounded places where innovation-driven enterprises (IDEs) flourish. Innovation ecosystems can be analyzed based on four core elements:

1. **Foundational Institutions** are those institutions, rules, practices and norms that are often taken for granted, but ensure that investments in a wide variety of capacities and assets can be effectively protected and leveraged to the benefit of the economy.
2. **Innovation Capacity (I-Cap)** is the capacity of a place – a city, a region or a nation – to develop 'new-to-the-world' ideas and to take them from 'inception to impact' (whether this be economic, social and/or environmental impact). In other words, innovation capacity covers not only the development of basic science and research but also the translation of their 'solutions' into useful products, technologies and/or services that truly solve problems.
3. **Entrepreneurship Capacity (E-Cap)** emphasizes a subset of the more general entrepreneurial capability and conditions for forming enterprises.
4. **Comparative Advantage** of any region's economy is based on specific areas of strength that differentiate it from others around it, including globally.

Taken together, these elements drive the **impact** of an innovation ecosystem which can vary from enhancing health and well-being, to supporting business growth – especially in the formation and growth of innovation-driven companies.[8]

**Figure 5: MIT Innovation Initiative Innovation Ecosystem Core Elements**



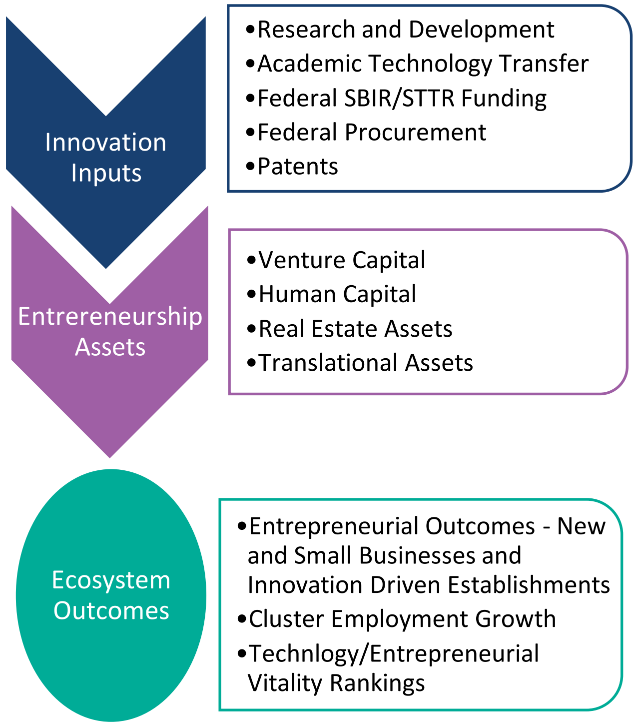

## Measuring Innovation Ecosystems

There are competing definitions of what an innovation system is applied to different levels of geography. These range from nations, to states/regions, to cities, as well as smaller place-based initiatives, such as innovation districts. There are multiple rankings of state innovation capacity and performance, such as the Information Technology & Innovation Foundation (ITIF)'s 2022 *The North American Subnational Innovation Competitiveness* Index (which ranked Maryland fourth among U.S. states and Canadian Provinces in the strength of its innovation economy) and the Milken Institute's *State Technology and Science Index* (which ranks Maryland fourth among

U.S. states in its knowledge-based economy). However, based on its review of the literature, the JFI could not identify a broadly accepted measurement system to evaluate and classify a state's innovation ecosystem.

Lacking a broadly used, state-level innovation ecosystem measurement approach to apply to this analysis of Maryland's innovation ecosystem, the JFI developed a framework to take available data and create a model to describe Maryland's Innovation ecosystem in three key domains: the ***inputs*** to the innovation process; the ***assets*** to support entrepreneurial and technology-based economic development; and ***outcomes***, in terms of the impacts of Maryland's innovation ecosystem on the State's economic performance. For this assessment of Maryland's Innovation Ecosystem, the JFI collected and analyzed measures of: 1) the *inputs* to the innovation process in the form of academic R&D activity, selected related commercialization activities to transfer innovations to the private sector, and patenting activity; 2) selected *entrepreneurial support assets* that enable private sector development of new innovations, with a focus on venture capital; and 3) selected economic outcomes of the innovation process in terms of company formation, employment and economic growth, and entrepreneurial/ecosystem vitality. (See Figure 6).

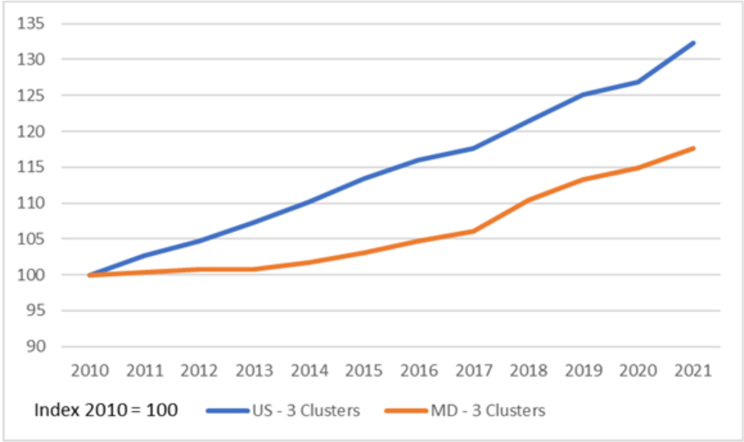
**Figure 6: JFI Innovation Ecosystem Model**




## Why is Maryland's innovation ecosystem important?

Maryland's economy is lagging the nation both in terms of long-term economic growth and in its recovery from the Covid Recession. Maryland is a leading high technology state, but our growth in the three targeted high technology sectors, Life Sciences, IT and Electronics that are core drivers of the Maryland economy, are lagging the nation in growth (Figure 7). ***Promoting renewed growth in these innovation-driven clusters through investments to strengthen Maryland's Innovation Ecosystem is the best means of promoting renewed economic and employment growth in Maryland.***

**Figure 7: U.S. and Maryland, Indexed Employment Growth 2010-21**



# QUANTITATIVE ASSESSMENT OF MARYLAND'S INNOVATION ECOSYSTEM

To assess the strength of Maryland's innovation ecosystem, the JFI collected and analyzed 12 sets of measurements across the three domains of ***Maryland's Entrepreneurial Ecosystem***: *Innovation Ecosystem Inputs*; *Entrepreneurial Ecosystem Assets*; and *Ecosystem Outcomes*. Where possible, data on Maryland's national performance/ranking, as well as comparisons to the core peer regional competitor states of North Carolina, Pennsylvania and Virginia, as well as aspirational peers, the leading innovation and technology states of California and Massachusetts, were collected and used.

## Innovation Ecosystem Inputs

As described above, the MIT D-Lab describes an innovation ecosystem as the integration of *innovation systems* that exist to produce innovation and support processes of innovation and *entrepreneurial ecosystems*, or the place-based factors that contribute to its ability to produce and sustain successful entrepreneurship. As a result, the innovation process begins with the development of "innovation" in the form of new ideas, products, processes or technologies. There is no way of measuring all of the knowledge or innovations generated in a state of region, or how they are disseminated and adopted. However, based on the review of the literature, the JFI identified the following measurable elements of a state or region's innovation system, including: 1) Research and development (R&D) activities; 2) Commercialization activities; and 3) Patenting activities. In addition to these three indicators, the JFI also analyzed federal procurement activities and Small Business Innovation Research awards as these are core drivers of innovation in Maryland, especially in the core IT, especially Cybersecurity, and Life Sciences focus areas for the MTC.

At a basic level, the innovation system begins with research and development as the core generator of new innovations. According to the World Economic Forum, "Public R&D funding is among the types of investments that can generate the highest number of good-quality jobs. It has been estimated that in OECD economies five new jobs are created with every 1 million dollars invested on public R&D, and twice as many when the investment is channeled through higher education institutions."[9] R&D activity can be performed by a variety of institutions, with industry accounting for 77% of U.S. performed R&D activities, academia for 11%, the federal government for 8%, and nonprofit entities for 4%.[10] With R&D activities serving as a measure of the input to the innovation process, the outputs of the innovation process can be measured in terms of commercialization and patenting activities. Innovations derived from industry performed R&D are generally commercialized, developed and utilized by private sector firms, with federal and especially, academic R&D-based innovations generally transferred to the private sector through the technology commercialization process through intellectual property (IP) licenses and new IP-based start-ups. R&D based innovations are often protected through the use of patents. Thus, the broad inputs to the Maryland innovation ecosystem is research and development and innovation outputs include commercialization and patenting activities.

## Research and Development Activities

***Maryland is a national leader in research and development activity, especially in the areas of academic and federal research***. Maryland has the fifth most R&D intensive economy in the nation[11], behind our aspirational peers of California and Massachusetts, but well ahead of our regional peers. Maryland has the fifth highest level of R&D intensity nationally, behind New Mexico, Massachusetts, Washington and California and is ranked highest in the nation in terms of both academic and federally performed R&D as a percentage of GDP.

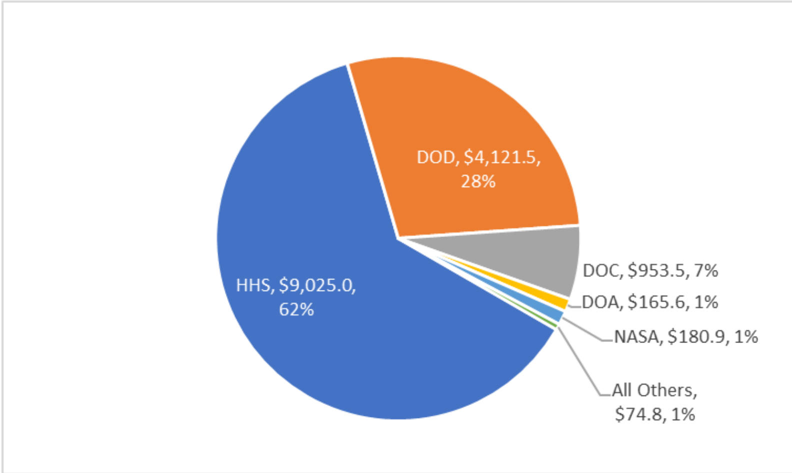
Maryland's federal laboratories stand out in terms of both their role in Maryland and share of federal intramural research. Federal research obligation data[12] shows two agencies, the Department of Health and Human Services (HHS) – mostly the National Institutes of Health (NIH) – and Department of Defense (DOD) account for 90% of federal intramural research obligations in Maryland. The U.S. Department of Commerce – mostly the National Institute of Standards and Technology (NIST) – Department of Agriculture (mostly Beltsville Agricultural Research Center), and the National Aeronautics and Space Administration (NASA) make up most of the remaining amount (Figure 8). Maryland accounts for 47% of HHS, 18% of DOD and 80% of U.S. Department of Commerce intramural research spending. Similarly, with two of the nation's top twenty research universities, Johns Hopkins (#1) and University of Maryland (#17), academic R&D activity stands out in Maryland. While Maryland is ranked in the middle of states (26th) in business R&D as a share of GDP, the amount of business R&D in Maryland at $5.9 billion is larger than the base of academic R&D performed in the State. This lags both our regional and aspirational peers but, still exceeds 30 other states in terms of total funding.

**Table 1: Research and Development Spending, By Selected Performer**

| | R&D (Mil $s) | | Growth (2015-20) | | R&D | |
|---|---|---|---|---|---|---|
| State/Cluster | 2015 | 2020 | $ | % | Intensity | Rank |
| **Maryland - Total R&D** | $20,385 | $27,853 | $7,468 | 37% | 6.8% | 5 |
| Federal | $10,462 | $14,521 | $4,059 | 39% | 3.5% | 1 |
| Business | $5,136 | $5,923 | $787 | 15% | 1.4% | 26 |
| Academic | $3,742 | $4,745 | $1,003 | 27% | 1.2% | 1 |
| **North Carolina - Total R&D** | $11,823 | $18,064 | $6,241 | 53% | 3.0% | 15 |
| Federal | $306 | $349 | $43 | 14% | 0.1% | 27 |
| Business | $8,572 | $13,369 | $4,797 | 56% | 2.2% | 12 |
| Academic | $2,815 | $3,386 | $571 | 20% | 0.6% | 6 |
| **Pennsylvania - Total R&D** | $14,839 | $21,687 | $6,848 | 46% | 2.8% | 16 |
| Federal | $663 | $420 | -$243 | (37%) | 0.1% | 28 |
| Business | $10,354 | $15,443 | $5,089 | 49% | 2.0% | 15 |
| Academic | $3,357 | $4,820 | $1,463 | 44% | 0.6% | 4 |
| **Virginia - Total R&D** | $10,107 | $13,317 | $3,210 | 32% | 2.4% | 25 |
| Federal | $2,733 | $2,019 | -$714 | (26%) | 0.4% | 6 |
| Business | $4,486 | $7,235 | $2,749 | 61% | 1.3% | 28 |
| Academic | $1,411 | $1,921 | $510 | 36% | 0.3% | 34 |
| **California - Total R&D** | $125,056 | $217,976 | $92,920 | 74% | 7.2% | 4 |
| Federal | $2,365 | $3,458 | $1,093 | 46% | 0.1% | 15 |
| Business | $107,982 | $193,063 | $85,081 | 79% | 6.4% | 2 |
| Academic | $8,657 | $10,911 | $2,254 | 26% | 0.4% | 30 |
| **Massachusetts - Total R&D** | $28,665 | $44,907 | $16,242 | 57% | 7.7% | 2 |
| Federal | $632 | $573 | -$59 | (9%) | 0.1% | 13 |
| Business | $21,484 | $32,737 | $11,253 | 52% | 5.6% | 3 |
| Academic | $3,674 | $4,361 | $687 | 19% | 0.7% | 2 |

Source: JFI Analysis of NSF Data

**Figure 8: Maryland Federal Intramural Research Obligations, By Agency (Mil. $s) 2020**




***Maryland is a national leader in academic research and development, especially in critical computer, life sciences and engineering domains***. As presented in Table 1, Maryland has the highest level of academic research and development intensity in the nation. Despite being a small state in population, Maryland is ranked fifth nationally in the total amount of academic R&D activity and ***first nationally*** in both the total amount of academic computer science and engineering R&D activity (Table 2). Maryland's proximity to the nation's capital and key federal agencies is a critical factor supporting academic R&D activity. Maryland is ranked third nationally in terms of federal academic R&D support, which accounts for 79% of total academic R&D (the highest rate in the nation). However, industry support for R&D activity in Maryland is low, below all of our peers and 38th nationally in terms of industry's share of academic R&D support (Figure 9).

**Figure 9: Academic Research, By Funding Source Maryland and Selected Peer States, % and Mil. $s**

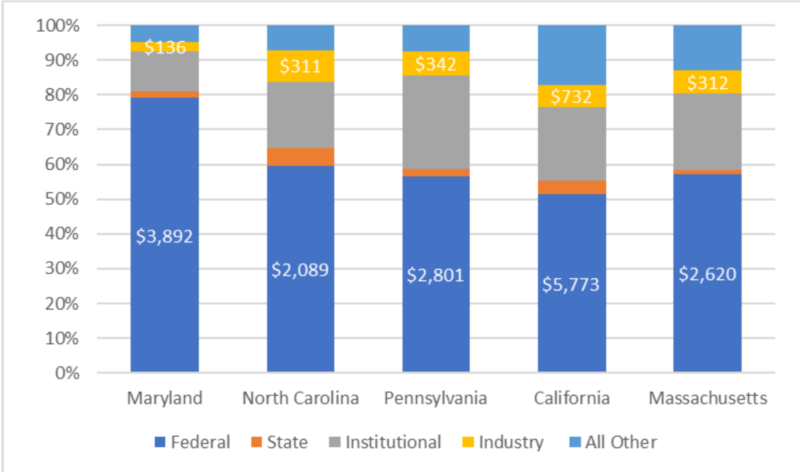


**Table 2: Academic Research and Development Spending, Total and for Selected Area**

| | R&D (Mil $s) | | Growth (2016-21) | | National Ranking | |
|---|---|---|---|---|---|---|
| State/Cluster | 2016 | 2021 | $ | % | R&D | Growth |
| **Maryland - Total R&D** | $3,801.5 | $4,916.4 | $1,114.9 | 29% | 5 | 17 |
| Computer and info. sciences | $191.9 | $335.5 | $143.6 | 75% | 1 | 12 |
| Life sciences | $1,656.2 | $2,102.9 | $446.7 | 27% | 6 | 28 |
| Engineering | $1,186.4 | $1,413.8 | $227.4 | 19% | 1 | 29 |
| **North Carolina - Total R&D** | $2,938.1 | $3,504.2 | $566.1 | 19% | 7 | 37 |
| Computer and info. sciences | $43.3 | $79.7 | $36.5 | 84% | 12 | 10 |
| Life sciences | $2,115.4 | $2,545.3 | $429.9 | 20% | 5 | 33 |
| Engineering | $274.6 | $335.8 | $61.1 | 22% | 14 | 26 |
| **Pennsylvania - Total R&D** | $3,963.8 | $4,950.5 | $986.7 | 25% | 4 | 26 |
| Computer and info. sciences | $211.1 | $324.4 | $113.3 | 54% | 2 | 20 |
| Life sciences | $2,378.9 | $3,094.8 | $715.9 | 30% | 4 | 24 |
| Engineering | $568.5 | $719.6 | $151.1 | 27% | 7 | 22 |
| **Virginia - Total R&D** | $1,466.3 | $1,946.4 | $480.0 | 33% | 13 | 12 |
| Computer and info. sciences | $54.6 | $92.5 | $38.0 | 70% | 10 | 13 |
| Life sciences | $714.5 | $950.6 | $236.1 | 33% | 18 | 16 |
| Engineering | $328.7 | $421.8 | $93.0 | 28% | 10 | 20 |
| **California - Total R&D** | $8,893.0 | $11,234.6 | $2,341.6 | 26% | 1 | 25 |
| Computer and info. sciences | $225.0 | $298.3 | $73.3 | 33% | 3 | 31 |
| Life sciences | $5,405.8 | $7,141.1 | $1,735.3 | 32% | 1 | 17 |
| Engineering | $1,026.6 | $1,171.8 | $145.2 | 14% | 2 | 34 |
| **Massachusetts - Total R&D** | $3,801.3 | $4,577.0 | $775.7 | 20% | 6 | 33 |
| Computer and info. sciences | $145.0 | $230.7 | $85.6 | 59% | 4 | 17 |
| Life sciences | $1,554.5 | $1,956.6 | $402.1 | 26% | 7 | 27 |
| Engineering | $784.3 | $914.4 | $130.1 | 17% | 6 | 32 |

Source: JFI Analysis of NSF Data

## Academic Technology Commercialization

While academic R&D is an important driver of innovation, it is in the translation of research into new products, processes and services that drives the innovation ecosystem. According to the Milken Institute's 2017 *Concept to Commercialization The Best Universities for Technology Transfer* report:

> University research funding can support the creation of both middle and high-skill industry jobs through innovation, commercialization, and technology transfer. As products and services are created and licensed, there are a myriad of multiplier impacts felt across the economy.
>
> Universities are a source of competitive advantage; they create a skilled workforce and through R&D and tech-transfer help create new technologies and new industries.[13]

University-developed innovations are translated into economic activity through the technology transfer process. After a discovery or invention is developed through research at a university, the first phase of the technology transfer process is the filing of an invention disclosure. If a technology is considered to have commercial potential, the university may seek to protect its intellectual property rights over the technology by filing for a patent. For a patent to be awarded, the technology must be judged to be novel, non-obvious, and useful. Once a new technology is identified, developed and protected by a university it is then transferred to the private sector to be developed into a product, with the two most common technology transfer mechanisms being: 1) licensing to an existing firm; or 2) forming a university-IP based start-up company. The Association of University Technology Managers (AUTM) collects information on the technology transfer and commercialization activities of major universities and the number of invention disclosures, patent applications, licenses/licensing revenues and university IP start-ups. These measures all serve as indicators of the level of university innovations being generated and commercialized. In order to assess the contribution of Maryland's major research colleges and universities to Maryland's innovation ecosystem, data on technology transfer activities were analyzed and compared to both regional and aspirational peers, normalized by the size of each state's (Table 3) and institution's (Table 4) level of academic research. ***Maryland and its key research institutions slightly lag the nation and most regional and aspirational peers in the level of university commercialization activities normalized by research and development expenditures.***

**Table 3: Technology Commercialization Metrics (Per $10 Mil. in R&D) – Maryland and Peer States, FY2021**

| State | Invention Disclosures | New Patent Applications Filed | Licenses & Options Executed | License Income | Cumulative IP-based Startups | IP-based Startups |
|---|---|---|---|---|---|---|
| **US Average** | 2.88 | 1.92 | 0.12 | $319,426 | 0.75 | 0.12 |
| Maryland | 2.57 | 1.22 | 0.12 | $89,936 | 0.70 | 0.09 |
| North Carolina | 3.14 | 1.51 | 0.15 | $453,504 | 1.50 | 0.18 |
| Pennsylvania | 3.52 | 1.89 | 0.15 | $928,728 | 1.00 | 0.14 |
| Virginia | 3.12 | 2.83 | 0.09 | $111,977 | 0.98 | 0.12 |
| California | 2.39 | 1.57 | 0.06 | $253,951 | 0.26 | 0.11 |
| Massachusetts | 3.65 | 2.56 | 0.05 | $584,466 | 0.32 | 0.17 |

Source: JFI Analysis of AUTM Data

**Table 4: Technology Commercialization Metrics (Per $10 Mil. in R&D) – Selected Maryland and Peer State Institutions, FY2021**

| Institution | Invention Disclosures | New Patent Applications Filed | Licenses & Options Executed | License Income | Cumulative IP-Based Startups | IP-based Startups |
|---|---|---|---|---|---|---|
| **US Average** | 2.88 | 1.92 | 0.12 | $319,426 | 0.75 | 0.12 |
| **Maryland** | | | | | | |
| Johns Hopkins University | 2.26 | 1.42 | 0.07 | $219,211 | 0.69 | 0.10 |
| Johns Hopkins University Applied Physics Laboratory | 2.63 | 0.55 | 0.04 | $5,147 | 0.14 | 0.01 |
| Morgan State University | 14.54 | 13.57 | 0.34 | $242 | 3.88 | 0.97 |
| University System of Maryland | 2.74 | 1.75 | 0.07 | $25,556 | 1.53 | 0.19 |
| **North Carolina** | | | | | | |
| Duke University | 3.45 | 1.65 | 0.11 | $842,357 | 1.22 | 0.12 |
| North Carolina State University | 4.93 | 1.61 | 0.37 | $107,700 | 3.03 | 0.37 |
| University of North Carolina Chapel Hill | 1.64 | 0.89 | 0.09 | $347,042 | 1.31 | 0.13 |
| **Pennsylvania** | | | | | | |
| Carnegie Mellon University | 9.65 | 8.15 | 0.13 | $393,350 | 4.39 | 0.11 |
| Drexel University | 2.39 | 1.61 | 0.08 | $51,045 | 0.00 | 0.17 |
| Penn State University | 2.05 | 0.86 | 0.01 | $56,137 | 0.67 | 0.03 |
| University of Pennsylvania | 2.93 | 1.26 | 0.26 | $2,766,699 | 1.33 | 0.21 |
| University of Pittsburgh | 3.30 | 1.23 | 0.11 | $95,058 | 0.00 | 0.18 |
| **Virginia** | | | | | | |
| University of Virginia Patent Foundation | 2.81 | 1.88 | 0.15 | $192,827 | 1.26 | 0.07 |
| Virginia Tech Intellectual Properties Inc. | 2.62 | 2.68 | 0.05 | $26,731 | 0.70 | 0.13 |
| **California** | | | | | | |
| California Institute of Technology | 3.77 | 3.75 | 0.11 | $128,607 | 2.79 | 0.16 |
| University of California System | 2.17 | 1.21 | 0.05 | $180,227 | 0.00 | 0.11 |
| University of Southern California | 2.61 | 1.02 | 0.06 | $61,855 | 1.00 | 0.12 |
| **Massachusetts** | | | | | | |
| Harvard University | 4.19 | 1.97 | 0.17 | $1,161,529 | 0.00 | 0.30 |
| Massachusetts Institute of Technology | 3.91 | 2.07 | 0.07 | $465,464 | 0.00 | 0.13 |
| University of Massachusetts System | 2.02 | 1.12 | 0.05 | $446,529 | 0.59 | 0.08 |

Source: JFI Analysis of AUTM Data

## Federal SBIR/STTR Activity

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are highly competitive programs that encourage domestic small businesses to engage in Federal Research/R&D with the potential for commercialization. Each year, Federal agencies with extramural R&D budgets that exceed $100 million are required to allocate 3.2% (since FY2017) of this extramural R&D budget to fund small businesses through the SBIR program. Federal agencies with extramural R&D budgets that exceed $1 billion are required to reserve 0.45% (since FY2016) of this extramural R&D budget for the STTR program. Currently, eleven Federal agencies participate in the SBIR program and five of those agencies also participate in the STTR program.[14] This program has been called America's Seed Fund and has helped seed companies such as Qualcomm, Symantec, and 23andMe. The program has resulted in 70,000 issued patents, close to 700 public companies, and approximately $41 billion in venture capital investments.[15]

***Maryland is a national leader in SBIR/STTR activity and this funding is a key driver of Maryland's Innovation Ecosystem***. Maryland, with its substantial base of federal agencies and federal labs, is a major beneficiary of the SBIR program and over the past five years, Maryland was ranked fifth nationally in the number of SBIR deals and third in the value of SBIR funding per $1 billion in State GDP. Over the past five years, between 233 and 362 SBIR projects have been funded annually in Maryland, providing more than $800 million in small business research, development and commercialization funding. The major funders of SBIR projects in Maryland are the DoD and HHS, which account for three-quarters of SBIR projects in Maryland.

**Table 5: SBIR/STTR Activity U.S., Maryland and Selected States, 2018-22**

| State | 2018 | 2019 | 2020 | 2021 | 2022 | National Ranking - 5 Year Awards/GDP |
|---|---|---|---|---|---|---|
| **Total Awards** | **5,656** | **7,031** | **7,310** | **6,871** | **6,577** | |
| Maryland | 274 | 302 | 362 | 294 | 233 | 5 |
| North Carolina | 183 | 195 | 215 | 236 | 202 | 17 |
| Pennsylvania | 234 | 260 | 283 | 243 | 265 | 19 |
| Virginia | 317 | 444 | 452 | 398 | 379 | 4 |
| California | 1,112 | 1,402 | 1,496 | 1,406 | 1,272 | 12 |
| Massachusetts | 593 | 725 | 732 | 680 | 634 | 1 |
| **Total Funding (Mil. $s)** | **$2,845.0** | **$3,806.0** | **$3,909.8** | **$3,610.7** | **$3,728.6** | |
| Maryland | $136.2 | $179.4 | $215.0 | $168.9 | $131.8 | 3 |
| North Carolina | $100.1 | $106.3 | $144.5 | $148.7 | $125.6 | 14 |
| Pennsylvania | $127.3 | $144.4 | $165.3 | $150.5 | $179.8 | 15 |
| Virginia | $167.5 | $212.2 | $233.1 | $222.5 | $212.5 | 5 |
| California | $553.9 | $778.6 | $833.9 | $742.8 | $742.0 | 12 |
| Massachusetts | $330.2 | $521.5 | $402.0 | $411.6 | $353.3 | 1 |

Source: JFI Analysis of SBIR.Gov Data

**Table 6: Maryland Share of SBIR/STTR Activity, By Agency 2017-22**

| Agency | Awards | % of Total | % of U.S. | Mil. $s | % of Total | %of U.S. |
|---|---|---|---|---|---|---|
| Department of Agriculture | 16 | 0.9% | 2.4% | $3.5 | 0.4% | 2.1% |
| Department of Commerce | 15 | 0.9% | 4.2% | $3.1 | 0.3% | 3.7% |
| Department of Defense | 914 | 51.8% | 4.8% | $458.8 | 46.5% | 4.6% |
| Department of Education | 2 | 0.1% | 1.5% | $0.4 | 0.0% | 0.7% |
| Department of Energy | 92 | 5.2% | 2.4% | $47.7 | 4.8% | 2.5% |
| Department of Health and Human Services | 459 | 26.0% | 5.3% | $380.8 | 38.6% | 5.9% |
| Department of Homeland Security | 25 | 1.4% | 10.1% | $8.3 | 0.8% | 7.8% |
| Department of Transportation | 15 | 0.9% | 8.4% | $6.1 | 0.6% | 9.5% |
| Environmental Protection Agency | | 0.0% | 0.0% | $0.0 | 0.0% | 0.0% |
| NASA | 130 | 7.4% | 4.1% | $41.8 | 4.2% | 3.9% |
| National Science Foundation | 96 | 5.4% | 3.5% | $37.0 | 3.7% | 3.4% |
| **Total** | 1,764 | 100.0% | 4.5% | $987.5 | 100.0% | 4.7% |

Source: JFI Analysis of SBIR.Gov Data

## Federal Procurement

***Maryland, with its proximity to the nation's capital, is a leader in federal procurement and these federal purchases are a key driver of innovation in the State***. Maryland is ranked third nationally in overall federal procurement per capita. Federal procurement in technology focused areas can be viewed as both an *innovation ecosystem input* and an *outcome*. Federal technology procurement can serve as an *innovation ecosystem input*, because federal purchases can drive innovation at the firms supplying the goods or services to the federal government. Alternatively, federal technology procurement can be viewed as an *innovation ecosystem outcome*, because federal government technology purchases themselves are based on the strength and competitiveness of the local innovation and technology business base. It became clear though the stakeholder interviews conducted, described in more detail below, ***that most of the stakeholders interviewed viewed federal procurement as a driver of innovation in the State***. Maryland is home to a large number of federal laboratories and research facilities, including the Beltsville Agricultural Research Center, NASA Goddard, Naval Air Station Patuxent River, NIH, NIST, and others, and with its proximity to the nation's capital, the DMV area is home to a large base of federal technology contractors. This activity has supported the development of a strong base of innovation and technology-based companies in Maryland, especially in the three leading areas of life sciences, information technology (including Cybersecurity) and electronics most relevant to the Maryland innovation and technology business base and the focus of this assessment. Many of these firms are leaders and key innovators in their respective fields. To assess the role of federal procurement as a driver of Maryland's innovation ecosystem, the JFI analyzed trends in federal procurement in the State in three target industry clusters: Electronics, Information Technologies, and Life Sciences (described in more detail below), as compared to regional and national peer states.

***Federal procurement is a driver not only of the Maryland economy, it is a critical component of the State's innovation ecosystem***. The Federal Government purchases $42.1 billion in goods and services from Maryland companies in 2022, with $4.1 billion in purchases of Life Sciences goods and services purchases, $12.6 billion in purchases of IT services purchases (30% of all federal procurement in Maryland), and $0.9 billion in purchases of

Electronic products. Federal procurement is clearly a driver of these sectors in Maryland, with Maryland ranked seventh nationally in the level of Federal Life Sciences Procurement per Life Sciences establishment, third in IT Services and sixth in Electronics.

**Table 7: Federal Total, Life Sciences, Information Technology and Electronics Procurement, 2017-22**

| | Procurement (Mil. $s) | | Growth (2017-22) | | Ranking Proc. Per |
|---|---|---|---|---|---|
| State/Cluster | 2017 | 2022 | # | % | Estab. |
| **Maryland - Total Procurement** | $30,862.2 | $42,076.9 | $11,214.7 | 36% | |
| Life Sciences | $351.3 | $4,124.7 | $3,773.4 | 1074% | 7 |
| Information Technology | $9,135.1 | $12,602.8 | $3,467.7 | 38% | 3 |
| Electronics | $1,294.5 | $896.4 | ($398.1) | (31%) | 6 |
| **North Carolina - Total Procurement** | $5,708.9 | $7,869.5 | $2,160.6 | 38% | |
| Life Sciences | $391.1 | $1,909.0 | $1,517.9 | 388% | 20 |
| Information Technology | $419.6 | $546.3 | $126.7 | 30% | 31 |
| Electronics | $105.7 | $131.4 | $25.7 | 24% | 35 |
| **Pennsylvania - Total Procurement** | $15,551.6 | $18,356.4 | $2,804.8 | 18% | |
| Life Sciences | $1,665.9 | $5,647.5 | $3,981.6 | 239% | 4 |
| Information Technology | $588.3 | $776.3 | $188.0 | 32% | 25 |
| Electronics | $310.0 | $294.2 | ($15.9) | (5%) | 20 |
| **Virginia - Total Procurement** | $54,029.9 | $90,594.3 | $36,564.4 | 68% | |
| Life Sciences | $233.2 | $4,337.8 | $4,104.6 | 1760% | 6 |
| Information Technology | $15,373.8 | $25,348.7 | $9,974.8 | 65% | 2 |
| Electronics | $2,044.8 | $2,123.4 | $78.6 | 4% | 4 |
| **California - Total Procurement** | $55,572.3 | $57,023.5 | $1,451.2 | 3% | |
| Life Sciences | $9,500.9 | $12,786.9 | $3,286.0 | 35% | 9 |
| Information Technology | $2,065.9 | $2,466.5 | $400.5 | 19% | 22 |
| Electronics | $1,248.3 | $1,455.8 | $207.5 | 17% | 28 |
| **Massachusetts - Total Procurement** | $13,368.4 | $18,656.9 | $5,288.5 | 40% | |
| Life Sciences | $706.8 | $3,580.0 | $2,873.2 | 407% | 12 |
| Information Technology | $309.0 | $453.6 | $144.6 | 47% | 33 |
| Electronics | $870.7 | $885.6 | $15.0 | 2% | 10 |

Source: JFI Analysis of SAM.Gov and Lightcast Data

## Patenting

In addition to R&D activities, the level of patenting activities is one of the most widely used proxies to measure levels of regional innovation. While R&D can be viewed as the *input* to the innovation process; patenting can be viewed as one of the core *outcomes* of the innovation process, measuring the level of new product or process innovations developed in the State. With 1,658 patents issued to Maryland assignees in 2021, Maryland is ranked 23rd nationally in patents issued, 27th in patents issued per capita, and 17th nationally in 2016-21 growth in patents issued. With 269 patents issued per million people in Maryland, the State is well below the average for the nation (503) and all regional and aspirational peer states (Figure 10). Maryland patenting activity is highly concentrated in the life sciences (pharmaceuticals, biotechnology, medical technology), information technology methods, and electronics sectors (digital communication, telecommunications and computer technology) areas that are driving Maryland's technology base. One reason that Maryland's overall level of patenting activity may be low is the State's lower levels of industry R&D, with most patents issued to companies nationally and in Maryland. Six of the top twenty patent recipients in Maryland accounting for about a quarter of patents are either universities or federal agencies.

**Figure 10. Total and Per Capita Patents Issued to Maryland Assignees in 2021, Maryland and Peer States**

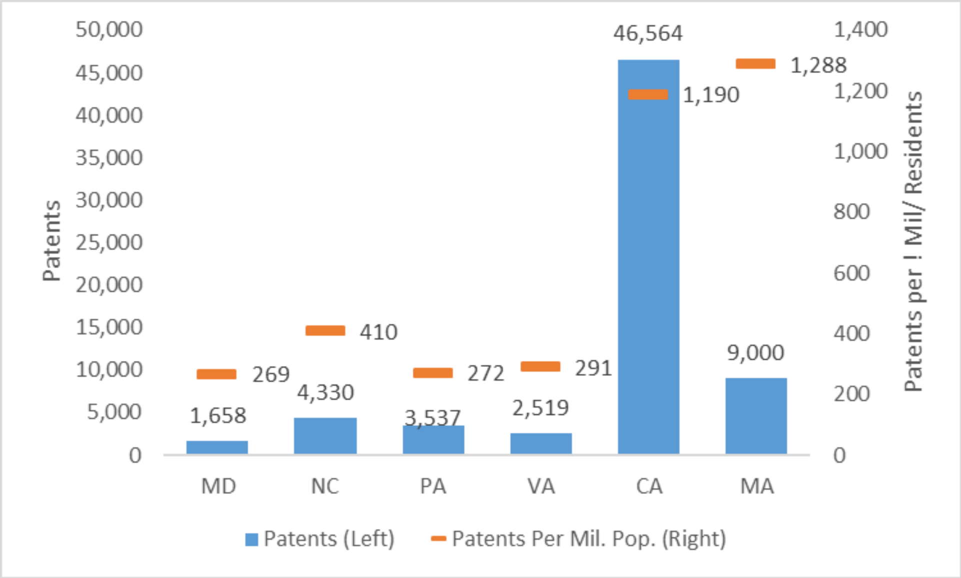



**Table 8: Patenting Activity By Assignee State, 2017-21**

| State | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Change 2016-2021 # | % |
|---|---|---|---|---|---|---|---|---|
| **50 State & D.C. Total** | **156,134** | **166,027** | **160,144** | **184,881** | **183,189** | **166,915** | **10,781** | **7%** |
| Maryland | 1,435 | 1,530 | 1,397 | 1,666 | 1,856 | 1,658 | 223 | 16% |
| North Carolina | 3,126 | 3,571 | 3,559 | 4,212 | 4,317 | 4,330 | 1,204 | 39% |
| Pennsylvania | 3,235 | 3,641 | 3,526 | 3,915 | 3,965 | 3,537 | 302 | 9% |
| Virginia | 1,456 | 1,654 | 1,855 | 2,583 | 2,910 | 2,519 | 1,063 | 73% |
| Massachusetts | 7,706 | 8,520 | 8,017 | 9,506 | 9,363 | 9,000 | 1,294 | 17% |
| California | 44,730 | 46,096 | 43,198 | 50,358 | 50,324 | 46,564 | 1,834 | 4% |

Source: JFI Analysis of USPTO Office of the Chief Economist Data

**Table 9: Maryland Patenting Activity By WIPO Area, 2017-21**

| WIPO Area | 2017-21 | % of Total | WIPO Area | 2017-21 | % of Total |
|---|---|---|---|---|---|
| Total | <u>**7,965**</u> | | | | |
| Pharmaceuticals | 1,570 | 20% | IT methods for management | 227 | 3% |
| Biotechnology | 1,324 | 17% | Basic materials chemistry | 200 | 3% |
| Digital communication | 1,226 | 15% | Handling | 182 | 2% |
| Computer technology | 1,001 | 13% | Basic communication processes | 159 | 2% |
| Medical technology | 1,000 | 13% | Engines, pumps, turbines | 159 | 2% |
| Telecommunications | 956 | 12% | Mechanical elements | 146 | 2% |
| Measurement | 874 | 11% | Furniture, games | 142 | 2% |

| WIPO Area | 2017-21 | % of Total | WIPO Area | 2017-21 | % of Total |
|---|---|---|---|---|---|
| Analysis of biological materials | 490 | 6% | Materials, metallurgy | 141 | 2% |
| None | 478 | 6% | Thermal processes and apparatus | 138 | 2% |
| Organic fine chemistry | 447 | 6% | Semiconductors | 131 | 2% |
| Chemical engineering | 377 | 5% | Surface technology, coating | 117 | 1% |
| Electrical machinery, apparatus, energy | 356 | 4% | Environmental technology | 105 | 1% |
| Optics | 337 | 4% | Civil engineering | 97 | 1% |
| Other special machines | 319 | 4% | Machine tools | 91 | 1% |
| Audio-visual technology | 294 | 4% | Macromolecular chemistry, polymers | 89 | 1% |
| Control | 285 | 4% | Micro-structural and nano-technology | 82 | 1% |
| Transport | 260 | 3% | Textile and paper machines | 67 | 1% |
| Other consumer goods | 241 | 3% | Food chemistry | 47 | 1% |

Source: JFI Analysis of Patents View Data

**Table 10: Maryland Patenting Activity for Top Twenty Assignees, 2017-21**

| WIPO Area | 2017-21 | % of Total |
|---|---|---|
| **Total** | **8,107** | **100%** |
| The John Hopkins University | 894 | 11% |
| Lockheed Martin Corporation | 728 | 9% |
| Ciena Corporation | 566 | 7% |
| U.S. Government - Air Force | 524 | 6% |
| Hughes Network Systems, LLC | 346 | 4% |
| Under Armour, Inc. | 331 | 4% |
| University of Maryland, Baltimore | 238 | 3% |
| University of Maryland, College Park | 189 | 2% |
| Meso Scale Technologies, LLC | 75 | 1% |
| Medimmune, LLC | 66 | 1% |
| Senseonics, Incorporated | 61 | 1% |
| W. R. Grace & Co.-Conn. | 58 | 1% |
| Noxell Corporation | 57 | 1% |
| Moskowitz Family LLC | 56 | 1% |
| The Henry M. Jackson Foundation for The Advancement of Military Medicine | 55 | 1% |
| University of Maryland | 55 | 1% |
| Macrogenics, Inc. | 47 | 1% |
| Lockheed Martin Energy, LLC | 40 | 0.5% |
| U.S. Government - Army | 39 | 0.5% |
| United Therapeutics Corporation | 39 | 0.5% |
| All Other | 3,643 | 45% |

Source: JFI Analysis of Patents View Data

## Summary and Conclusion Innovation Ecosystem Inputs

***Maryland is well positioned in Innovation Ecosystem Inputs but could improve in translating research and development into commercializable products.*** Maryland is ranked fifth nationally in R&D intensity, and first nationally in both federal and academic research intensity. Despite this nationally leading position in research and development activities, the fundamental input to the innovation process. Maryland performs well, but is not a leader in the translation of locally developed ideas, products and services into early stage products through the commercialization of new products through academic R&D, and lags the nation and peer states in patenting activity. ***The Federal government, through both procurement and SBIR program awards is a key driver of Maryland's innovation ecosystem***.

## Entrepreneurial Ecosystem Assets

The MIT Innovation Ecosystem model shown above identifies 1) Innovation Capacity and 2) Entrepreneurship Capacity as the "twin engines" of an innovation ecosystem. Entrepreneurship Capacity is the capacity to start, build and scale new-to-the-world enterprises to maturity. The MIT model identified five key inputs of regional entrepreneurship capacity, including: human capital; funding; infrastructure; demand; and culture and incentives. Because this model is being deployed to assess innovation ecosystem strength at the state rather than national level, this analysis focused on three of these key inputs: human capital; venture capital funding; and infrastructure.

## Venture Capital

Innovation ecosystems are built on the deployment, commercialization and translation of research and innovations into marketable processes and products. For new innovation-based startups, access to capital to is critical to success. According to McKinsey and Company's 2023 report, *Building innovation ecosystems: Accelerating tech hub growth*:

> Scaling up R&D, both academic and private, can help ensure that innovation remains robust. Those ideas can then be translated into start-ups by attracting entrepreneurs, fostering tech transfers, and building out IP assets. Seed, angel, and broader venture capital funding nurtures start-ups so that they survive and scale up past infancy. Early-stage companies—part of the integrated innovation funnel and value that the ecosystem promises—also need access to capital and structured support.[16]

In 2023, the Maryland Technology Development Corporation (TEDCO) commissioned the *MARYLAND INNOVATION Competitiveness Study* conducted by RTI and Keen Point Consulting, which found that,

> Nationally, Maryland ranks 17th in Venture Capitalist (VC) dollars invested in Maryland companies, compared to its rank as the 15th largest state by GDP. Over the past 5 years, Maryland's strongest deal activity has been in Software, Biotech/Pharma, Devices, B2B, and Health Tech …
>
> To benchmark Maryland, RTI leveraged a recent study of VC activity in nine Southeastern states conducted by Panoramic Ventures and analyzed PitchBook data for Maryland to enable comparisons. Maryland ranked fifth out of 10 states for total number of deals and VC dollars invested from 2017 through the first half of 2022 (1H 2022… States like North Carolina that are 50% bigger in terms of GDP attracted 125% more VC investment over the same period.

Maryland tied for third with Georgia for VC investment dollars attracted relative to the size of its economy—or $1.71 for every $1,000 of GDP.[17]

***Maryland lags our aspirational and regional peers in overall levels of venture capital investment and in per capita investment.*** Building on the TEDCO report, the JFI analyzed national levels of venture capital investment and management using data from the 2023 National Venture Capital Association (NVCA) Yearbook, based on PitchBook data.[18] Based on this data, Maryland is in the second tier of states in terms of venture capital investment, and lags its aspirational and regional peers in both total and per capita venture capital investment. Nationally, venture capital investment is highly concentrated in just two states, California and Massachusetts, which together accounted for 38% of companies receiving venture capital funding, 52% of venture capital invested, and 65% of venture capital assets under management. In contrast, Maryland, with 190 companies receiving $1.6 billion in venture capital funding and $9.0 billion in venture capital assets under management accounted for 1% of companies receiving venture capital funding, venture capital investment, and venture capital assets under management. However, Maryland is ranked 9th in total Venture Capital Assets Under Management and 10th in Venture Capital Assets Under Management measured per capita.

**Table 11: Venture Capital Activity, 2022**

| State | Venture Capital Deals | | | Venture Capital Assets Under Management (Mil. $) | VC Investment / Capita | VC AUM/ Capita |
|---|---|---|---|---|---|---|
| | # of Companies | # Deals Closed | Capital Invested (Mil. $s) | | | |
| **Total U.S.** | **15,301** | **16,380** | **$240,539** | **$895,123** | **$722** | **$2,686** |
| Maryland | 190 | 200 | $1,582 | $9,028 | $257 | $1,465 |
| North Carolina | 289 | 306 | $4,407 | $3,425 | $412 | $320 |
| Pennsylvania | 352 | 392 | $4,684 | $2,914 | $361 | $225 |
| Virginia | 249 | 266 | $3,104 | $9,354 | $357 | $1,077 |
| California | 4,956 | 5,274 | $104,021 | $479,136 | $2,665 | $12,276 |
| Massachusetts | 928 | 998 | $21,354 | $102,487 | $3,058 | $14,679 |

Source: JFI Analysis of NVCA Data

The NVCA also produces an analysis of venture capital investments by state in the regional data section. According to this analysis, from 2017-2021, 783 Maryland-based startups raised venture funding and received $6.5 billion to fund their innovative ideas and grow their businesses. In 2021, 169 companies (16th in the nation) raised $2.37 billion (15th in the nation), with most of the investment being made in the Healthcare (including Life Sciences) with $1.35 billion in funding, and Information Technologies with $780 million.[19]

***Venture capital investment in Maryland is highly concentrated in the core Life Sciences and IT clusters.*** For this project, the JFI utilized the Crunchbase database to analyze actual venture capital deals in Maryland, unlike the TEDCO and NVCA reports, which used PitchBook.[20] As a result, this analysis of the venture capital deals in Maryland differs from the NVCA analysis above. Based on the Crunchbase database, venture capital deals in Maryland grew from 90 deals and $460 million in funding in 2017 to 226 deals and $1.9 billion in investment (down from a high of $2.2 billion in investment in 2021) in 2022 (Figure 11).[21] The majority of investments are in IT-related companies 297 (37%) of companies and $2.4 billion (36%) of investment) and Life Sciences (193 (24%) companies and $1.5 billion (26%) in investment (Figures 12 and 13).[22] Within IT-related companies, Artificial

Intelligence ($104 million) and Cyber ($534 million), and in Life sciences, BioPharma/Biotechnology ($1.3 billion) and Medical Devices ($118 million) all stand out as high focus areas.

**Figure 11: Crunchbase Venture Capital Deals, 2017-22**

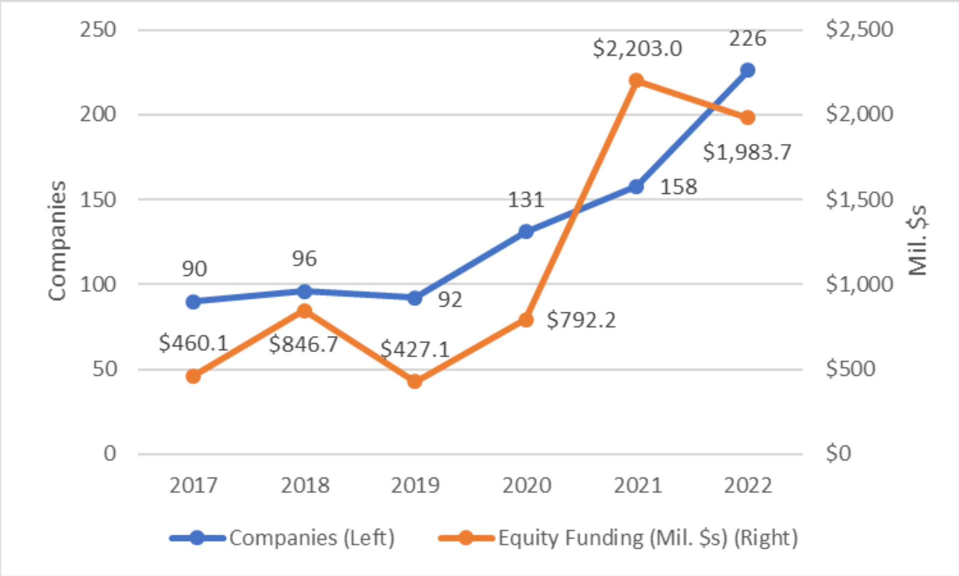



**Figure 12: Crunchbase Venture Capital Deals by Cluster 2017-22**

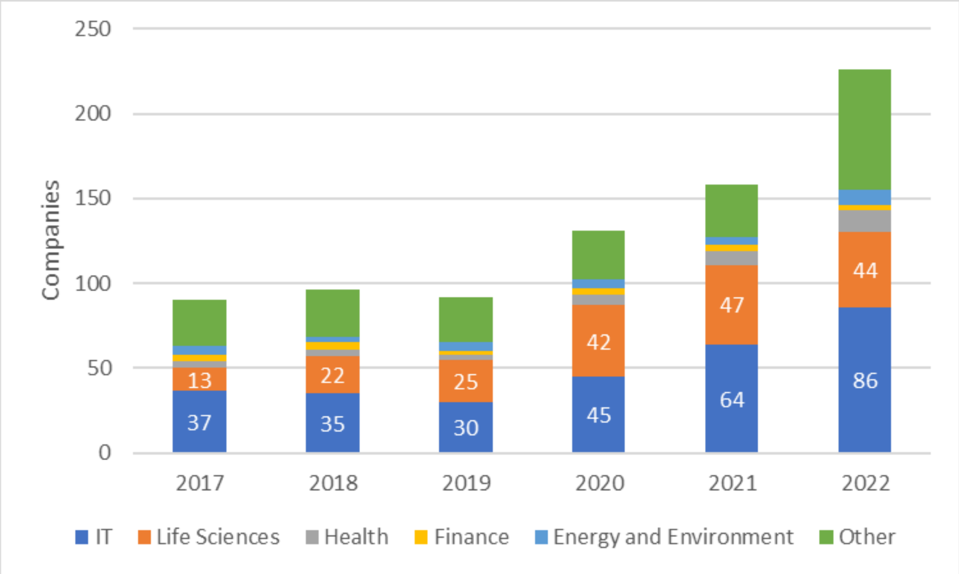
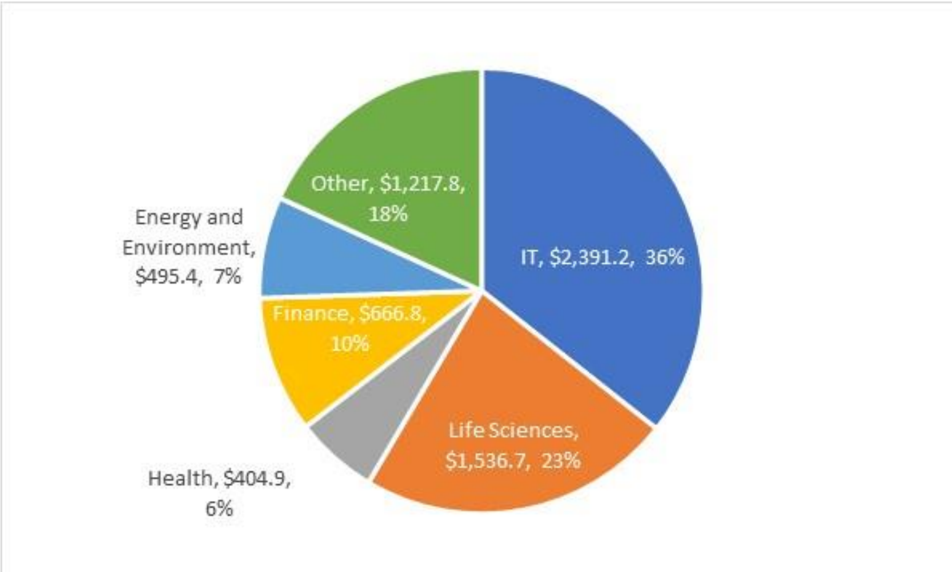


**Figure 13: Crunchbase Five Year Venture Capital Deals Amount by Cluster 2017-22 – New**




## Human Capital

Human capital resources drive both the innovation and the translation of new ideas and products into commercial and economic activity. According to the 2023 McKinsey and Company report, *Building innovation ecosystems: Accelerating tech hub growth*, "Another critical component of successful ecosystems is a coordinated talent strategy. A scarcity of talent can severely constrain an ecosystem's growth. For knowledge-based industries, location decisions often hinge on the available talent pool and the ability to develop and attract qualified candidates."[23] The availability, cost and quality of labor is a core driver of the economic development process, with Labor Cost and Labor Availability ranked as the first and third most important site selection factor considered by corporate executives in the Area Development Magazine *37th Annual Corporate Survey: Economic Pressures Exerting Greatest Effect on Decision-Makers*.[24] The MIT innovation ecosystem assessment model includes human capital as a core component of both innovation and entrepreneurial capacity, with the supply of Science, Technology, Engineering and Mathematics (STEM) graduates and researchers engaged in R&D included as inputs to innovation capacity and higher education enrollment as indicators of entrepreneurial capacity.

***Access to Talent is one of Maryland's critical innovation ecosystem strengths.*** In order to assess Maryland's competitive position in human capital, the JFI analyzed three indicators: 1) the educational attainment of the resident workforce; 2) the concentration of resident employment in key management and STEM occupations; and 3) the generation of STEM talent in the form of degrees granted. Maryland is well positioned in all of three of these indicators:

- With 42.5% of Maryland residents 25 and older having a Bachelors and above Maryland, is ranked 6th nationally and ahead of all peer states except Massachusetts (Figure 14);
- With 2.7% of Maryland residents 25 and older having a Doctoral degree, Maryland is ranked 3rd nationally and ahead of all peer states except Massachusetts (Figure 14);

- The JFI assessed the relative concentration of resident employment in the key business and STEM occupations in Maryland and peer states compared to the nation using occupational location quotients (LQ).[25] An LQ above one indicates a higher concentration of employment in a specific occupational grouping than the national average. Maryland has:
    - The third-highest concentration of resident employment in management, business, and financial occupations among peer states, behind Massachusetts and Virginia and has the sixth-highest concentration of employment in these occupations nationally;
    - The highest concentration of resident employment in computer and mathematical occupations among peer states and second-highest concentration of employment in these occupations nationally;
    - The third-highest concentration of resident employment in architecture and engineering occupations among peer states, behind California and Massachusetts and has the 12th-highest concentration of employment in these occupations nationally; and
    - The second-highest concentration of resident employment in Life, physical, and social science occupations among peer states, behind Massachusetts, and has the third-highest concentration of employment in these occupations nationally (Figure 15);
- The JFI analyzed the generation of STEM talent in the form of Associate's degrees and higher in key STEM fields. While Maryland produces fewer STEM degrees than our regional and national peers, the state is behind only Massachusetts and is ranked fifth nationally in STEM degree production per million residents (Table 12).

**Figure 14: Educational Attainment by State**

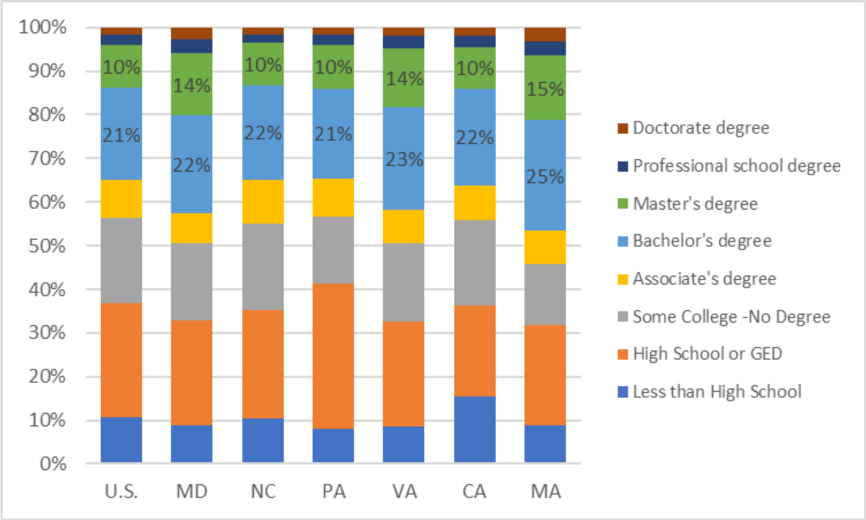


**Figure 15: Concentration of Employment in Selected Occupations**

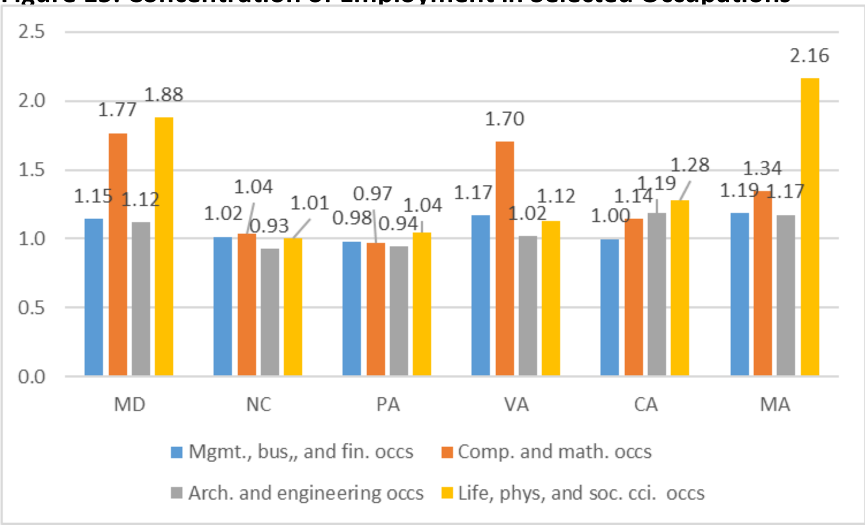



**Table 12: STEM Degree Generation - Maryland and Selected Peer States, 2021**

| State | Total STEM Degrees | Associate's Degree | Bachelor's Degree | Master's Degree | Doctoral Degrees | STEM Degrees per Million Residents |
|---|---|---|---|---|---|---|
| Maryland | 24,455 | 1,900 | 13,955 | 7,753 | 847 | 3,961 |
| North Carolina | 27,053 | 2,742 | 16,528 | 6,603 | 1,180 | 2,560 |
| Pennsylvania | 44,360 | 2,636 | 28,530 | 11,546 | 1,648 | 3,409 |
| Virginia | 26,589 | 4,443 | 16,865 | 4,430 | 851 | 3,071 |
| California | 137,390 | 36,634 | 73,100 | 23,536 | 4,120 | 3,510 |
| Massachusetts | 39,725 | 1,592 | 21,271 | 15,021 | 1,841 | 5,683 |

Source: JFI Analysis of Lightcast Data

## Real Estate Assets

The increasingly important role of placemaking in the geography of innovation is arguably the most important change in innovation and technology-based economic development in the past decade. The development of Live-Work-Play-Learn environments has become a core driver of building an innovation economy. According to the 2023 McKinsey and Company report, *Building innovation ecosystems: Accelerating tech hub growth:*

> Say that sufficient talent has been attracted to an area and that large anchor tenants are coexisting with accelerators, incubators, start-ups, and academic entities. But to be sustainable, an ecosystem needs to remain attractive to businesses, institutions, and workers. That enduring appeal is anchored in two types of infrastructure: first, the physical and virtual infrastructure aligned to the specific needs of the prioritized sectors (for example, wet-lab space for life sciences), and second, the "placemaking" infrastructure that informs quality of life. Leaders typically focus on the physical and virtual, which are crucial, but placemaking is also key for facilitating an inclusive community, vibrant and successful start-ups, collaboration, ideas, and growth, as well as making people who live and work in the ecosystem happier and more productive.[26]

The development of place-based ***Innovation Districts*** that combine: *Economic assets* (firms, institutions and organizations); *Physical assets* (open and connected research, employment, residential and retail spaces); and *Networking assets* (connections between individuals, firms, and institutions involved in innovation) are essential for the success of an innovation ecosystem. According to the Brooking Institution's *The Rise of Innovation Districts: A New Geography of Innovation in America* report, "Innovation districts reach their potential when all three types of assets, combined with a supportive, risk-taking culture, are fully developed, creating an innovation ecosystem."[27]

The availability and cost of appropriate real estate has long been a recognized driver of economic development. According to Site Selection Magazine's 37th Annual Corporate Survey, real estate costs and availability are two of the top ten site selection factors considered by businesses and quality of life factors are now the second most important factor (up from 11th in the prior survey). With three large university-anchored innovation districts (the Discovery District, East Baltimore Development, Inc., and the University of Maryland, Baltimore [UMB] BioPark) and the planned The Labs at Belward project[28], Maryland is well served with innovation spaces in three of its main employment centers. In order to assess the impact of real estate assets on Maryland's innovation ecosystem, the JFI analyzed CoStar data on the cost, availability and supply of office, industrial and flex space in Maryland and the selected peer states. With 293.2 million square feet of office space, 350.6 million square feet of industrial space, and 89.2 million square feet of flex space, Maryland has a large inventory of space for innovation companies. Maryland's vacancy rate is below the national average for office space and above the national average for industrial and flex space (Figure 16). In terms of real estate costs, Maryland is generally competitive in terms of the cost of office space with our regional peers and below our aspirational peers but the cost of industrial and flex space tends to be higher than our regional peers. (Figure 17).

**Figure 16: Vacancy by Major Real Estate Class, Maryland and Selected Peer States**

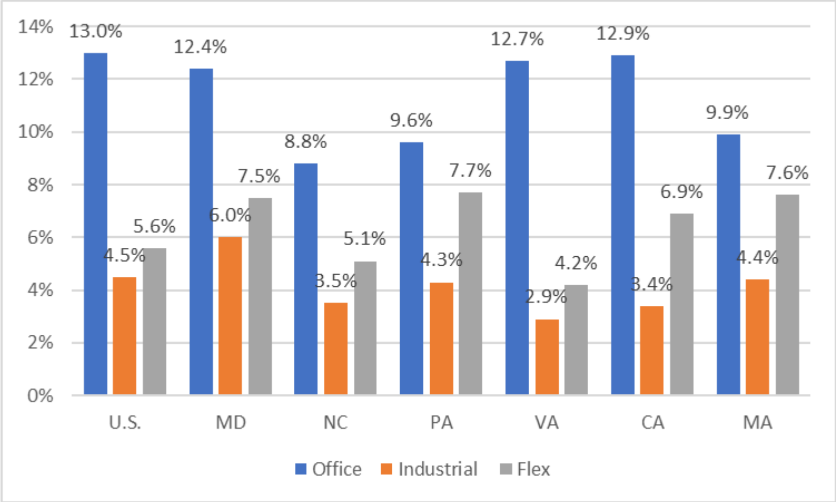
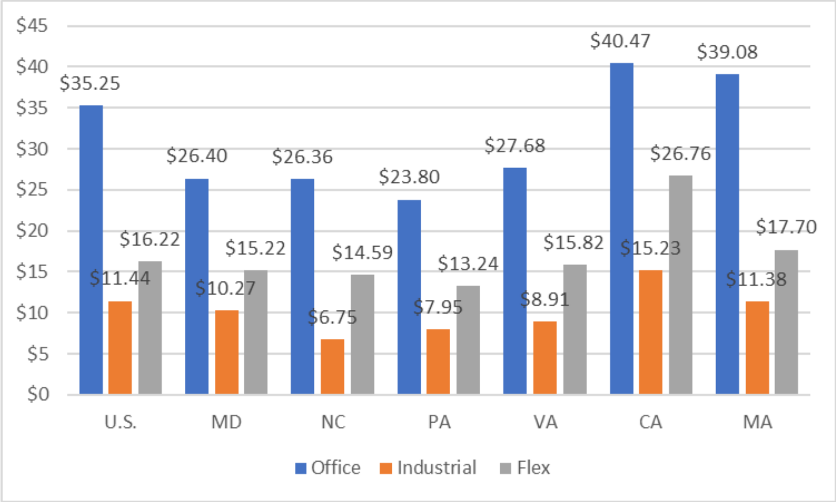


**Figure 17: Average Rent by Major Real Estate Class, Maryland and Selected Peer States**




There is no national database for the wet lab space required by the life sciences sector comparable to the CoStar database, so the JFI reviewed the CBRE *Despite Rising Vacancy, Life Sciences Real Estate Development Continues U.S. Life Sciences | Q1 2023* report.[29] This report assessed the Washington D.C./Baltimore area (most of the space analyzed is in Maryland) and found that the region has 12.6 million square feet of Lab/R&D space with only 2.6% vacancy. Rents average $65.62 per square foot and there is 1.6 million square feet under construction. The Washington D.C./Baltimore market is the fifth largest of the 13 markets analyzed (behind Boston, San Francisco, San Diego and New Jersey) and has the lowest level of vacancy, second lowest rents (behind Raleigh-Durham) and 1.6 million square feet of Lab/R&D Space under construction. Based on interviews, the R&D/wet lab inventory in Maryland is adequate for current needs, while shortages were reported in submarkets, especially in the Baltimore area.

## Translational Assets

Commercializing new technologies and innovations into new products, services and/or start-up companies requires more than venture capital, talent and appropriate space. Translational assets exist in the form of the many programs, networks and other organizations existing to support innovation and entrepreneurship. According to the 2023 McKinsey and Company *Building innovation ecosystems: Accelerating tech hub growth* report:

> Ecosystems can support activities across the integrated innovation funnel in several ways. University anchors can empower tech transfer offices to scout and support developing technologies more proactively. Incubators and accelerators can help entrepreneurs on their journeys. Ecosystem leaders can coordinate start-up showcases by building out physical hubs that allow VC firms to interact with the ecosystem organically.[30]

One important group of translational assets are Entrepreneurial Support Organizations (ESOs), which include incubators, science and technology parks, accelerators, and, more recently, many maker spaces and coworking spaces that have been created by numerous state and local governments, universities and other organizations involved in technology-based economic development. The goal of ESOs is to support innovation ecosystems by catalyzing entrepreneurial activity and providing entrepreneurs with support.[31]

***Maryland is well served with incubators and accelerators***. There are a number of translational assets that support, grow and sustain Maryland's innovation ecosystem, including the MTC itself. It is outside of the scope of this brief and limited engagement to catalog and assess all of the translational assets serving Maryland; therefore, the JFI focused this analysis on two types of ESOs – incubators and accelerators. Because there is no data source on business incubators and accelerators nationally and most peer state economic development websites do not have complete lists of business incubators, this analysis focused on Maryland alone. The Maryland Department of Commerce lists 54 business incubators and accelerators in Maryland.[32] There are incubators and accelerators in every region of the State, with the Baltimore Metropolitan region having the most with 26, including 14 in Baltimore City. That is followed by the Washington Suburbs, with 17; the Eastern Shore, with seven, and two each in Southern and Western Maryland. Thirty-nine of the 54 Maryland business incubators and accelerators are business incubators, nine are both accelerators and incubators, four are coworking spaces, and two are accelerators. Maryland incubators and accelerators operate across all major industry and technology focus areas, with 20 being general business incubators serving all types of businesses, 20 targeted broadly to technology companies, 17 focusing on biotechnology and health, 17 on information technologies (Table 13 - incubators/accelerators can serve more than one focus area).

**Table 13: Focus Areas for Incubators and Accelerators in Maryland**

| Focus Areas | Number of Incubators/ Accelerators | % of Facilities |
|---|---|---|
| General Business | 20 | 37% |
| Technology | 20 | 37% |
| Biotechnology/Health | 17 | 31% |
| IT | 17 | 31% |
| Clean Tech/Environmental | 6 | 11% |
| Cyber | 4 | 7% |
| Ed Tech | 3 | 6% |
| Defense | 2 | 4% |
| International | 2 | 4% |

Note: Maryland's 54 Incubators can list multiple focus areas.

Source: JFI Analysis of Maryland Department of Commerce Data

## Summary and Conclusion Innovation Entrepreneurial Ecosystem Assets

***Maryland is well-positioned in terms of human capital, real estate and translational assets but lags our aspirational and regional peers in the level of venture capital investment. Expanding access to venture capital is seen as critical for the State to fulfill the potential of its robust innovation ecosystem.*** Entrepreneurship capacity is the capacity to start, build and scale new-to-the-world enterprises to maturity based on the innovations and technologies developed by Maryland's strong innovation ecosystem. The JFI assessed Maryland's competitive position in venture capital, human capital, real estate and translational assets. Maryland significantly lags our aspirational peers of California and Massachusetts in terms of access to, and levels of venture capital investment. The State also trails our regional peers in overall levels of investment. As will be discussed in the qualitative analysis section below, access to venture capital in Maryland is seen as moderate and improving. However, expanding access to this type of investment is seen as critical to achieving the potential of its robust innovation ecosystem.

### Innovation Ecosystem Outcomes

The reason for investing in innovation ecosystems is made clear in the McKinsey *Building innovation ecosystems: Accelerating tech hub growth* report. It found that innovation driven economies "outperform other regions and business districts economically, financially, and socially. In the most successful examples, the unifying, mission-driven spaces they create open new avenues for healthier, more diverse, and more connected communities."[33]

According to the MIT report, *A systematic MIT approach for assessing 'innovation-driven entrepreneurship' in ecosystems (iEcosystems)*, the impact of innovation ecosystems can be captured in the form of economic or social progress indicators, and

> At a more granular level, impact can be captured in terms of the types of start-ups that are being created and grow within the ecosystem – e.g., the level of job creation and levels of valuation. One novel metric of particular interest is the rise in the number and quality of 'innovation-driven enterprises' (IDEs) - enterprises that blend innovation and entrepreneurship, and in doing so have the potential for extraordinary job creation and the potential to develop solutions to important problems (at a scale that is more significant than traditional small/medium-sized enterprise (SME) start-ups).[34]

The Kauffman Foundation's *Measuring an Entrepreneurial Ecosystem* report identifies multiple points to measure the strength and performance of entrepreneurial ecosystem, including the number of new and young firms, the share of employment in new and young firms, and the density of employment in high technology firms.[35] The JFI modified and utilized these measures to assess the outcomes of Maryland's innovation ecosystem. Additionally, the JFI presents data from national reports that rank Maryland's innovation and entrepreneurial ecosystem.

### Entrepreneurial Outcomes - New and Small Businesses and Innovation Driven Establishments

In order to assess the overall *entrepreneurial ecosystem outcomes* in Maryland, the JFI analyzed the share of both firms and employment in young (less than five years old) and small (less than 19 employees) firms as well as the growth of establishments in the three high technology clusters, (Life Sciences, IT, and Electronics) targeted by MTC. Maryland has a lower than national share of young firms (30%) as a share of total firms than the national average (34%) and a slightly lower share of employment in young firms (9%) than the national average. Similarly, Maryland has a both lower share of small firms than the national average (83% compared to 88% nationally) and a slightly lower share of employment in small firms (16% compared to the national average of 17%). However, the state is generally competitive with both our regional and aspirational peer states (Figure 18). There is no database of the innovation driven enterprises identified by the Kaufman report, so the JFI tracked the level of establishment growth in the three targeted high technology clusters. While Maryland lagged the nation and all comparison states in the overall rate of establishment formation, the State outperformed the nation and most peers in Life Sciences and Electronic establishment growth but underperformed in IT establishment growth (Figure 19).

**Figure 18: Share of Firms and Employment in Young and Small Firms**

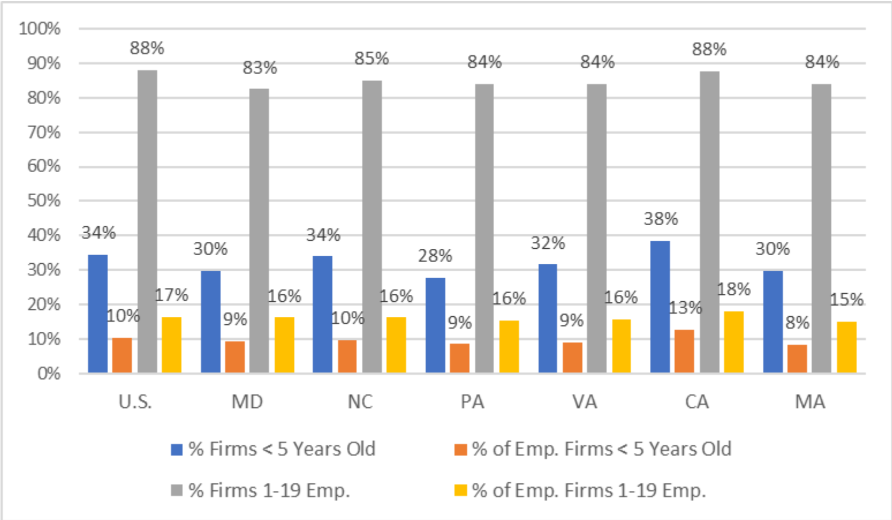
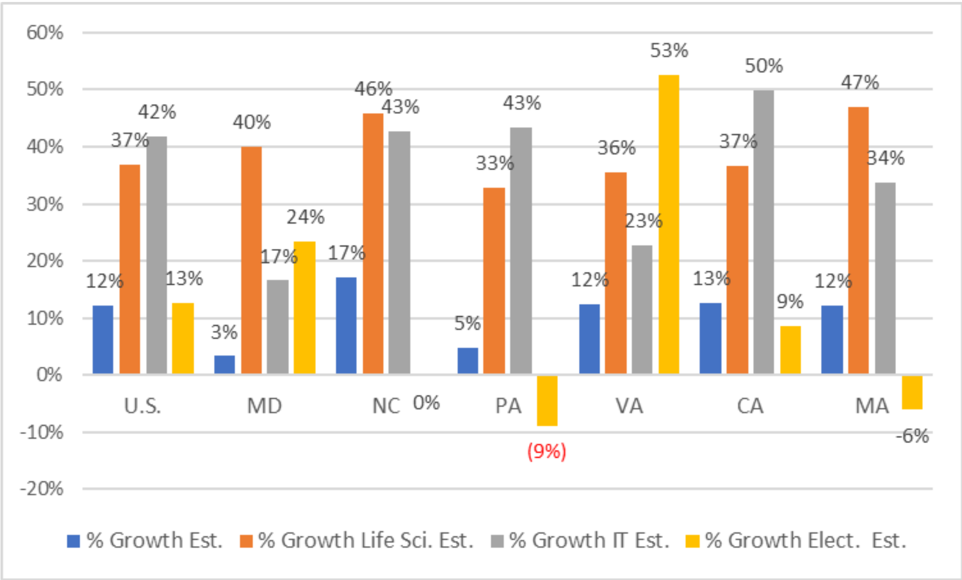



**Figure 19: Growth in Total and Technology Cluster Establishments, 2016-21**




## Cluster Employment Growth

***Maryland's three target technology industry clusters are strong and growing***. The key outcome of a states' innovation ecosystem is the strength of its base of high technology and innovation driven industry clusters. The JFI analyzed Maryland's total employment, employment concentration (as measured by employment Location Quotients (LQ)[36]), and employment growth in the three technology clusters: 1) Life Sciences; 2) Information Technologies; and 3) Electronics; targeted by MTC.[37] Data on the relative concentration of employment by cluster is presented for each state in Figure 20 and data on cluster growth is presented in Figure 21, with the data for each cluster presented in Table 14. Based on this data:

- The Maryland **Life Sciences** cluster provides 51,965 jobs, the second largest of the three target clusters. Maryland is highly specialized having a LQ of 1.6, signifying a concentration 60% above the national



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average, higher than all regional and aspirational peers except Massachusetts and the fifth highest nationally. Between 2016 and 2021, Maryland Life Sciences cluster employment grew by 19%, outpacing national employment growth of 16% but lagging all peer states except Pennsylvania;

- The Maryland **IT** cluster is the largest of the three target clusters with 103,170 jobs. Maryland is highly specialized having a LQ of 1.44, signifying a concentration 44% above the national average, behind Virginia and Massachusetts. Between 2016 and 2021, Maryland IT cluster employment grew by 10%, lagging national employment growth of 17% and lagging all peer states except Virginia; and
- Maryland is not specialized in employment in the **Electronics** cluster, the smallest of three target clusters with 7,694 jobs. However, the cluster is growing in Maryland, while Electronic Cluster employment fell nationally and in all peer states except Virginia and California.

**Figure 20: Concentration of Employment, By Cluster**

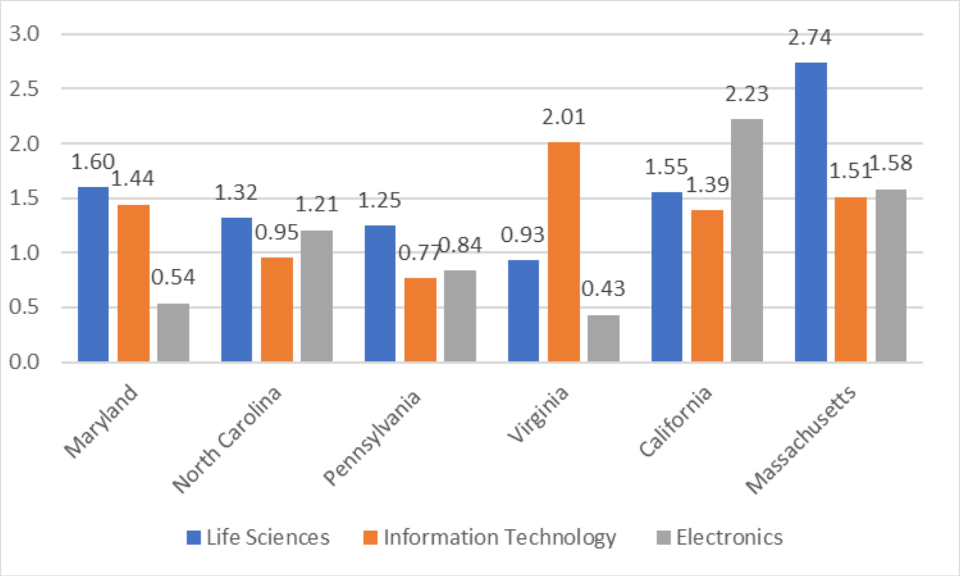


**Figure 21: Employment Growth 2016-21, By Cluster**

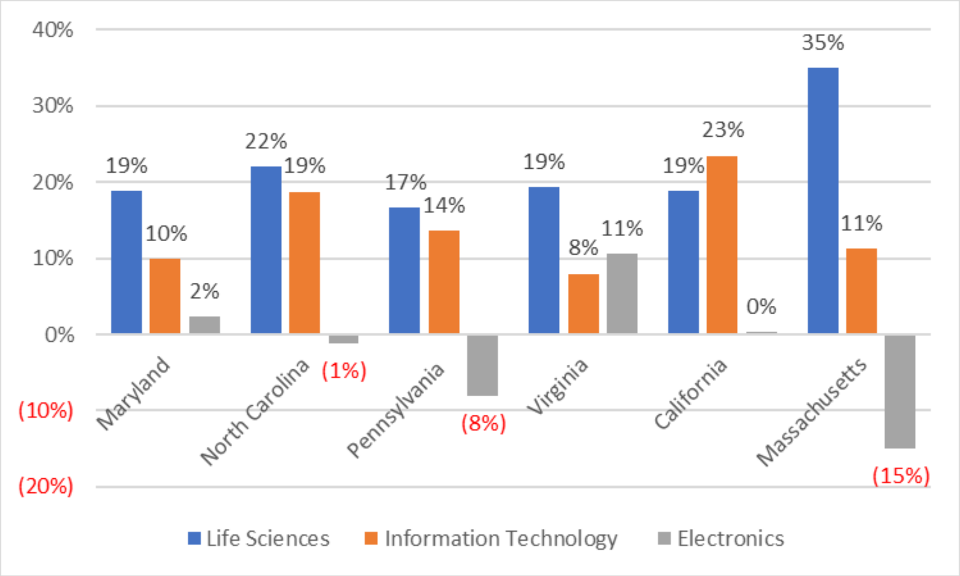



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**Table 14: Three Target Technology Clusters - Size, Concentration, Performance and Rankings**

| State/Cluster | Employment 2016 | Employment 2021 | LQ 2021 | Growth (2016-21) # | Growth (2016-21) % | National Rankings Emp. | National Rankings LQ | National Rankings Growth % |
|---|---|---|---|---|---|---|---|---|
| **Maryland - Total Private** | 2,141,805 | 2,099,419 | | (42,386) | (2%) | 22 | | 38 |
| Life Sciences | 43,709 | 51,965 | 1.60 | 8,256 | 19% | 12 | 5 | 20 |
| Information Technology | 93,860 | 103,170 | 1.44 | 9,310 | 10% | 15 | 6 | 28 |
| Electronics | 7,519 | 7,694 | 0.54 | 175 | 2% | 28 | 33 | 20 |
| **North Carolina - Total Private** | 3,565,929 | 3,828,857 | | 262,928 | 7% | 9 | | 5 |
| Life Sciences | 64,226 | 78,338 | 1.32 | 14,112 | 22% | 7 | 8 | 13 |
| Information Technology | 104,563 | 124,169 | 0.95 | 19,606 | 19% | 12 | 15 | 15 |
| Electronics | 31,743 | 31,377 | 1.21 | (366) | (1%) | 6 | 10 | 25 |
| **Pennsylvania - Total Private** | 5,062,672 | 4,998,653 | | (64,019) | (1%) | 5 | | 34 |
| Life Sciences | 83,038 | 96,836 | 1.25 | 13,798 | 17% | 4 | 11 | 27 |
| Information Technology | 115,381 | 131,072 | 0.77 | 15,691 | 14% | 11 | 24 | 22 |
| Electronics | 30,841 | 28,359 | 0.84 | (2,482) | (8%) | 8 | 19 | 32 |
| **Virginia - Total Private** | 3,095,184 | 3,147,453 | | 52,269 | 2% | 12 | | 19 |
| Life Sciences | 33,901 | 40,436 | 0.93 | 6,535 | 19% | 16 | 23 | 28 |
| Information Technology | 199,561 | 215,480 | 2.01 | 15,919 | 8% | 5 | 1 | 34 |
| Electronics | 8,403 | 9,292 | 0.43 | 889 | 11% | 24 | 37 | 14 |
| **California - Total Private** | 14,288,358 | 14,575,306 | 1.01 | 286,948 | 2% | 1 | | 17 |
| Life Sciences | 294,807 | 350,173 | 1.55 | 55,366 | 19% | 1 | 6 | 22 |
| Information Technology | 559,813 | 691,189 | 1.39 | 131,376 | 23% | 1 | 7 | 11 |
| Electronics | 219,770 | 220,392 | 2.23 | 622 | 0% | 1 | 4 | 23 |
| **Massachusetts - Total Private** | 3,065,883 | 3,039,122 | | (26,761) | (1%) | 13 | | 32 |
| Life Sciences | 95,347 | 128,676 | 2.74 | 33,329 | 35% | 2 | 2 | 3 |
| Information Technology | 140,884 | 156,771 | 1.51 | 15,887 | 11% | 8 | 5 | 25 |
| Electronics | 38,407 | 32,673 | 1.58 | (5,734) | (15%) | 5 | 7 | 43 |

Source: JFI Analysis of Lightcast Data

## Technology and Entrepreneurial Vitality Rankings

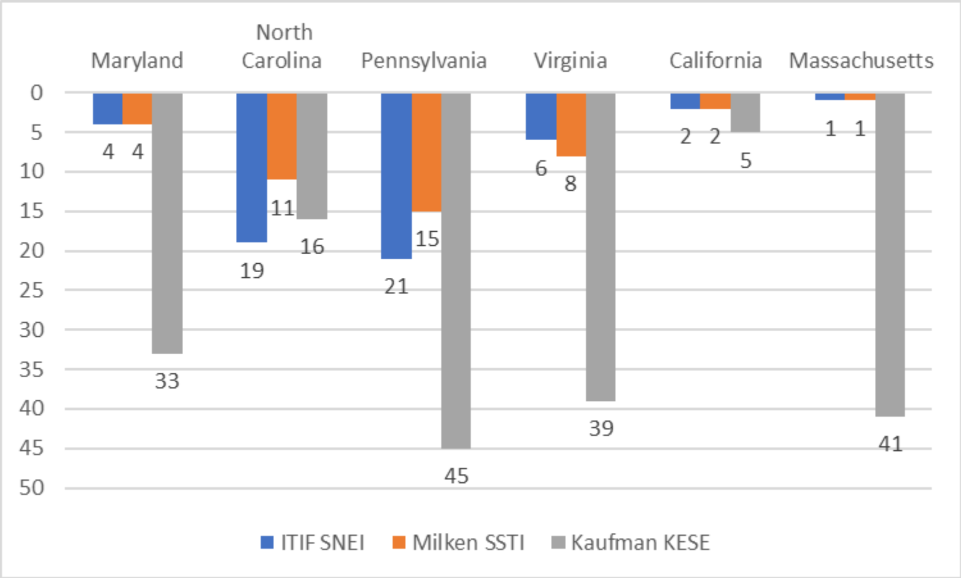
***Maryland generally performs well in terms of rankings of its overall technology capacity, being ranked fourth nationally by both the ITIF State New Economy Index and Milken Institutes State Science and Technology Index, scoring below national leaders (CA and MA) but better than our regional peers.*** It is important to note that these two indices are comprehensive assessments of knowledge or technology sector capacity and include diverse measures including R&D, risk capital, human capital, workforce, and technology sector performance, and exports, and, thus, include measures described above. Restricting these vitality indices to the performance of our ecosystem in terms of *Economic Dynamism* (ITIF) and *Technology Concentration and Dynamism* (Milken)[38], Maryland still performs well,

- **Economic Dynamism** – the ITIF SNEI's measure of economic dynamism includes four key aspects of economic dynamism: 1) the degree of business "churn" in the economy; 2) the number of fast-growing firms; 3) the number and value of companies' IPOs; and 4) the number of individual inventor patents granted. Within this Area, Maryland is ranked 13th, compared to 6th for Virginia, 21st for Pennsylvania, 23rd for North Carolina (regional peers), and 2nd for California and 4th for Massachusetts (aspirational peers); and

- **Technology Concentration and Dynamism** – The Milken Institute SSTI's Technology Concentration and Dynamism subindex measures the intensity of high-technology business growth. Within this Area Maryland is ranked 7th, compared to 5th for Virginia, 33rd for Pennsylvania, 16th for North Carolina (regional peers) and 2nd for California and 6th for Massachusetts (aspirational peers).

***It is interesting to note that using both of these national indices, Maryland's ranking for impacts of the innovation and technology-based economic development process is lower than its overall state-level index ranking, indicating that Maryland is not performing as well in translating its substantial technology resources into new companies, jobs and job growth***. This finding is consistent with Maryland's ranking in The Kauffman Early-Stage Entrepreneurship (KESE) Index, where Maryland is ranked 33rd nationally. The KESE Index presents data on and evenly weights contributions on the four indicators of early-stage entrepreneurial activity: 1) Rate of New Entrepreneurs; 2) Opportunity Share of New Entrepreneurs; 3) Startup Early Job Creation; and 4) Startup Early Survival Rate. The Kauffman Foundation suggests not ranking based on the overall index, but instead based on each of the four indicators utilized, with Maryland ranked 31st, 21st, 50th, and 23rd respectively.

**Figure 22: National Rankings**




## Summary and Conclusion Innovation Ecosystem Outcomes

Based on the JFI's quantitative assessment, Maryland's innovation capacity is strong in terms of research and development activities but is not performing as well as other states in translating the new innovations developed into patenting and commercialization activities. Maryland's entrepreneurial assets are strong in human capital, real estate and business incubation assets, but the State faces gaps in venture capital funding. As a result, innovation ecosystem outputs in terms of young and small business activity is not as strong as the nation. While Maryland has strong technology clusters, growth in these areas lags peer competitor states. Maryland's technology system is well-ranked in terms of technology assets, but is lacking in terms of economic and employment growth outcomes. ***As a result, efforts to strengthen the State's overall innovation ecosystem, especially in the areas of patenting, commercialization and venture capital are necessary to promote growth.***

## QUALITATIVE ASSESSMENT OF MARYLAND'S INNOVATION ECOSYSTEM

The JFI's *Quantitative Analysis* benchmarked Maryland to selected regional and aspirational competitor peer states in twelve areas of indicators across the three key domains of Maryland's innovation ecosystem and found both strengths and weaknesses. While the quantitative analysis above assesses the State's position relative to the competition, it only tells part of the story about the performance of Maryland's innovation ecosystem. Equally, if not more important, are the perceptions of the academic institutions, innovation support organizations, government and technology businesses that make up the State's innovation ecosystem. The JFI conducted 21 interviews and one focus group with five BCTF businesses across these key innovation ecosystem innovation ecosystem stakeholder engagement areas including: 12 businesses, three venture capital companies, Maryland's two leading research universities, and eight government and technology/innovation support organizations (see Appendix B for a list of the key stakeholders interviewed). While there was general agreement with the findings of the quantitative assessment, especially in terms of the strength and key drivers of Maryland's innovation ecosystem, there is a diversity of opinions in terms of the overall performance of the State's innovation ecosystem, and steps that need to be taken to strengthen it.

***Most innovation ecosystem stakeholders interviewed view Maryland's innovation ecosystem as moderately strong, with university and federal research and development as the core ecosystem strength and lack of venture capital and the lack of a cohesive technology development strategy as the core weakness.*** The 21 key stakeholders interviewed were asked to rate the strength of both Maryland's overall innovation ecosystem and in each of the key ecosystem drivers, and also to identify key ecosystem strengths and weaknesses. A summary of the responses is presented in Table 15, with core responses as follows:

- Most key stakeholders interviewed view the strength of Maryland's innovation ecosystem as *moderate* (14 of 21 responses) with five viewing it as *strong* and two as *weak*;
- Most key stakeholders view academic and federal research as *strong* (15 of 19 responses for each);
- Stakeholder perceptions of the availability of translational assets (such as entrepreneurial support programs, incubators, accelerator, and peer support networks are mixed, with nine stakeholders viewing these as *moderate*, compared to five viewing them as *strong* and one viewing them as *weak*;
- Peer entrepreneurial/innovation networks are viewed as *moderate* (6) or *weak* (5) with only two stakeholders viewing them as *strong*;
- Access to business support providers (such as legal, accounting and related services to support innovation-based companies are rated as *moderate* (8) to *strong* (4);
- Access to talent (skilled and educated workers) is viewed as a strength, with 9 rating it as *strong* and seven as *moderate*, with only two stakeholders viewing it as *weak*. For the two stakeholders viewing access to talent as *weak*, the lack of "C" suite talent with start-up experience was the most important issue; and
- Access to venture capital is overwhelming seen as *moderate* in Maryland (15 of 18 stakeholders) with one perceiving it as *strong* and two as *weak*.

The innovation ecosystem stakeholders interviewed were also asked to identify Maryland's key ecosystem strengths and weaknesses, with:

- Maryland's ***key innovation ecosystem strengths*** identified as: federal research/agencies (seven responses); academic research and development, access to talent, and the State's focus on technology-based economic development (four each); and
- Maryland's ***key innovation ecosystem weaknesses*** identified as: the lack of a cohesive and organized technology development strategy (five responses); lack of venture capital (four), lack of "C" suite talent, reliance on federal contracting, and lack of a strategy for leveraging federal resources (two responses for each).

**Table 15: Stakeholder Ranking of Maryland Innovation Ecosystem and Assets**

| Innovation Ecosystem Component | Strong | Moderate | Weak |
|---|---|---|---|
| **Maryland's Overall Ecosystem** | 5 | 14 | 2 |
| **Key Drivers** | | | |
| University Research Activities | 15 | 3 | 1 |
| Federal Research Activities | 15 | 4 | |
| Translational Assets | 5 | 9 | 1 |
| Peer Business Networks | 2 | 6 | 5 |
| Business Support Providers | 4 | 8 | |
| Access to Talent (Skilled and Educated Workforce) | 9 | 7 | 2 |
| Access to Venture Capital and Business Financing | 1 | 15 | 2 |

Source: JFI Analysis of Interview Responses

The 21 interviews conducted and the focus group provided a significant level of information on stakeholder perceptions of both the functioning of and suggested ideas to improve Maryland's innovation ecosystem. In terms of perceptions of ***Maryland's overall innovation ecosystem***, Maryland was seen as an emerging ecosystem, "lacking the scale of California, Massachusetts or even Pennsylvania." One stakeholder reported, "Maryland is a first-generation innovation ecosystem, we don't see people from past generations investing in the current generation, we don't see the churn occurring in stronger ecosystems." Another reported that "Maryland is strong in generating ideas but weak in commercializing them. Lots of technologies are licensed and moved out of state." One stakeholder reported that "Maryland punches below its weight given the R&D assets in the state." There was broad agreement that academic and federal research and development, access to federal regulatory agencies (for Life Sciences), and federal purchases (for IT - especially for Cyber) were core Maryland innovation ecosystem assets. One potential criticism of Maryland's innovation ecosystem reported by several respondents is the disconnect between Maryland's technology regions, "in Life Sciences we have clusters in Montgomery County, in Baltimore City and in Fredrick County, there is not a lot of collaboration between these submarkets."

In the area of ***access to venture capital*** that was a central factor in the MTC sponsoring this report, there was a general consensus among the stakeholders interviewed that expanding access to venture capital is a critical need for Maryland's innovation ecosystem. Maryland was perceived as having a large number of programs to support early-stage and start-up companies at the Seed funding stage, with programs provided by TEDCO and the University System of Maryland's Maryland Momentum fund seen as strong programs. Many of the successful start-up and technology companies interviewed participated in at least one TEDCO or related program. Access to Angel investments was seen as moderate to strong with one stakeholder reporting "Maryland has a strong but small angel community." However, in terms of Angel funding, there was a feeling expressed that many successful entrepreneurs either leave the State or are not following up on their success by re-investing in other local start-ups. According to one stakeholder, "ecosystems do better when you have a class of successful entrepreneurs, who invest money and time in growing new companies through early stage investment. This is not yet happening in Maryland." However, one stakeholder had a contrarian view on Maryland's focus on financial support for early state firms and said "we are skewing the system and empowering companies that can't get to the next deal."

Views on access to later stage venture capital investing were mixed. Several stakeholders reported that Maryland does well in early stage (Seed and Angel) rounds of venture capital but faces gaps in attracting later stage investments, and that this gap is impacted by the lack of local venture capital companies. On the other hand, several respondents reported that especially in the post-Covid environment, proximity to venture capital firms has become less important. For instance, one respondent said "all VCs are looking nationally and internationally, where (a) company was founded is now less important, Covid killed that notion, a successful start-up can be anywhere it wants and attract interest." Another reported that high quality universities are able to get interest from national venture capital firms, all large venture capital firms are willing to come to Baltimore, there is no problem getting to pitch ideas and even with recent downturn in venture capital, local companies are getting funded." However, another stakeholder reported that the lack of local venture capital firms is an innovation ecosystem barrier, "Maryland companies do not have a lot of personal venture capital relationships, this is the challenge." Despite the emphasis placed on attracting venture capital to Maryland in the interviews, at least one stakeholder questioned the importance of attracting more outside venture capital to Maryland, reporting that, "only certain types of deals, like therapeutics need venture capital. Outside venture capital makes 'employment disappear' by moving companies out of state. The State needs more local private equity which creates firms that grow deeper roots and tend to not disappear." The federal SBIR program was seen by several stakeholders as a critical source of funding for technology businesses in Maryland, with two of the stakeholders interviewed receiving multiple rounds of SBIR funding, with one of these firms reporting "why would I want dilutive venture capital when I can get direct SBIR funding."

The role of ***Maryland's substantial base of federal agencies*** in the State's innovation ecosystem was seen as offering both substantial benefits as well as drawbacks. Access to federal research; proximity to federal regulatory agencies, especially for the life sciences sector cluster; and federal procurement, especially for IT/Cyber cluster; were all seen as a key strength of Maryland's innovation ecosystem. However, several stakeholders discussed the drawbacks of Maryland's reliance on the federal government. One stakeholder reported that "Maryland has a unique reliance on federal activities compared to peer regions. It offers a wealth of idea generation, but some federal innovators are 'not entrepreneurial' and reluctant to leave federal employment." Another said "it is a huge benefit to be near NIH, but they are hard to partner with and 'place agnostic' on promoting the localized commercialization of innovations." Specifically, on the critical role of NIH in Maryland Life Sciences, one stakeholder reported that "for NIH innovators, the government won't let you straddle, you can take the technology out, but can't keep your NIH job. If you spin it out, why stay here?" Finally, one key stakeholder reported, "While the presence of federal labs is very important, the risk adverse nature of government agencies when it comes to entrepreneurial activity such as strict conflict of interest rules prevents Maryland from truly growing its entrepreneurial ecosystem." There was a broad consensus in the interviews that Maryland is not doing enough to capitalize on its federal innovation assets. One stakeholder reported, "Maryland's twenty-one federal labs offer incredible technology, but it is difficult to make connections. Maryland used to assist in this, but that program was cut." Another noted that, "Federal labs are Maryland's biggest and most under-utilized innovation asset."

There was a clear, and nearly universal opinion expressed during the interviews that among the best ways of enhancing Maryland's innovation ecosystem is investing in and improving both the *translational assets* supporting commercialization activities and *peer networks* to support the entrepreneurial ecosystem. In the area of ***translational assets***, Maryland is seen as not offering best in practice policies, programs and resources to translate its innovation resources into marketable products and services. While dramatic improvements have been made, including an increasingly strong emphasis on technology commercialization, especially at Johns Hopkins, which has made "enormous changes in the last ten years," and also University System of Maryland, more can be done. One stakeholder reported that university translational assets are "way better than they were, but not where they need to be." University technology transfer offices are slowed by "lots of red tape," and are "too transactional" and "hard to work with." One stakeholder reported that "Maryland's big universities need to work on turning their tech transfer offices into a Stanford/MIT model and maximize volume. They need to motivate and incentivize getting technology out." Another reported that "at MIT you are encouraged to publish and commercialize, I am not sure this is the case in Maryland." University commercialization efforts are institutionally siloed, with one stakeholder reporting that "JHU and UMB efforts need to work together to promote the success of Baltimore's overall innovation ecosystem." TEDCO is seen as an important and successful bridging organization, with one stakeholder "reporting TEDCO is a powerhouse." But, another reported "but everything they do is sub-scaled." Maryland offers a large number of translational programs, with one stakeholder reporting "there are a ton of them, a proliferation of resources, I am unclear if quantity equals quality and outcomes." Maryland is seen as offering a large number of incubators/accelerators with one stakeholder reporting "we are fortunate to have so many incubators." However, another stakeholder reported that "county incubators are not well run and that the state needs to pull together incubators to improve services." Maryland is seen as offering strong resources for contract manufacturing and prototyping.

The overall consensus of the interviews was that ***peer networks*** in Maryland are moderate to weak. As with translational assets, Maryland is similarly seen as offering a large variety of programs. However, greater coordination is needed and focus on key issues could be improved. One stakeholder reported "they try but there are too many nonprofits chasing too few businesses. Maryland needs to focus on the businesses, not the nonprofits." Many of the stakeholders interviewed reported a lack of peer networking events for both early stage firms, with one firm reporting "there is no networking for entrepreneurs." For key business clusters, one stakeholder reported "there is some biotech networking, but not much entrepreneurial networking." Another said that "MTC is too focused on Bio and offers limited networking for IT." One stakeholder reported "In RTP every month they had networking organized by [the North Carolina Biociences Organization]. I learned something each time. It was not all service providers and lots of peers attended. Content drove attendance. There is not much of a coordinated network in Maryland." The Maryland technology community is seen as regionally siloed with a stakeholder reporting "Networks are useful most when they are shared across a state. Regional silos are a problem. Talent networking and business opportunity networking are very different and would require different meeting places." Yet another reported that he rarely has the time to attend events in other regions of the State.

Stakeholders discussed the role of ***Baltimore City in the State's innovation ecosystem***, with strongly divergent opinions. Baltimore is home to the nation's largest research university as well as UMB and two Innovation Districts. ***The City should be at the forefront of Maryland's innovation ecosystem***. Several key stakeholders reported that there has been considerable improvement in Baltimore City's innovation ecosystem efforts, most importantly at Johns Hopkins, however, barriers remain. One stakeholder reported "Baltimore is and remains a tough sell for recruitment, it needs to grow its own companies." Crime and leadership were seen as a barrier by some key stakeholders, with one stakeholder reporting that, "drugs, crime and education, as in many major cities is a barrier. Baltimore not unique, not the worst, but is seen as such. It is not seen as a safe/good place to start a business." Another reported "there is terrible leadership in City, they are not our friends. We have a good friend in the Governor." On a positive note, Baltimore was seen have having an increasingly strong innovation ecosystem driven by organizations such as UpSurge. One stakeholder reported "Baltimore has a good start-up ecosystem, people give a damn and work together, it is very focused and benefits from strategic geographic driven investment." This stakeholder also reported that "Baltimore has a significant value proposition, it is low cost so an investment goes further than in more established markets." Another stakeholder reported "Baltimore is stronger than Maryland, the City actually has a local ecosystem." According to one stakeholder, Baltimore City is "benefiting from a change at Johns Hopkins. Johns Hopkins is clearly leaning in and taking as much as they can from MIT model."

In the area of ***Access to Talent and Workforce***, stakeholders generally view workforce conditions as moderate to strong as demonstrated by statements like "Maryland has a strong workforce at all levels" and Maryland's workforce situation is "excellent and our chief asset." However, despite the overall positive view of workforce conditions, improvements can be made. A critical area of potential improvement is in preparing workers for middle skill jobs not requiring a four-year degree, with one stakeholder reporting, Maryland is too reliant on a traditional four-year model and does not have a community college-based approach." North Carolina was recognized in the interviews as well as in the literature review as offering a strong model for a community college-based approach to workforce training. Creating educational and training opportunities for production workers and upskilling the State's workforce were identified as another key area for improvement, with one stakeholder reporting that "while workforce is Maryland's chief asset, we need more of a focus on continuous learning and competency-based workforce development." Stakeholders also identified the need for improvements in college and university training, as demonstrated by quotes such as: "USM creates an attractive pool of candidates but 'moonshot' R&D focused education does not teach the skills applicable to today's IT business"; and, "teaching at Maryland colleges and universities is based on what the university/professor wants to offer, it is not based on industry need." Competition for limited STEM graduates, especially for small and entrepreneurial companies, and in the IT sector in general, were identified as workforce system barriers. Overall stakeholders reported a need for: targeted industry-driven training at occupational and community college levels; more engagement with business to identify industry skills needs; efforts to link college/university training to entrepreneurial companies, and "more engagement with HBCUs to increase business, management and STEM candidate diversity."

While stakeholder views on workforce supply were generally positive, one area of gaps is in ***C Suite Talent***. This is demonstrated by comments such as: "Maryland lacks an entrepreneurial class compared to Boston, NYC and California"; "in the past 2 years, I have met with 60 individuals to attract C suite talent, but people are reluctant to re-locate to Maryland, they are afraid won't be able to find another job." One stakeholder reported

"Maryland's biggest weakness is a lack of management talent, entrepreneurs, and seasoned early-stage experienced executives. This is our biggest gap." Another reported that "Maryland needs more cashed-out entrepreneurs that know how to run a start-up business, to stay in area and grow new companies."

Stakeholder views on ***State or Local Programs to Strengthen Maryland's Innovation Ecosystem*** were mixed. While most stakeholders were supportive of Maryland's efforts to support technology and innovation-based development, others had a more critical view. One stakeholder said "The State has no strategy, the State needs a strategy" and another reported that "Maryland's success was based on dumb luck, based on our location and assets. Massachusetts has a strategy, North Carolina has a strategy, Maryland does not have a strategy. The State keeps ignoring the fact that our success is luck." There was a broad consensus that Maryland's innovation ecosystem supports were not at sufficient scale as demonstrated by stakeholder statements like "there are many good programs but none operate at scale" that there is a lack of coordination between the various programs, and the State is underleveraging its federal and academic resources. Innovation ecosystem efforts are seen as siloed and the "USM and Johns Hopkins ecosystems are not integrated." One key stakeholder reported "Maryland talks a lot about building an ecosystem, but we need to what identify what we want from it and consolidate programs. An existing group of people have been doing this for decades and they haven't been successful so far." Another reported, "we are doing a lot of patting ourselves on the back, we are not doing best practices, efforts are run by an 'old guard.'" In terms of Maryland's life sciences efforts, one stakeholder reported "the State has lost its focus on Life Sciences and Bio, having a strategy and significantly more money would be a strong positive." Another stakeholder reported, "Maryland lacks a coordinated effort. Maryland as a scarcity mind set not an abundance mind set. Maryland efforts are both programmatically and geographically siloed." Other stakeholders criticized the State's technology development efforts, "In 2016 we created the BioHealth Acceleration Initiative. The State person took the 2016 plan seriously, but then all work came to a halt. If we could just do that plan, it would be really powerful." Another stakeholder reported that many of Maryland's core economic development programs are based on traditional, not innovation-based economic development models and are seriously underfunded.

Key stakeholder ***recommendations for improving Maryland's innovation ecosystem*** include increasing funding for innovation and technology-based support programs and promoting greater coordination across the diverse state, local and institutional programs. Efforts need to be made at meeting the capital and operational support needs of early stage companies advancing from the start-up/development phase to the middle phase of testing and production. One recommendation made by multiple stakeholders is to bring more local companies to national venture capital investment events and attracting more national venture capital company visits to Maryland, with one stakeholder saying "we can't make venture capital invest in Maryland, but we can better market our opportunities to them – at national events and by bringing them here." Investing in supporting bio-manufacturing is seen as critical with one stakeholder reporting that "Maryland policies drove out six biotechnology companies moving into production." Expanding mentorship between established and start-up firms for supporting both product development and entrepreneurial success are seen as critical. The State also needs to invest in workforce development programs focusing on specific industry/occupational needs (rather than traditional two- and four-year degrees where the State is already doing well) are necessary to meet the needs of the technology sector. There is a broad consensus among stakeholders that the State needs an innovation ecosystem strategy that will: 1) better coordinate and de-silo existing programs; 2) promote greater cooperation between institutions (JHU and USM) and regional efforts; 3) provide better supports for middle stage innovation, technology and entrepreneurial companies; 4) better market Maryland investment opportunities to national funders; 5) align State economic development funding and incentives to the needs of the innovation sector; and 6) broaden the capabilities of our workforce development system to provide industry and skills based educational and training opportunities with a specific focus on unmet community college and occupational training needs. Maryland's technology and innovation efforts are dispersed across a wide range of organizations, including MTC, TEDCO, the Maryland Department of Commerce; and a host of regional and institutional efforts. One stakeholder reported that "Maryland needs a '***technology champion'*** to coordinate and de-silo Maryland's fragmented efforts." Others report that this type of effort needs to be industry led and focused on sector-based strategies to meet the different needs of the Life Sciences, IT, and Electronics clusters that make up our innovation ecosystem.

## IMPLICATIONS OF FINDINGS AND HIGH-LEVEL RECOMMENDATIONS

The JFI's *Quantitative Analysis* of twelve groupings of indicators across the three key domains of Maryland's innovation ecosystem benchmarked Maryland to key regional and aspirational peer states and found that the State has a competitive innovation ecosystem and excels in academic and federal research and development activities, but lags in translating this source of innovation into new products, services, companies and economic activity. As a result, Maryland's strong technology sector and the overall State economy are lagging our peers in economic growth. The JFI's *Qualitative Analysis* collected input from key stakeholders, including academia, business, venture capital companies, and innovation ecosystem support organizations. This analysis found a broad consensus that Maryland's innovation ecosystem is of moderate strength, and more can be done to capitalize on the State's federal and university research resources and facilitate the translation of locally generated innovations into business and economic activity. Maryland is seen by the stakeholders interviewed as offering a large number of translational resources and entrepreneurial support organizations; however, these efforts are often fragmented and geographically and organizationally siloed. There was a broad consensus that Maryland needs an ***Innovation Ecosystem Strategy*** to coordinate these efforts, organized by a ***Technology Champion***, with strong industry involvement, and sufficient resources to offer programs "at scale." Other states, most importantly North Carolina and Massachusetts, but also Georgia, Texas and Virginia are seen as benefitting from strongly supported, targeted, industry-led and supported innovation and technology-based economic development strategies.

Maryland's competitor states are making significant investments in nurturing and growing their innovation ecosystems and technology business base. According to the TEDCO *MARYLAND INNOVATION Competitiveness Study*:

> Competitor states are making investments to expand their high-tech industries. These range from North Carolina and Massachusetts that have each made $100 million-dollar-a-year, ten-year investments in life sciences business development, workforce development, and research activity to Virginia's Commonwealth Cyber Imitative that is investing $15-$20 million a year in cyber research competitiveness, commercialization, and workforce development. In each case, the investments are aligned to identified gaps and opportunities and consensus priorities that emerged during strategic planning processes. For example, North Carolina invested $134.6 million in biomanufacturing working training programs and physical infrastructure at North Carolina State University, North Carolina Central

University, an HBCU, and the North Carolina community college system. The BioWork certificate is a non-degree certificate offered by 11 community colleges. It teaches students how to use process equipment and to understand cell separation methods following quality systems such as International Standards Organization and current Good Manufacturing Practices.

Some examples of programs, policies and efforts similar to those recommended by the stakeholder interviews that are underway in competing states are described below.

**Private Sector Led Innovation Planning** – many states are engaged in state-level, private sector led initiatives to support innovation ecosystem development, with a recent example being:

**NCInnovation** is a private-sector-led initiative to build North Carolina's innovation economy. NCI began in 2018 as a discussion between North Carolina business executives with an interest in bringing C-suite leadership to impact North Carolina's innovation future. The concept, then named "The Innovation State," grew from there. "The Innovation State" evolved into a nonprofit 501(c)(3), called NCInnovation, that has raised more than $20 million to build the foundation for North Carolina's innovation future. NCI partnered with TEConomy, a leading economic research firm, to commission a comprehensive report analyzing the North Carolina innovation ecosystem's strengths, weaknesses, and opportunities.[39] According to an NCInnovation press release, "NCInnovation will support rural economic development by partnering with UNC System universities to commercialize applied research." Other states have deployed billions of dollars in an "***innovation arms race***," and NCInnovation looks to position North Carolina for continued growth by centering rural economic development on UNC System schools around the state.[40] In May 2023, the North Carolina Senate release a budget that "allocates $1.425 billion in non-recurring funds to improve applied research outputs at UNC System schools and to help commercialize the results of that research, particularly in regions outside the state's urban centers.[41]

In 2022 NCInnovation commissioned a strategic plan – *Optimizing North Carolina's Innovation Ecosystem: Recommendations to Accelerate Commercialization of University-Based Innovations through Public-Private Partnerships to accelerate commercialized innovation from its research-intensive universities through public-private partnerships* that focused on four strategic recommendations:

- Develop applied research collaborations across universities structured to solve marketplace problems with commercially viable solutions.
- Infuse real-world business development acumen into university research efforts to help commercialize applied research.
- Create university-focused seed to early-stage capital funds to capitalize ventures that stem from applied research.
- Develop regional innovation networks to provide value-added services and connect academia, industry, and capital.[42]

**University Research and Entrepreneurship Programs** – Many states have funded large scale efforts to enhance university R&D and technology commercialization, with one best practice example being:

- The **Georgia Research Alliance** (GRA) was founded in 1990, by a group of Georgia leaders to help business, research universities and state government collaborate to build a technology-driven economy fueled by breakthrough university research. The goal of GRA is helps the state's universities conduct more research and create more companies — all to grow Georgia's economy. GRA has a portfolio of 146

Life Sciences and 99 Technology companies. Since 1991, GRA has received state funding of $690 million, which has attracted $11.7 billion in research grants, venture capital, matching funds and other forms.[43]

**State Technology and Innovation Programs** – Many states have state level organizations focused on growing their technology business base, with a recognized best practice example being:

The **Massachusetts Technology Collaborative** (MassTech) has supported has supported the evolving needs of the state's innovation economy for more than four decades. MassTech was founded in 1982 as the Massachusetts Technology Park Corporation. It was established by the legislature to advance the growth of the technology sector of the state's economy. In 1994, the agency changed its name and mission to the Massachusetts Technology Collaborative, becoming a strategic agent and a facilitator of innovative and collaborative ventures. MassTech supports business formation and growth in the state's technology sector, helping Massachusetts lead in the global digital economy, by:

- Building strategies, strengthen connections, assist companies, make investments, and lead programs;
- Developing meaningful collaborations across industry, academia, and government, turning shared challenges into economic opportunity; and
- Supporting the Commonwealth's tech sector with a strategic focus on talent, ecosystems, and innovation infrastructure across key divisions and programs.

MassTech has five divisions: the MassCyberCenter; the Massachusetts Broadband Institute; the Massachusetts eHealth Institute; The Innovation Institute; and The Center for Advanced Manufacturing; and offers programs in the areas of Talent and Workforce; Ecosystem and Industry Support; Healthcare Innovation; and Local Level Support.[44]

**Sector Development Strategies** – Many states have well-funded efforts to support the development of specific technology clusters, with three examples being:

The **Massachusetts Life Sciences Center** (MLSC) is an economic development and investment agency with a mission of supporting the growth and development of the life sciences in Massachusetts. Through public-private funding initiatives, the MLSC supports innovation, research and development, commercialization, and manufacturing activities in the fields of biopharma, medical device, diagnostics, and digital health. As a quasi-public agency, MLSC also offers programs that fund innovation-driven economic and workforce development initiatives in Massachusetts.

The MLSC's mission is to serve as the "hub" of the Massachusetts life sciences ecosystem, encourage innovation through investments in good science and good business, strengthen and protect Massachusetts' global leadership position in the life sciences, accelerate the commercialization of promising treatments, therapies, and cures that will improve patient care, and create jobs and drive economic and STEM workforce development. MLSC had revenues of $37.6 million in FY2022.[45]

The **North Carolina Biotechnology Center** (NCBiotech) was created in 1984 as the nation's first state-sponsored initiative in biotechnology development. For nearly four decades, NCBiotech has effectively designed and implemented programs and initiatives that span the broad set of unique development requirements for the life sciences and provide a competitive advantage for North Carolina. The Center has established itself as a trusted partner, working to ensure life sciences companies of all sizes and stages of development are able to access and effectively leverage the research, technology, talent, and capital resources across North Carolina and beyond. Today, NCBiotech plays this role and delivers its extensive programming through five primary domain areas:

- Funds for commercializing university research and boosting early-stage company development;
- Talent development initiatives and career networking;
- Investor and industry connections to fill gaps;
- Unique spaces to accelerate company growth; and
- Access to high-value information resources.[46]

NCBiotech had a FY2023 budget of $17.1 million.

The Virginia **Commonwealth Cyber Initiative** (CCI) was established into serve as an engine for research, innovation, and commercialization of cybersecurity technologies, and address the Commonwealth's need for growth of advanced and professional degrees within the cyber workforce. CCI's mission encompasses research, workforce development, and innovation at the intersection between cybersecurity, autonomy, and intelligence. CCI's network includes 41 higher education institution across the Commonwealth, with $114.5 million in sponsored programs supporting more than 320 researchers.

**Technology Workforce Development Programs** – Many states support targeted training and workforce development programs to create the talent pipelines required by technology clusters. Cybersecurity workforce development is a core component of the Virginia CCI Program (above). In addition, selected programs include:

North Carolina has invested significant resources in developing the workforce required by its successful life sciences clusters. Selected North Carolina programs of note include:

Golden LEAF **Biomanufacturing Training and Education Center** (BTEC) provides educational and training opportunities to develop skilled professionals for the biomanufacturing industry and create the best-trained, most industry-focused workforce possible. Founded to help establish, attract and expand biomanufacturing in North Carolina and thus drive innovation and job creation, BTEC is located on North Carolina State University's Centennial Campus in Raleigh. It operates under the auspices of the university's College of Engineering (COE). BTEC operates two facilities: the 77,700-gross-square-foot main building and the approximately 5,000-gross-square-foot BTEC Annex in the Keystone Science Center. The two facilities feature more than $18 million of industry-standard equipment and a simulated cGMP (current Good Manufacturing Practice) pilot plant facility capable of producing biopharmaceutical products using cell growth and expression, recovery, and purification processes. Undergraduates, graduate students and working professionals come to BTEC for hands-on learning with the latest biomanufacturing technologies. In the 2020–2021 academic year, a total of 487 individual undergraduate and graduate students filled an all-time high of 957 seats in BTEC classes, topping the previous year's record enrollment of 893. In addition, 4,566 industry professional completed professional development classes since the program's inception in 2008 and BTEC's Bioprocess Services and Analytical Services units served industry and academic partners from within and outside North Carolina by carrying out 16 projects during the year.[47]

North Carolina Central University's **Biomanufacturing Research Institute and Technology Enterprise** (BRITE), has the dual missions of applied research and workforce development, is perfectly positioned to support Life Sciences cluster growth. Built in 2008, the BRITE's state-of-the-art facility is home to over 40 scientists whose research and training efforts contribute to workforce development for the biomanufacturing and pharmaceutical industries in North Carolina.

The North Carolina **BioNetwork** provides high-quality economic and workforce development for the biotechnology and life science industries across North Carolina through education, training, and laboratory resources. BioNetwork also supports the future biotechnology and life science workforce through teacher training and outreach.

# DATA APPENDICES

**Appendix A – Cluster Industry Definitions**

| Cluster | Code | Description |
|---|---|---|
| Life Sciences | 325411 | Medicinal and Botanical Manufacturing |
| | 325412 | Pharmaceutical Preparation Manufacturing |
| | 325413 | In-Vitro Diagnostic Substance Manufacturing |
| | 325414 | Biological Product (except Diagnostic) Manufacturing |
| | 334510 | Electromedical and Electrotherapeutic Apparatus Manufacturing |
| | 334516 | Analytical Laboratory Instrument Manufacturing |
| | 334517 | Irradiation Apparatus Manufacturing |
| | 339112 | Surgical and Medical Instrument Manufacturing |
| | 339113 | Surgical Appliance and Supplies Manufacturing |
| | 339114 | Dental Equipment and Supplies Manufacturing |
| | 339115 | Ophthalmic Goods Manufacturing |
| | 541380 | Testing Laboratories |
| | 541713 | Research and Development in Nanotechnology |
| | 541714 | Research and Development in Biotechnology (except Nanobiotechnology) |
| | 541715 | Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology) |
| | 621511 | Medical Laboratories |

| Cluster | Code | Description |
|---|---|---|
| Information Technology | 511210 | Software Publishers |
| | 517311 | Wired Telecommunications Carriers |
| | 517312 | Wireless Telecommunications Carriers (except Satellite) |
| | 517410 | Satellite Telecommunications |
| | 517919 | All Other Telecommunications |
| | 518210 | Data Processing, Hosting, and Related Services |
| | 519130 | Internet Publishing and Broadcasting and Web Search Portals |
| | 541511 | Custom Computer Programming Services |
| | 541512 | Computer Systems Design Services |
| | 541513 | Computer Facilities Management Services |
| | 541519 | Other Computer Related Services |

| Cluster | Code | Description |
|---|---|---|
| Electronics Equipment and Batteries | 334111 | Electronic Computer Manufacturing |
| | 334112 | Computer Storage Device Manufacturing |
| | 334118 | Computer Terminal and Other Computer Peripheral Equipment Manufacturing |
| | 334210 | Telephone Apparatus Manufacturing |
| | 334220 | Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing |
| | 334290 | Other Communications Equipment Manufacturing |
| | 334310 | Audio and Video Equipment Manufacturing |
| | 334412 | Bare Printed Circuit Board Manufacturing |
| | 334413 | Semiconductor and Related Device Manufacturing |
| | 334416 | Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing |

## Appendix A – Cluster Industry Definitions

| Cluster | Code | Description |
|---|---|---|
| Electronics Equipment and Batteries | 334417 | Electronic Connector Manufacturing |
| | 334418 | Printed Circuit Assembly (Electronic Assembly) Manufacturing |
| | 334419 | Other Electronic Component Manufacturing |
| | 334512 | Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use |
| | 334513 | Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables |
| | 334514 | Totalizing Fluid Meter and Counting Device Manufacturing |
| | 334515 | Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals |
| | 334519 | Other Measuring and Controlling Device Manufacturing |
| | 334613 | Blank Magnetic and Optical Recording Media Manufacturing |
| | 334614 | Software and Other Prerecorded Compact Disc, Tape, and Record Reproducing |
| | 335911 | Storage Battery Manufacturing |
| | 335912 | Primary Battery Manufacturing |

**Appendix B- List of Stakeholders Interviewed**

| | Title | Organization |
|---|---|---|
| **Government** | | |
| Brad Stewart | SVP of Business Development | Montgomery County Economic Development |
| Troy LeMaile-Stovall | CEO | Technology and Economic |
| Jack Miner | Chief Investment Officer | Development Corporation |
| Allyson Redpath | Director, Entrepreneurship | Maryland Department of Commerce |
| Ulyana Desiderio | Director, Life Sciences | |
| Tom Sadowski | Executive Director | Maryland Economic Development |
| **Private Companies/Start-ups** | | |
| Doug Doerfler | President & CEO | MaxCyte |
| Husein Sharaf | CEO | Cloudforce |
| Jon Rowley | Founder & Chief Product | RoosterBio |
| Patricia Larrabee | President | Facility Logix |
| Matt Brady | Principal, Executive VP | Scheer Partners |
| Ted Olsen | Co-Founder, Former CEO | Aqualith |
| Tina Williams | Founder, CEO | CyDeploy |
| **Technology Support Organizations** | | |
| Chris Frew | CEO | BioBuzz and Workforce Genetics |
| Brian Darmody | Chief Strategy Officer | Association of University Research |
| Madeleine Stokes | Chief Operating Officer | UpSurge |
| Chris Bunner | Data Analyst | |
| **Universities** | | |
| Helen Montag | Sr Dir for Corp Partnerships | Johns Hopkins Technology Ventures |
| Mary Morris | Director, Baltimore Fund | UM Ventures |
| **Venture Capital** | | |
| Emily Durfee | Co-Manager | 1501 Health |
| David Warschawski | Managing Director | W Ventures |
| Ken Malone | Managing Director | Early Charm Ventures |
| **BCTF Focus Group** | | |
| Michael Berman | Chief Education Officer | Language Arts Press |
| Cyrus Etemad-Moghadam | President/Founder | RPM Tech, LLC |
| Doug Holly | Principal | Eagle Management Group |
| Cheryl Lohman | CEO/Founder | MedApptic, LLC |
| Steve Myers | President/CEO | E-Medical Sentry |

[1] https://www.montgomerycountymd.gov/council/Resources/Files/agenda/cm/2020/20200622/20200622_PHED1.pdf.

[2] JFI Analysis of U.S. Bureau of Economic Analysis Data.

[3] JFI Analysis of U.S. Bureau of the Census Population Data.

[4] JFI Analysis of Lightcast data.

[5] https://www.weforum.org/reports/the-global-competitiveness-report-2020/in-full/section-4-innovation-ecosystem.

[6] These definitions and measurement systems are focused on national level systems – but can be applied to both regional and local efforts.

[7] https://d-lab.mit.edu/sites/default/files/inline-files/Understanding_Innovation_Ecosystems_FINAL_JULY2019.pdf

[8] Materials extracted and summarized from https://innovation.mit.edu/assets/Assessing-iEcosystems-V2-Final.pdf.

[9] See note 5.

[10] By performer, JFI analysis of National Science Foundation, National Patterns of R&D Resources data.

[11] R&D intensity is the ratio of total R&D performed in a state to its state GDP.

[12] Obligations are for money obligated (different than expenditures above) and can include multi-year obligations. They are the only data source available for spending by agency.

[13] https://milkeninstitute.org/sites/default/files/reports-pdf/Concept2Commercialization-MR19-WEB_2.pdf.

[14] https://www.sbir.gov/about.

[15] https://www.sbir.gov/birth-and-history-of-the-sbir-program

[16] https://www.mckinsey.com/industries/public-and-social-sector/our-insights/building-innovation-ecosystems-accelerating-tech-hub-growth.

[17] https://www.tedcomd.com/sites/default/files/2023-01/RTI-KeenPoint_TEDCO_report_01_19_2023%20FINAL.pdf.

[18] https://nvca.org/wp-content/uploads/2023/03/NVCA-2023-Yearbook_FINALFINAL.pdf.

[19] https://nvca.org/wp-content/uploads/2022/08/Maryland.pdf.

[20] PitchBook is the most widely used resource on tracking venture capital investment and is used in both the TEDCO and MEDCO reports described above. Crunchbase is also well-used, including by the Maryland Department of Commerce to track venture capital investment and venture-backed companies.

[21] The JFI analyzed each deal in Crunchbase. Our analysis included companies receiving Angel, Convertible Note, Corporate Round, Debt Financing, Equity Crowdfunding, Grant, Pre-Seed, Private Equity, Secondary Market, Seed, Series A-E, Undisclosed, and Venture - Series Unknown. The JFI excluded selected non-profits and entities that received grants funds.

[22] Crunchbase does not have data on NAICs codes – companies were coded into areas/clusters based on a JFI analysis of each deal.

[23] See note 16.

[24] https://www.areadevelopment.com/Corporate-Consultants-Survey-Results/Q1-2023/37th-annual-corporate-survey-decison-makers-feel-economic-pressures.shtml.

[25] According to the U.S. Bureau of Labor Statistics - Location quotients are useful for studying the composition of jobs in an area relative to the average, or for finding areas that have high concentrations of jobs in certain occupations. As measured here, a location quotient shows the occupation's share of an area's employment relative to the national average. For example, a location quotient of 2.0 indicates that an occupation accounts for twice the share of employment in the area than it does nationally, and a location quotient of 0.5 indicates the area's share of employment in the occupation is half the national share. See https://www.bls.gov/oes/highlight_location_quotients.htm.

[26] See note 16.

[27] https://c24215cec6c97b637db6-9c0895f07c3474f6636f95b6bf3db172.ssl.cf1.rackcdn.com/content/metro-innovation-districts/~/media/programs/metro/images/innovation/innovationdistricts1.pdf.

[28] https://www.trammellcrow.com/en/about/media-center/trammell-crow-company-announces-plans-for-a-life-sciences-campus-in-maryland.

[29] https://www.cbre.com/insights/figures/q1-2023-us-life-sciences-figures.

[30] See note 16.

[31] Bergman, B., Helping Entrepreneurs Help Themselves: A Review and Relational Research Agenda on Entrepreneurial Support Organizations, July 2021, Entrepreneurship: Theory and Practice 46(1)

[32] https://commerce.knack.com/find-a-maryland-incubator-or-accelerator.

[33] See note 16.

[34] See note 8.

[35] https://www.kauffman.org/wp-content/uploads/2019/12/measuring_an_entrepreneurial_ecosystem.pdf.

[36] According to the U.S. Bureau of Labor Statistics, location quotients are ratios that allow an area's distribution of employment by industry, ownership, and size class to be compared to a reference area's distribution. If an LQ is equal to 1, then the industry has the same share of its area employment as it does in the nation. An LQ greater than 1 indicates an industry with a greater share of the local area employment than is the case nationwide. Based on the JFI's work on technology and cluster based development in Maryland and across the nation, industries with an LQ above 1.2 are generally considered specialized and may indicate the presence of a local comparative advantage.

[37] See Appendix A for a list of the industries that comprise each cluster.

[38] And even these focus areas include multiple sub-areas.

[39] https://ncinnovation.org/about/.

[40] https://ncinnovation.org/app/uploads/2023/05/NCInnovation-Will-_Generate-Homegrown-Companies-that-Will-Stay-in-North-Carolina_.pdf

[41] https://ncinnovation.org/app/uploads/2023/05/230515-NCI-press-release.pdf

[42] https://ncinnovation.org/app/uploads/2023/01/Optimizing-North-Carolinas-Innovation-Ecosystem-ExecutiveSummary.pdf

[43] Data extracted from the GRA website - https://gra.org/.

[44] Data extracted from the MassTech website - https://masstech.org/.

[45] Data extracted from the MLSC website - https://www.masslifesciences.com/.

[46] https://www.ncbiotech.org/sites/default/files/2022-12/TEConomy-NCBiotech%20Evidence%20and%20Opportunity%202022%20%28Full%20Layout%29%20%281%29.pdf.

[47] Data extracted from the BTEC website - https://www.btec.ncsu.edu/about/index.php.

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