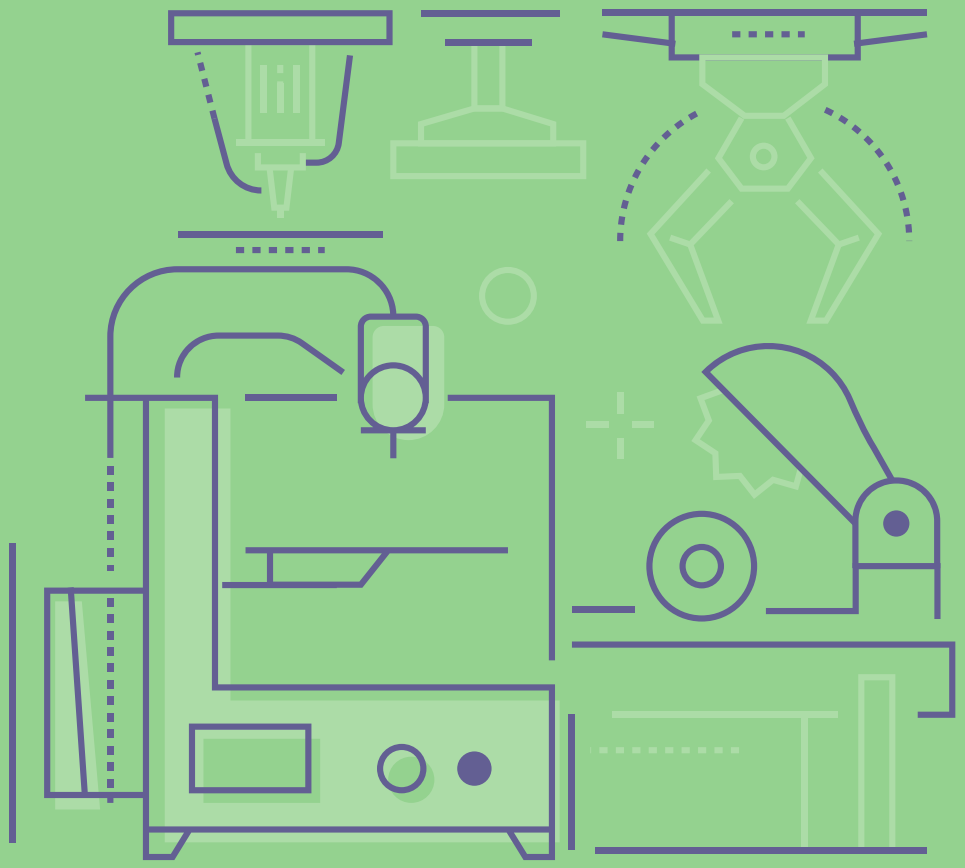
Vision 2030:

KENTUCKY SCIENCE & TECHNOLOGY PLAN



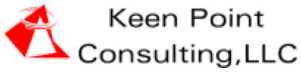
July 2023

KY NSF EPSCoR

KY EPSCoR Research Innovation Education

RTI INTERNATIONAL

Keen Point Consulting,LLC



The development of the Kentucky Statewide Science & Technology Plan: Vision 2030 was led by Jennifer Ozawa at RTI International and Anthony Gillespie at Keen Point Consulting in collaboration with the Kentucky EPSCoR State Committee. Alison Bean de Hernandez and Pearl Sullivan of RTI supported research, data collection, and analysis. Lisa Gardner created the report design, and Christina Rodriguez was the editor. The plan was adopted by the Kentucky EPSCoR Statewide Committeeon July 31, 2023.

July 1, 2023

Dear Colleagues,

The National Science Foundation (NSF) Established Program to Stimulate Competitive Research (EPSCoR) catalyzes and enhances research infrastructure and capacity through innovation in science and engineering research and education, particularly by broadening and supporting workforce development.

The Kentucky Statewide EPSCoR Committee, the jurisdictional governing body of the Kentucky EPSCoR Program, comprises representatives from academia, government, and industry. The State Committee, in partnership with the Kentucky Science and Technology Corporation (KSTC), and with support from RTI International and Keen Point Consulting, have developed the *Kentucky Science & Technology Plan: Vision 2030* (the S&T Plan). The S&T Plan is intended to serve as a strategic roadmap for science and technology initiatives and to help guide efficient and wise use of resources and investments in the Commonwealth over the next 7 years. We seek to leverage and build upon the state's existing areas of strength while positioning it to meet the future needs of industry. This plan incorporates wide-ranging stakeholder involvement and input from industry, state government, and academia.

Nationally, this is an exciting and challenging time for NSF EPSCoR. The 2022 CHIPS and Science Act, which is the largest federal investment ever recommended for EPSCoR jurisdictions, includes a 20% set aside for NSF funding and scholarships. The S&T Plan and the Statewide Committee will ensure our state is best poised to take advantage of these new opportunities to continue building our research capacity and STEM workforce. At its foundation, the S&T Plan is designed to foster success for the economy of the Commonwealth and improve the prosperity and lives of our citizens.

The Kentucky EPSCoR program has directly touched the lives of many citizens in the Commonwealth over the past three decades by supporting and advocating for science and engineering research, education, and workforce development across the state. On behalf of the Kentucky EPSCoR State Committee, KSTC, and many thoughtful contributors, we are pleased to present the S&T Plan to the Commonwealth of Kentucky's policymakers, industry leaders, university researchers, and our fellow citizens—thereby benefitting our state's students, institutions, residents, and economy for years to come.

Cathleen Webb, PhD
Executive Chair
Kentucky Statewide EPSCoR Program

KSTC
KENTUCKY SCIENCE & TECHNOLOGY CORPORATION

June 21, 2023

Cathleen Webb, PhD
Executive Chair, Kentucky EPSCoR Statewide Committee
1906 College Heights Blvd.
Bowling Green, KY 42101

Dear Chair Webb,

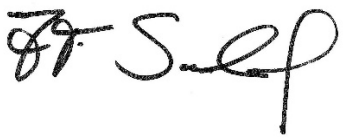
Last year, the Kentucky Statewide Committee for the National Science Foundation Established Program to Stimulate Competitive Research (NSF EPSCoR) determined that, to stay relevant to the needs of Kentucky's innovation ecosystem and the goals of NSF, a complete update of Kentucky's science and technology plan was required. Thus, Kentucky's EPSCoR Statewide Committee engaged RTI International and Keen Point Consulting (RTI-Keen Point) to develop the *Kentucky Science and Technology Plan: Vision 2030* (also known as the S&T Plan). As an active and engaged member of the Statewide Committee, the Kentucky Science and Technology Corporation (KSTC) fully supports the development and implementation of the S&T Plan.

As a private, nonprofit corporation established in 1987 and committed to the advancement of science, technology, and innovative economic development in Kentucky, KSTC's mission aligns flawlessly with the goals of the S&T Plan. Our portfolio of programming, which includes middle and high school science, technology, engineering, and math (STEM) education, support and assistance to Kentucky's university and non-university researchers in commercializing their discoveries, early-stage investment in start-up businesses, including a focus on businesses owned or controlled by socially and economically disadvantaged individuals (SEDI), and assisting maturing companies to access customers and talented employees, stands ready to support the full implementation of this Plan.

Since Kentucky's last version of the S&T Plan in 2017, the impact of our Commonwealth's science and technology ecosystem on the state economy has grown significantly, with strong support from the Kentucky Cabinet for Economic Development. The implementation of the S&T Plan is critical to the continued advancement of science and technology in Kentucky's economy, particularly as Kentucky has recently lagged behind the national average in terms of gross domestic product and population growth. The S&T Plan addresses Kentucky's need for and path to higher-wage, higher value-added industry, investment in K–20 STEM education, and critical infrastructure to catalyze the growth of new and existing companies—from start-up enterprises to large multinationals—in sectors such as advanced manufacturing and materials, supply chain, health, agriculture, and resiliency against climate change.

Over the next 10 years, Kentucky STEM and STEM-related jobs are expected to grow at a faster rate than non-STEM jobs. The *Kentucky Science and Technology Plan: Vision 2030* will be integral to how well Kentucky's economy capitalizes on and even exceeds this growth. KSTC is wholeheartedly committed to the success of the S&T Plan and will actively support its implementation.

Sincerely,



F.T. Samuel, Jr.
President

Kentucky Established Program to Stimulate Competitive Research State Committee Members

Executive Chair

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Lisa Cassis, PhD, University of Kentucky
Emmanuel Collins, PhD, University of Louisville
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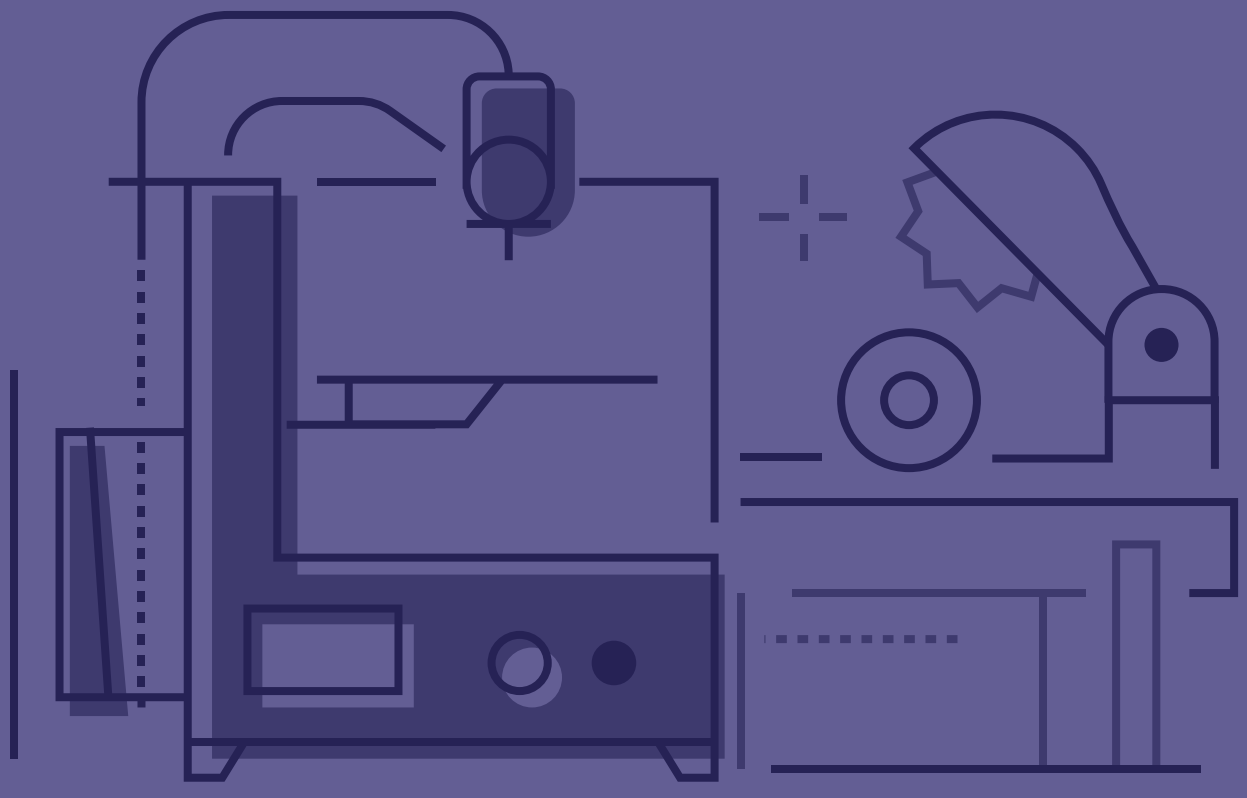


Executive Summary

S&T Plan Vision

The *Kentucky Science & Technology Plan: Vision 2030* (the S&T Plan) presents a stakeholder- and data-driven vision and strategy for the role that science and technology can play in advancing Kentucky's economy and research enterprise. The plan helps to set a strategic direction around which university-industry-government-economic development stakeholders can collaborate to advance these goals.

The four areas for action and the vision stakeholders have articulated for each are presented below:

- **Science, Technology, Engineering, and Mathematics (STEM) Education**: Recognizing that jobs in science and technology pay higher salaries and are more resilient to economic downturns, Kentucky makes greater investments in K–20 STEM education to build the skills students need. Kentucky students and families understand how a STEM education can benefit them. Students are able to access and pursue this education, which enhances the lives of graduates and their communities.

- **Research Competitiveness:** Kentucky understands the connection between universities, research, student preparation, and the technology-based economy. This understanding leads to broader public support and public investment in S&T infrastructure (people, equipment, and facilities). Kentucky is known for its world-class universities and research institutions and their strong partnerships with innovative companies.

- **Innovation and Entrepreneurship:** Kentucky leverages its research and manufacturing industry base to encourage more commercialization and startup activity. Over time, successful exits of venture-backed companies infuse Kentucky's startup ecosystem with more experienced entrepreneurs and capital. Kentucky is consistent and persistent in investing for the long term.

- **High-Tech Industry Growth:** Kentucky partners and invests with regions that are trying to build on their unique comparative advantages. Kentucky's investment in stronger regional S&T infrastructure attracts and supports the growth of high-wage companies and industries. Science and technology fuel a diverse economy in Kentucky that provides a wide range of economic opportunities for its residents.

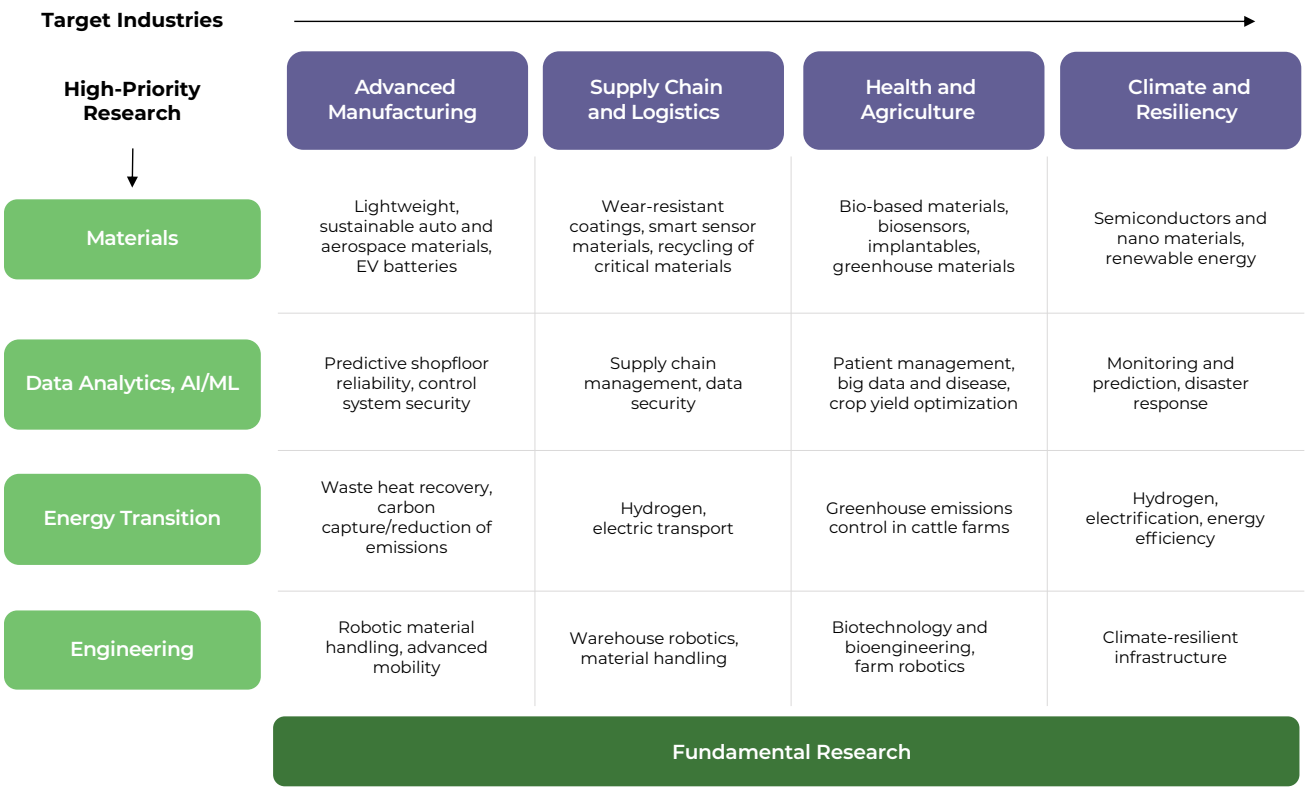
Target Industry Sectors and High-Priority Research Areas

The S&T Plan identifies four S&T-intensive target industry sectors that are important to Kentucky's economic growth and development: Advanced Manufacturing, Supply Chain and Logistics, Health and Agriculture, and Climate and Resiliency (listed across the top row in Figure 1).

The Plan also focuses attention on four high-priority research areas: Materials; Data Analytics, Artificial Intelligence (AI)/Machine Learning (ML); Energy Transition; and Engineering (listed in the column on the left in Figure 1).

Examples of applications of these research areas within the target industry sectors are presented in the cells of the matrix in Figure 1. An example of a materials research application within Kentucky's advanced manufacturing industry is the development of lightweight, sustainable materials used by the auto or aerospace industry. An example of a data analytics and AI/ML research application to the work of Kentucky's first responders in the Climate and Resiliency sector is improved monitoring and prediction of extreme weather events and better real-time disaster response.

Figure 1. Kentucky Target Industries and High-Priority Research Areas



Note: EV = electric vehicles. Fundamental research and workforce training incorporate every field of science and engineering. They are required to support the four high-priority research areas and four industry sectors for growth.

Figure 2. Kentucky S&T Plan: Vision 2030 Goals and Actions

STEM EDUCATION AND WORKFORCE	
Goal 1: Increase student enrollment in STEM postsecondary education.	
STEM Pipeline (Enrollment)	***Action 1:*** *Increase the number of students attracted to and prepared to pursue STEM degrees, including first-generation college students, women, and students of color.*
Goal 2: Increase number of STEM degrees awarded at all levels and among first-generation college students, women, and students of color.	
STEM Pipeline (Graduates)	***Action 2:*** *Pursue and provide additional support to retain and graduate students in STEM degrees, especially first-generation college students, women, and students of color.*
RESEARCH COMPETITIVENESS	
Goal 1: Increase research competitiveness through capacity-building (people, equipment, and facilities).	
People	***Action 1:*** *Invest to increase the pool of high-quality students available to support research activity across all science and engineering disciplines..*
Equipment	***Action 2:*** *Increase financial support to replace and upgrade equipment in core research facilities (to help recruit and retain top research faculty).*
Facilities	***Action 3:*** *Provide and maintain state-of-the-art facilities aligned to strategic research areas to recruit and retain top research faculty.*
Goal 2: Increase recognition that applied and basic research are needed to tackle 21st century challenges, including economic and societal challenges.	
Promotion and Tenure Guidelines	***Action 1:*** *Identify the value of industry-driven and use-inspired research (e.g., industry-sponsored research projects, Small Business Innovation Research grants) in promotion and tenure guidelines.*
Industry Connections	**Action 2***: Continue to build industry-university connections and collaborations.*
INNOVATION AND ENTREPRENEURSHIP	
Goal 1: Increase business R&D and innovation activity in target industries.	
Business R&D	***Action 1:*** *Provide funds that can be used to support small- and medium-sized manufacturers, biotech, and high-tech companies with applied R&D projects and access to talent.*
Goal 2: Increase availability of Seed through Series B+ stage capital.	
Venture Capital	***Action 2:*** *Expand the amount of VC available to Kentucky companies that hit business and technical milestones and advance to the next stage of growth*
HIGH-TECH INDUSTRY	
Goal 1: Tell Kentucky's technology story better.	
Branding	***Action 1:*** *Develop a compelling storyline and draw on branding and communications best practices from neighboring states to communicate this story.*
Goal 2: Support corporate recruitment, expansion, and growth.	
Recruitment and Retention	***Action 2:*** *Work collaboratively across industry, higher education, and government to recruit and retain companies in target industries.*

About This Plan

Purpose

The *Kentucky Science & Technology Plan: Vision 2030* (hereafter, the S&T Plan) presents a stakeholder- and data-driven vision and strategy for the role that science and technology should play in advancing Kentucky's economy and research enterprise.

The plan serves to set a strategic direction and coordinate university-industry-government collaboration on initiatives to advance these goals. The plan is informed by Kentucky's economic development priorities and includes four areas for action: High-Tech Industry Growth; Innovation and Entrepreneurship, Research Competitiveness, and Science, Technology, Engineering, and Mathematics (STEM) Education.

This 5- to 7-year plan also satisfies a requirement of Kentucky's 2023 research capacity–building proposal to the National Science Foundation's (NSF)'s Established Program to Stimulate Competitive Research (EPSCoR). This S&T Plan updates the previous plan: **2017 Kentucky Statewide Science, Technology, and Innovation Plan.**

Approach

The Kentucky EPSCoR Statewide Committee led the S&T Plan development. The Statewide Committee engaged **RTI International** and **Keen Point Consulting** (hereafter, RTI-Keen Point) to facilitate the development and preparation of the revised S&T Plan.

Over the course of this 6-month project, RTI-Keen Point collected and analyzed a variety of economic, science and engineering, innovation and entrepreneurship, and education data from state and national sources. They benchmarked Kentucky's competitive positioning against other states and the national average. RTI-Keen Point interviewed 112 stakeholders representing higher education, industry, startup and venture development, government, and nonprofit and trade organizations to understand Kentucky's strengths and weaknesses for pursuing science- and technology-driven growth. These interviews generated recommendations that Kentucky can take to build capacity and become more competitive in both research and industry development over the next 5 to 7 years.

Report Organization

The first section of the report presents the case for why Kentucky needs an S&T plan as well as stakeholders' vision for the role that science and technology can play in advancing Kentucky's economy and higher-wage job opportunities. The second section identifies key science- and technology-intensive industry sectors and high-priority research fields on which the recommended actions are focused. The third section presents 5- to 7-year goals and initiatives for each of the four areas for action. The appendix includes the full list of stakeholders who contributed to this S&T Plan, as well as indicators and analysis of data that RTI-Keen Point used to assess Kentucky's performance and benchmark against other states and over time.

Why Kentucky Needs an S&T Plan

Kentucky's real GDP growth has lagged U.S. GDP growth

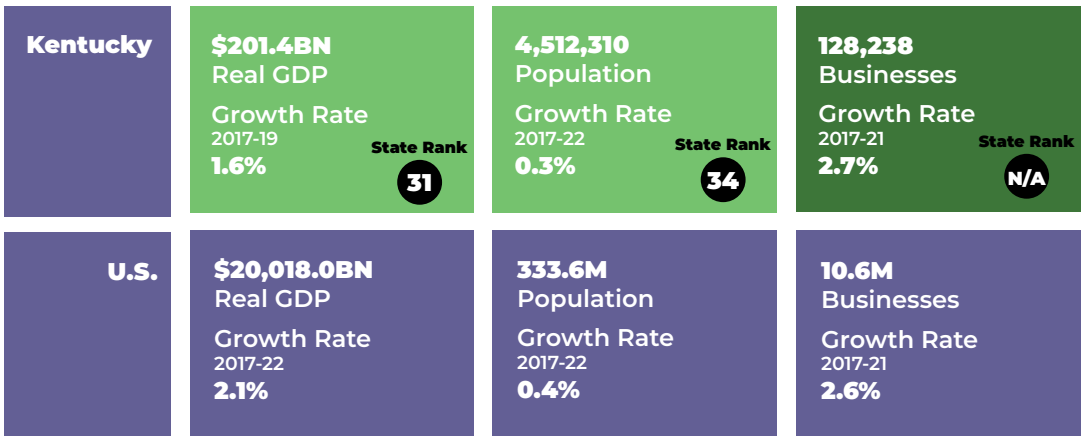
Kentucky's $200 billion economy generated real gross domestic product (GDP) growth of 1.6% per year over the past 5 years, compared to 2.1% real GDP growth nationally. Kentucky needs faster economic growth to raise per capita incomes. One bright spot is that Kentucky's rate of new business growth (2.7% per year) exceeded the national average. One drag on GDP growth is Kentucky's population growth rate, which grew very slowly over the same period (0.3% per year). Overall U.S. population growth has also grown slowly, with the exception of some parts of the country that experienced faster population growth due to inward migration of both domestic and foreign-born residents.

Which industries are driving Kentucky's economy today?

The contributions of Kentucky's different industry sectors vary based on whether GDP or employment is used as the measure. Some industries rank very high or low in both.

- Measured by contribution to GDP: Manufacturing, real estate, healthcare, wholesale trade, and retail trade.
- Measured by employment: Healthcare and manufacturing are usually close competitors for first, followed by retail trade, accommodation and food service, and transportation and warehousing.

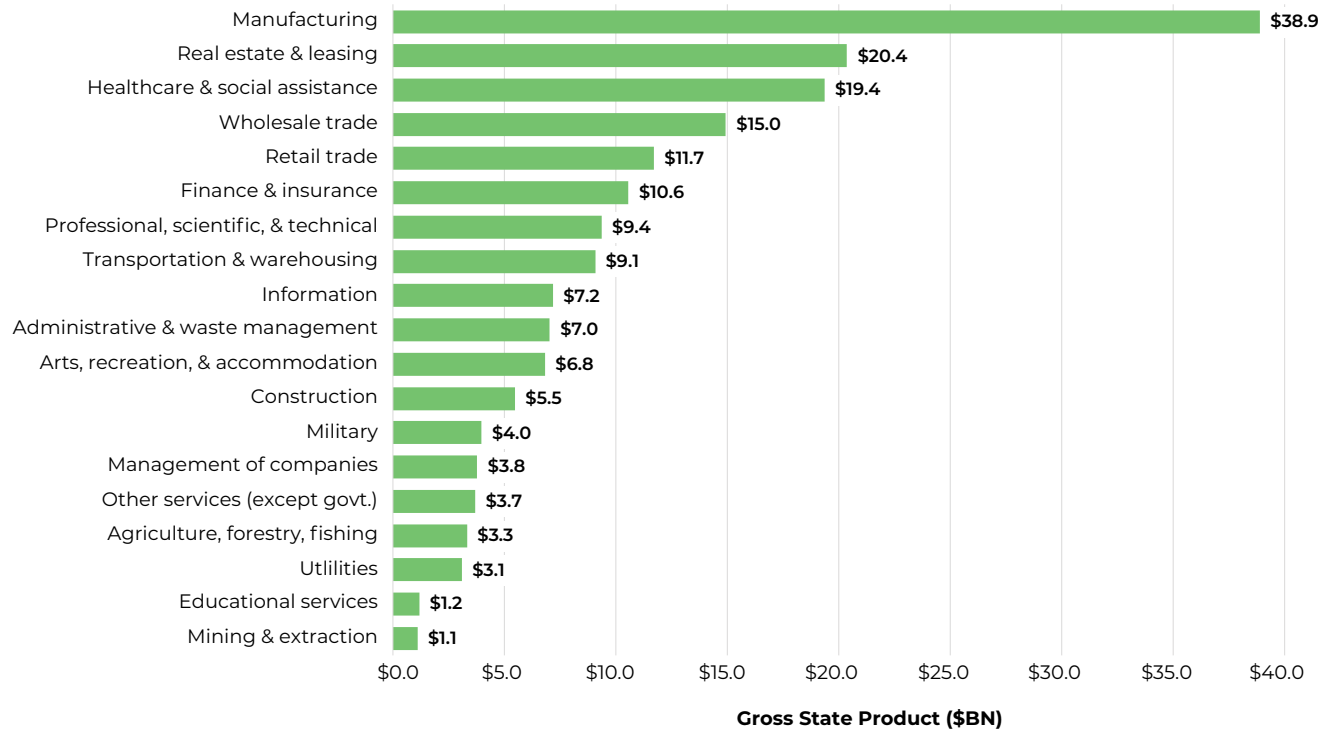
Figure 1. Kentucky Performance on Key Economic Indicators, 2017–2022



Note: Purple is the U.S. compound average growth rate (CAGR); dark green indicates > 2% CAGR; light green indicates a 0–2% CAGR; red (not pictured) would indicate a negative CAGR for Kentucky.

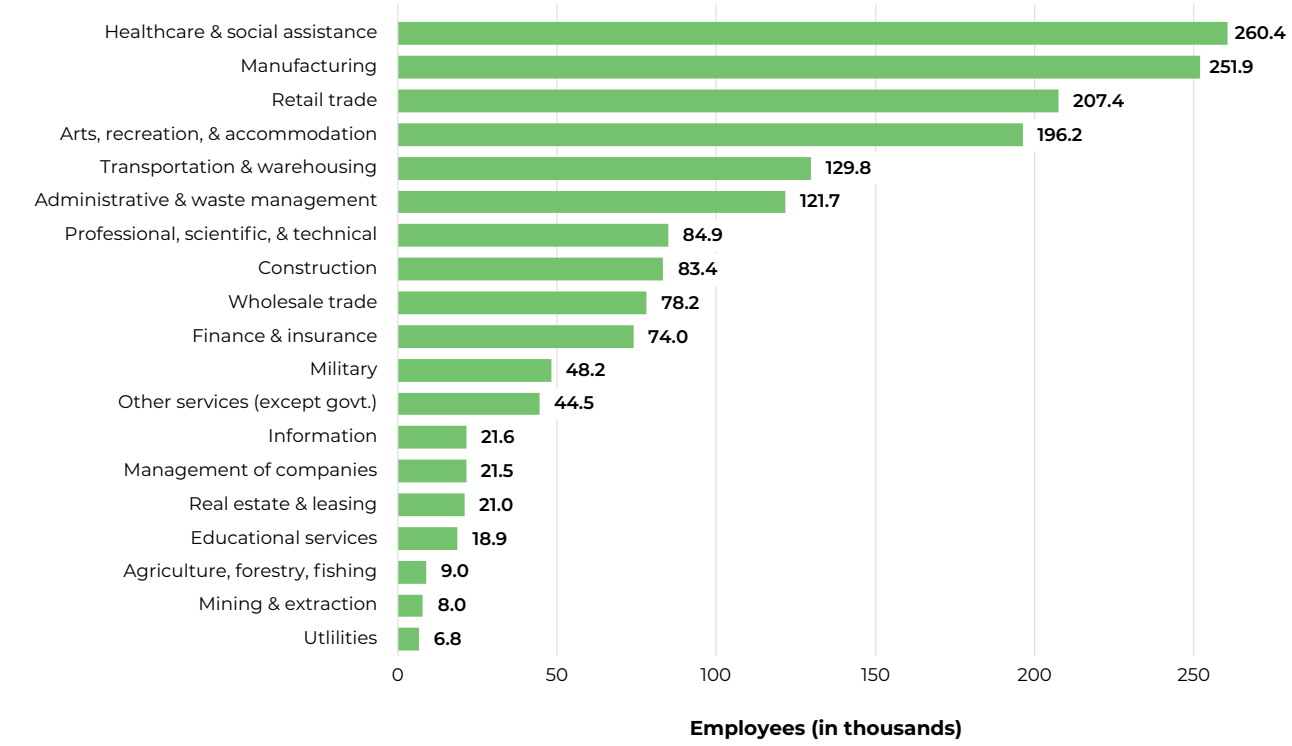
Source: U.S. Bureau of Economic Analysis, U.S. Census Bureau, Population Estimates Program; U.S. Census Bureau, County Business Patterns and Nonemployer Statistics.

Figure 2. Kentucky Industries Ranked by GDP, 2022



Source: U.S. Bureau of Economic Analysis.

Figure 3. Kentucky Industries Ranked by Employment, 2022



Source: U.S. Bureau of Economic Analysis.

Kentucky needs growth in additional industries and diversification within existing industries.

Kentucky needs growth in additional high-wage, high-value-added industries that are relatively small today in terms of total employment. For example, the professional and technical services industry includes companies that specialize in computer systems design, scientific R&D services, engineering services, and software development. Kentucky should support startup companies in these industries, as well as ensure the correct incentives are in place to recruit them. Kentucky also needs to leverage the larger companies in its manufacturing base and diversify by recruiting additional business functions of these companies (e.g., sales and marketing, customer service, accounting and finance, research and development). To support both of these activities, the state should invest more at all stages in the K–20 STEM education to build the future technical workforce required to support the growth of companies in these industries.

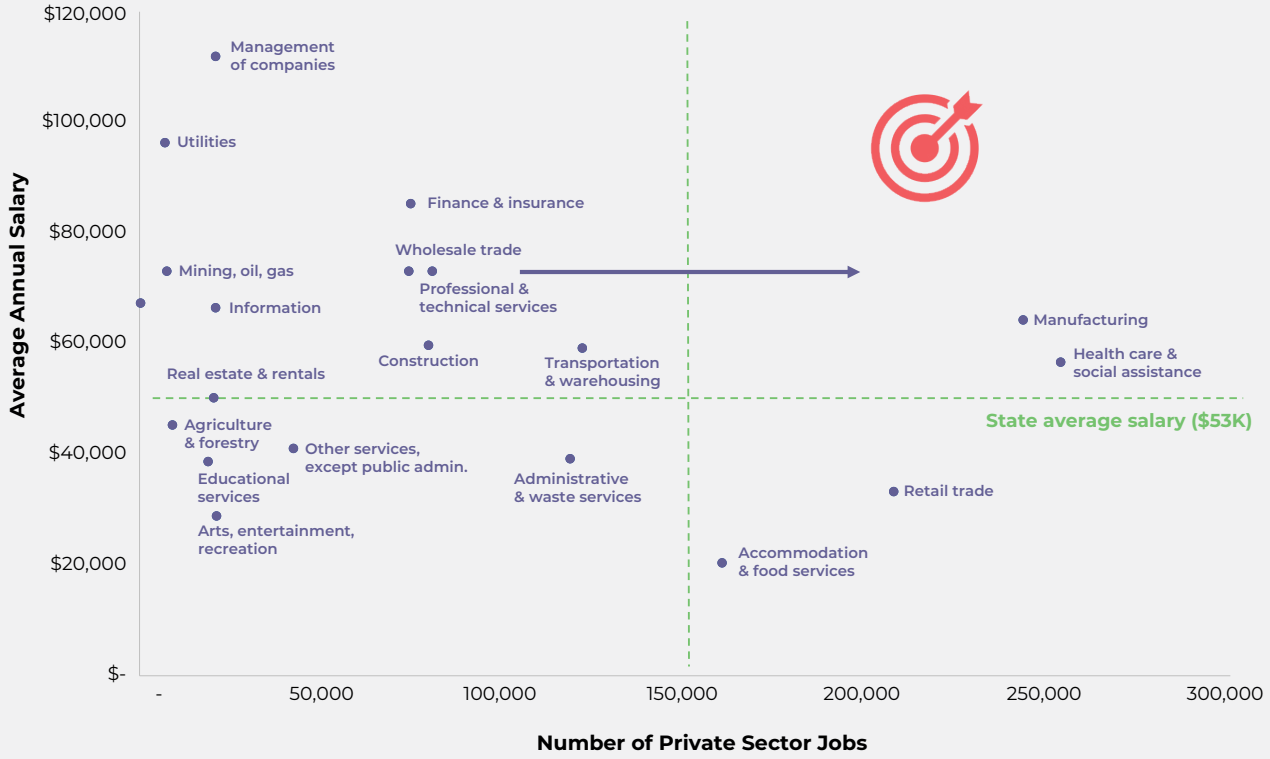
Figure 4 organizes Kentucky's industries by average salary and level of employment. Over time, Kentucky should be aiming to have more industries in the top right quadrant. Among the patterns that can be seen in Kentucky's current industry structure:

- Two of the five largest industries measured by employment—retail trade ($33,000) and accommodation and food services ($20,000)—have average salaries that are significantly lower than the state's average private sector salary of $53,000.

- Stronger employment growth of science- and technology-driven industries, which would fall under professional and technical services ($73,000), management of companies ($112,000), and high-end manufacturing (e.g., electronics, machinery; high-end is rolled into overall manufacturing category) would raise Kentucky's average private sector salary.[1]

1 Industry code 54 in the North American Industrial Classification System (NAICS) includes engineering services, environmental and technical consulting, computer programming, computer systems design, and scientific research and development (R&D) services. NAICS industry code 55 includes headquarters, subsidiary, and corporate offices of companies. NAICS industry code 51 includes software publishing, data processing and hosting, and telecommunications.

Figure 4. Kentucky Industries by Total Employment and Average Salary, 2021



Source: Bureau of Labor Statistics. (2021). Quarterly Census of Employment and Wages.

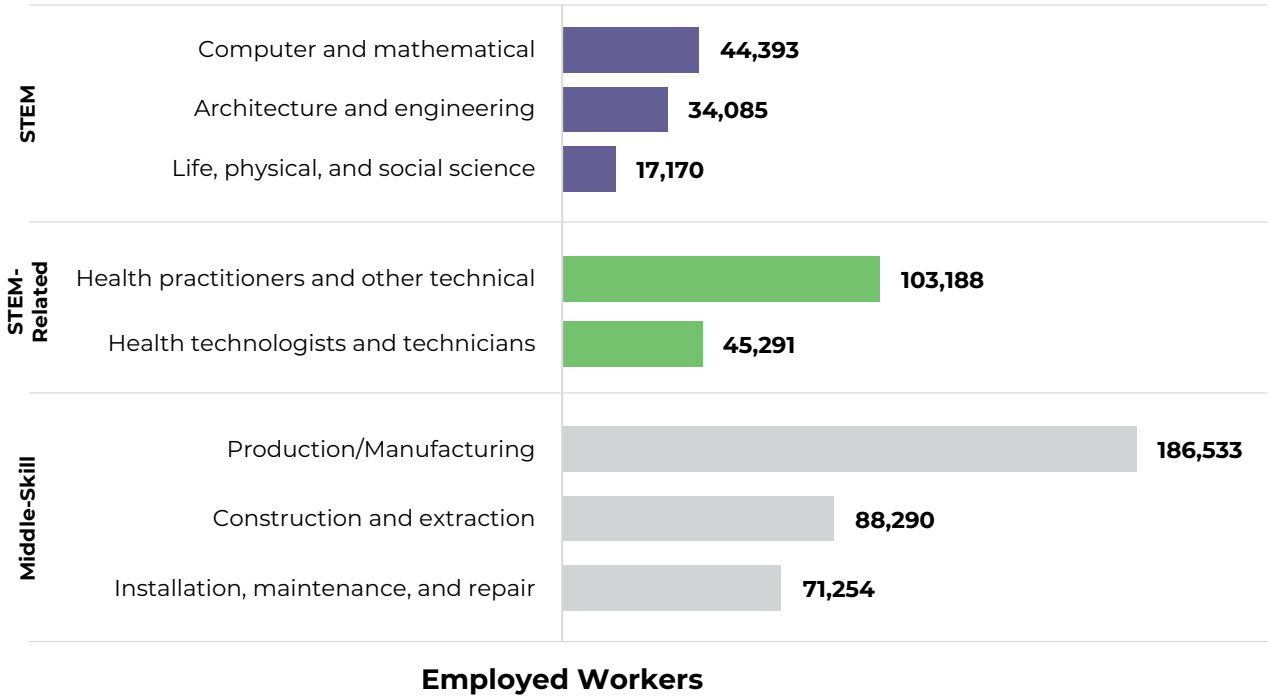
Educational Attainment and Workforce

Why should Kentucky care about STEM workforce?

STEM jobs pay higher-than-average salaries and are more resilient to economic downturns. The NSF defines STEM workers as people who are employed in Science and Engineering (S&E), S&E-related, or "middle-skill" occupations. S&E occupations include computer scientists; biological, agricultural, and environmental scientists; physical scientists; social scientists; and engineers. S&E-related occupations include all health-related occupations, as well as S&E teachers, managers, and technologists. Middle-skill occupations are those in manufacturing/production; installation, maintenance, and repair; and construction and extraction. They do not require a bachelor's degree.

Kentucky's STEM employment reflects its very large manufacturing and healthcare industries. Kentucky's employment is concentrated in middle-skill occupations, followed by S&E-related occupations (mainly in healthcare), and then S&E occupations. Companies that provide high-tech and R&D-intensive services or products (e.g., computer systems design, software, engineering services, scientific R&D services) represent a much smaller share of Kentucky's economy today.

Figure 5. Kentucky Workers Employed in STEM Occupations, 2021

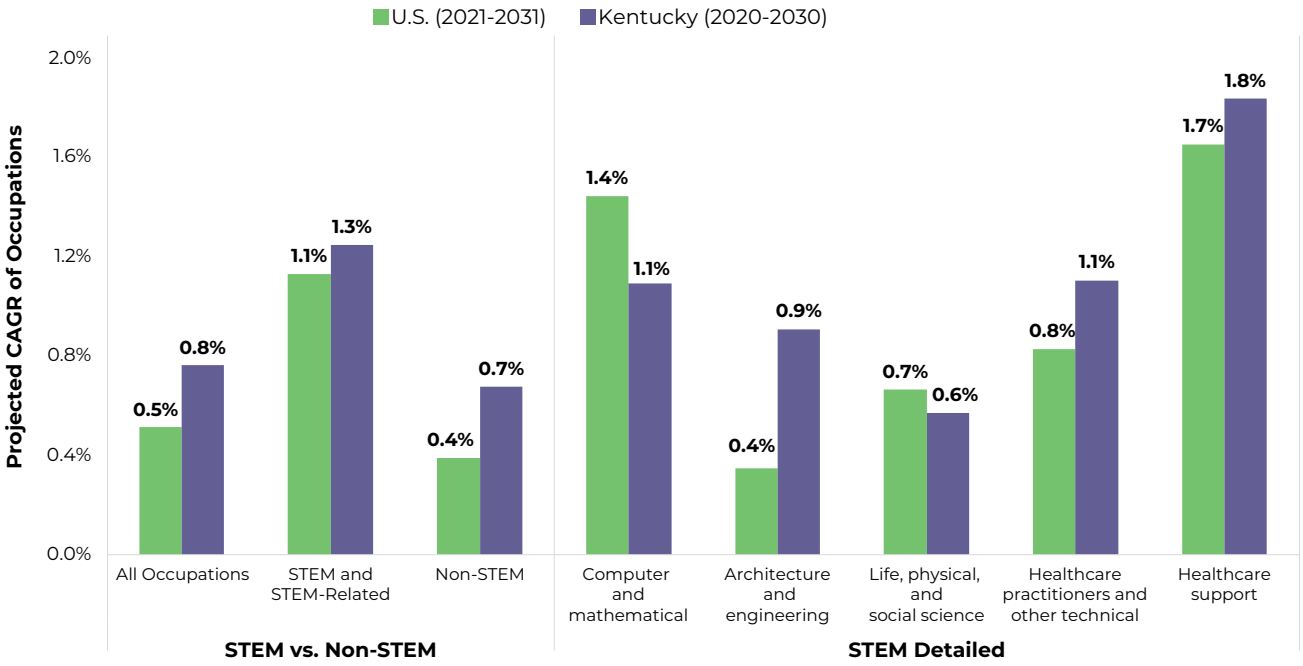


Source: U.S. Census Bureau. (2021). American Community Survey.

STEM jobs will grow faster than non-STEM jobs over the next 10 years.

Over the next 10 years, Kentucky STEM and STEM-related jobs are expected to grow faster than non-STEM jobs: 1.3% per year versus 0.7% per year through 2030. Within STEM, job growth is expected to be strongest in healthcare (1.8% per year for healthcare support jobs and 1.1% a year for practitioners), followed by computer science and math (1.1% per year), and architecture and engineering (0.9% per year). Growth in middle-skill jobs is also expected to be higher than growth in non-STEM jobs overall.

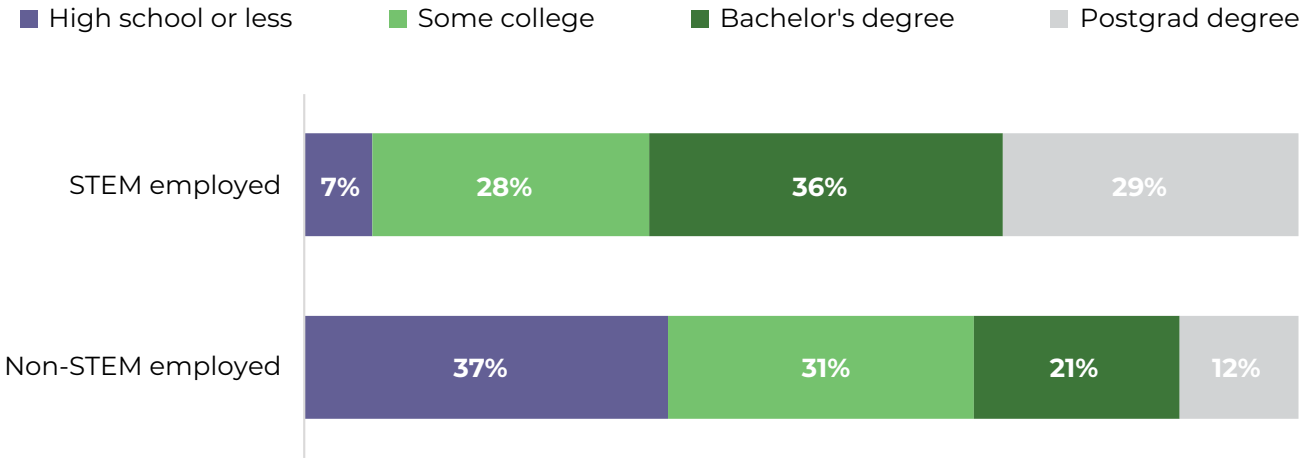
Figure 6. 10-Year Projected Growth in STEM and STEM-Related Occupations vs. Non-STEM Occupations in the United States and Kentucky



Sources: U.S. Bureau of Labor Statistics. (2022). Employment Projections Program; Kentucky Center for Statistics. (2022). Quarterly Census of Employment and Wages.

Kentucky needs to increase its college-going rate to generate a skilled workforce.
STEM workers have higher levels of postsecondary education than non-STEM workers. This trend will continue, driven by the digitization of industries and changes in the structure of the U.S. economy. Kentucky must increase the college-going rate of its residents and the number of students pursuing STEM degrees: nationally, 65% of workers have earned a bachelor's degree or higher versus 33% of non-STEM workers.

Figure 7. Comparison of STEM Employed and Non-STEM Employed Individuals by Educational Attainment in the U.S., 2016



Sources: U.S. Census Bureau, American Community Survey, 2014–2016; Pew Research Center. (2018) Diversity in the STEM Workforce Varies Widely Across Jobs.

Kentucky's Vision for Science & Technology

Stakeholders expressed ideas of what a Kentucky that embraces science and technology and leverages it for economic growth looks like. The stakeholder quotes below speak to a shared vision of the roles that science and technology play in Kentucky's economy, policies, and long-term investments.

> Kentucky understands the connection between universities, research, student preparation, and a technology-based economy."

> This understanding leads to broader public support and public investment in S&T infrastructure."

> Kentucky's future is greatly enhanced by a stronger S&T infrastructure that attracts and supports the growth of companies and industries."

> Kentucky does not miss this once-in-a-lifetime opportunity presented by the national focus on supply chain reshoring."

> Kentucky makes greater investment in STEM education to build the skills of students. Students and families understand how an education in S&T can benefit them, and students are able to access this education."

> This education enhances the lives of graduates and communities, nowhere more so than in very rural parts of the state."

Target Industry Sectors and High-Priority Research Areas

To sharpen the path forward, the Kentucky S&T Plan identifies four target industry sectors and four high-priority research areas. These industry sectors and research areas were selected based on analysis of economic data, research expenditure data, and stakeholder interviews that addressed the following questions:

1. Which science- and technology-driven industries are important to Kentucky's economic growth and development?

2. In which research fields does Kentucky have a distinct advantage for advancing these industries or a disadvantage that will impede progress if not addressed?

3. In which technology areas is Kentucky seeing innovation and startup activity?

4. What type of talent does Kentucky need to support growth and competitiveness in these areas?

The top row of Figure 8 presents the four S&T-driven target industry sectors: Advanced Manufacturing, Supply Chain and Logistics, Health and Agriculture, and Climate and Resiliency. The high-priority research areas are listed in the left column. The matrix provides representative examples of research applications to each industry sector.

Figure 8. Kentucky Target Industries and High-Priority Research Areas

High-Priority Research ↓ / Target Industries →	Advanced Manufacturing	Supply Chain and Logistics	Health and Agriculture	Climate and Resiliency
Materials	Lightweight, sustainable auto and aerospace materials, EV batteries	Wear-resistant coatings, smart sensor materials, recycling of critical materials	Bio-based materials, biosensors, implantables, greenhouse materials	Semiconductors and nano materials, renewable energy
Data Analytics, AI/ML	Predictive shopfloor reliability, control system security	Supply chain management, data security	Patient management, big data and disease, crop yield optimization	Monitoring and prediction, disaster response
Energy Transition	Waste heat recovery, carbon capture/reduction of emissions	Hydrogen, electric transport	Greenhouse emissions control in cattle farms	Hydrogen, electrification, energy efficiency
Engineering	Robotic material handling, advanced mobility	Warehouse robotics, material handling	Biotechnology and bioengineering, farm robotics	Climate-resilient infrastructure
Fundamental Research				

Note: EV = electric vehicles. Fundamental research and workforce training incorporate every field of science and engineering. They are required to support the four high-priority research areas and four industry sectors for growth.

Target Industry Sectors

The justification for the selection of each of the four high-tech industry sectors to target is summarized below.

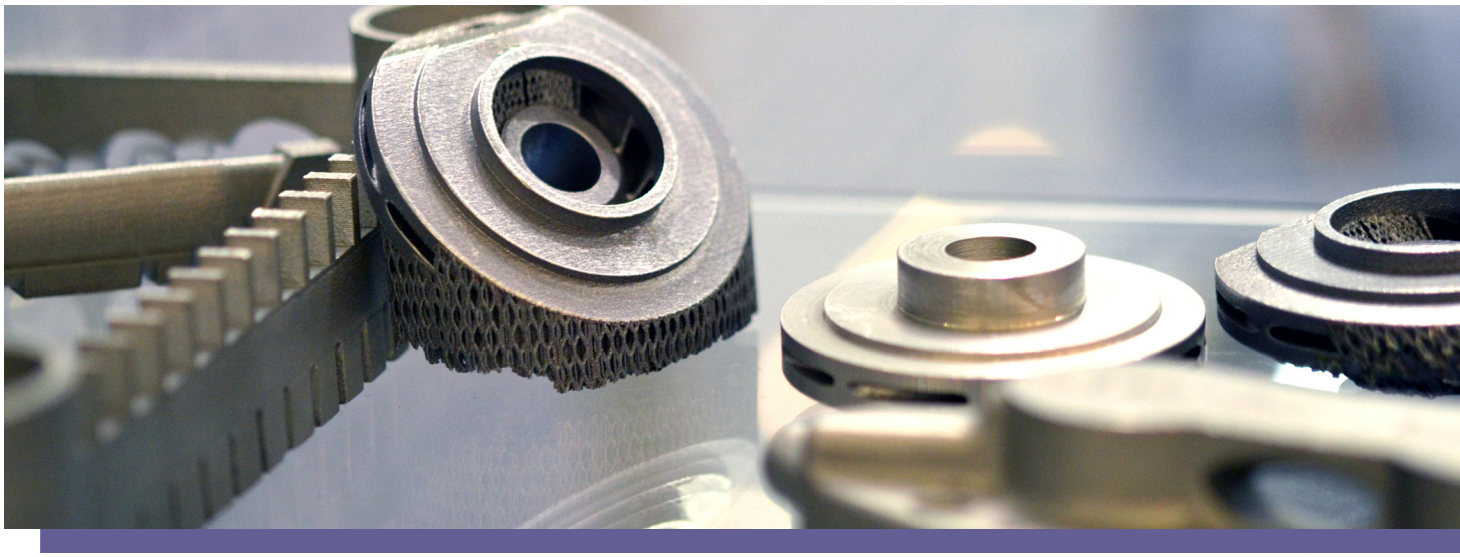
Advanced Manufacturing: Manufacturers in Kentucky employed 252,000 workers in 2022 and nearly 260,000 in April 2023, which is midway between its 25-year high of 312,000 employees (2000) and its low of 208,000 employees (2009, repeated in 2020 due to COVID).[2] Manufacturing is neck-and-neck with healthcare as Kentucky's largest industry employers. As a mid-sized state, Kentucky ranks 19th nationally for total manufacturing employment, but fifth for manufacturing jobs as a share of total non-farm employment (13% of nonfarm employment).[3]

"Advanced" manufacturing refers to those manufacturing industry segments that have a higher R&D intensity (measured by an industry's R&D expenditures as a share of total value-added output). [4]Companies in these segments include automotive companies (e.g., Ford, Toyota, General Motors, and their suppliers); durable equipment manufacturers (e.g., GE Appliances, a Haier company); metals manufacturers (e.g., Nucor Steel, UACJ Corporation); laser printer and imaging companies (e.g., Lexmark); jet aircraft engine manufacturers (e.g., GE Aviation); and chemical companies (e.g., Dow Chemicals, Sherwin Williams). Kentucky also announced two new electric vehicle battery manufacturing facilities: the Ford-SK Innovation joint venture near Elizabethtown, KY, and Envision AESC near Bowling Green, KY.

Supply Chain and Logistics: Kentucky is a global air cargo leader, leveraging its central geographic location for the distribution of products across the United States and globally. UPS, DHL, and Amazon all have global air cargo hubs in Kentucky. After Ford, UPS and Amazon are the largest individual private sector employers in Kentucky, with over 12,000 employees each. Kentucky's supply chain and logistics infrastructure and companies support a range of business-to-business (B2B) supply chain management activity in addition to distribution and package delivery to consumers. The COVID-induced bump in e-commerce and shipping has not abated; some segments, like healthcare shipping, are continuing to experience very rapid growth. UPS is expanding its healthcare shipping operations in Louisville to meet the growing demand for temperature-controlled mRNA vaccines and other biologics. DHL and Amazon are also planning expansions at and Cincinnati/Northern Kentucky International (CVG) Airport in Covington, as total annual cargo tonnage doubled from 2016 to 2021 and grew by 17% from 2021 to 2022.[5]

Health and Agriculture: Kentucky's healthcare sector employed 259,000 employees in 2021. Humana, a for-profit health insurance company based in Louisville, employs more than 10,000 people. Major healthcare providers include University of Kentucky Health, UofL Health, Kindred Healthcare, St. Elizabeth Healthcare, Trilogy Health Services, Baptist Health, and Appalachian Regional Healthcare. In 2022, in response to a finding that Kentucky is operating between 12 and 20% below needed nursing staff levels (and at similar rates for other healthcare workers), the legislature funded the $10 million Kentucky Healthcare Workforce Collaborative. The Collaborative provides grants to Kentucky's public

2 U.S. Bureau of Labor Statistics. (2023). Current Employment Statistics. Employment, Hours, and Earnings.
3 U.S. Bureau of Labor Statistics 2022 employment data show that Indiana ranked first (17%) in manufacturing jobs as a share of total nonfarm employment, followed by Wisconsin (16%), Michigan (14%), and Iowa (14%).
4 The NSF uses the definition of high-tech and advanced manufacturing industries developed by the Organisation for Economic Co-operation and Development (OECD). The OECD's taxonomy categories industries by R&D intensity. High- and medium-high R&D intensity industries are classified as knowledge- and technology-intensive industries, i.e., high-tech and advanced manufacturing industries.
5 Ohio-Kentucky-Indiana Regional Council of Governments and CVG Airport.



universities and community and technical colleges to support programs that train healthcare workers.[6] Both University of Kentucky and University of Louisville have medical schools and other healthcare worker training programs, as do the six comprehensive universities and most of the state's community and technical colleges.

On the agriculture side, Kentucky is home to nearly 76,000 farms, most of which are small family-run operations. About 66% (49,942) of these farms report annual sales of less than $10,000. Given the "small business nature of many Kentucky farms, employment in the sector is relatively low, with approximately 3,170 workers.[7] Kentucky's top three agricultural commodities are corn, soybeans, and livestock (poultry, horses and equine, and cattle).[8] AgriTech companies span animal nutrition and crop science (e.g., Alltech), farm management (e.g., Ag Connections, acquired by Syngenta, and Smart Farm Systems), and novel food system companies (e.g., AppHarvest, Kentucky Fresh Harvest, West KY Aquaponics).[9]

Climate and Resiliency: Companies in this industry provide products and services aimed at designing and constructing more resilient buildings, civil infrastructure, and agricultural systems; assisting with disaster recovery; monitoring and predicting changes in the weather and climate; improving energy efficiency; and generating clean and renewable energy. In Kentucky, companies in this sector include engineering firms, such as CMTA, Stantech Consulting Services, HDR Engineering, Turner Engineering, and RJ Corman, a railroad track construction and railroad services emergency company.

In recent years, Kentucky has experienced droughts, floods, severe storms, and tornadoes. The droughts of 2012 and 2022 had significant negative impacts on agriculture, river barges, and ecosystems.[10] At the same time, the increasing intensity of rainfall events that occur on top of drought-impacted soil leads to runoff and flash flooding that has destroyed homes and businesses and taken the lives of Kentuckians. These short but intense downpours often do not alleviate drought conditions.

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6 Kentucky Council for Postsecondary Education. (2023). Kentucky Healthcare Workforce Collaborative. https://cpe.ky.gov/ourwork/ky-hwc.html

7 U.S. Bureau of Labor Statistics. (2023). State Occupational Employment and Wage Estimates: Kentucky. https://www.bls.gov/oes/current/oes_ky.htm#45-0000

8 U.S. Department of Agriculture, Economic Research Service. (2022). National Agricultural Statistics Service: Kentucky Fact Sheet. https://data.ers.usda.gov/reports.aspx?StateFIPS=21&StateName=Kentucky&ID=17854

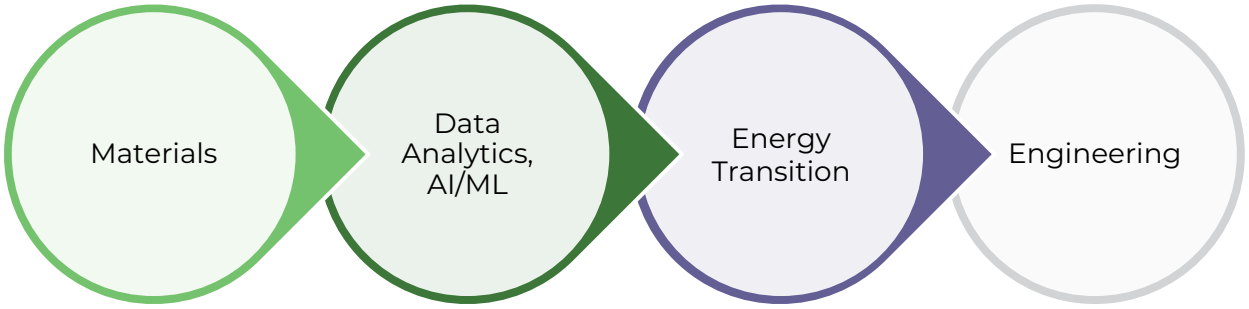
9 Commonwealth of Kentucky. (2023). Kentucky Agritech: Success Stories. https://agritech.ky.gov/Success-Stories/Pages/default.aspx

10 Giffen, C. (2022, October 18). Gripped by Drought, Kentucky Sees Weather Whiplash Following Summer Storms. Louisville Courier journal. https://www.courier-journal.com/story/news/local/2022/10/18/drought-in-kentucky-commonwealth-sees-climate-extremes/69556781007/

High-Priority Research Areas

Stakeholders identified four high-priority research areas for the S&T Plan. The four areas build on existing competitive advantages or address gaps that require capacity-building, so they do not hold other areas back. These areas are aligned with the funding priorities of federal agencies.

Figure 9. Figure 9. High-Priority Research Areas for Kentucky S&T Plan



Note: AI/ML = Artificial Intelligence/Machine Learning

Materials: Materials spans primary metals (e.g., aluminum, copper, steel) to advanced materials. Kentucky is a major manufacturer of chemicals, plastics and rubber, primary metals, and metals products. Advanced materials are those that are specifically engineered to exhibit novel or enhanced properties that confer superior performance relative to conventional materials. Like artificial intelligence (AI) and data science, advanced materials research supports technological advances in nearly all other S&E applications, including batteries and solar cells, metals and materials for the automotive and aerospace industries, and medical devices.

Many academic research institutions have strengths in materials science research. The University of Kentucky has a Center for Advanced Materials, and the university's total metallurgical and materials engineering research expenditures totaled $4.5M in 2021, third after engineering not elsewhere classified (which is mainly energy-related) and civil engineering research expenditures. Materials is being designated as the University of Kentucky's eighth strategic research priority in 2023. The University of Louisville has a Micro/Nano Technology Center and is an NSF-supported National Nanotechnology Coordinated Infrastructure site (2020–2025 award extension). Western Kentucky University has an Advanced Materials Institute. Murray State University has strengths in polymer and materials science, and Eastern Kentucky University has strengths in analytical chemistry and polymer science. The Metals Innovation Initiative, a new industry-led initiative, was launched to promote research and innovation, talent attraction and development, and sustainability in Kentucky's metals industry.

Data Analytics, AI, Machine Learning: Data analytics is the process of answering questions, extracting insights, and identifying trends by analyzing data. Different statistical techniques are applied to large datasets (e.g., manufacturing production data, healthcare data, online user data). AI is a field that combines computer science and

data science to interpret historical data, recognize patterns, and make predictions the way humans do. At the University of Louisville's Louisville Automation and Robotics Research Institute (LARRI), work focuses on human-robot collaboration, networked robots, autonomous vehicles, and micro and nano robots.

Machine learning is a subset of AI that draws on statistics and algorithms to provide models for learning and processing data autonomously without human intervention (e.g., supply chain inventory management).[11] Although AI and machine learning techniques are increasingly applied across all research areas, computer science R&D represents only 0.65% of Kentucky's total academic R&D expenditures versus 4% nationally.

Energy Transition: Energy transition is an interdisciplinary area of research focused on the technologies and systems needed to transition from production and consumption of fossil fuels to those that emit very little to zero carbon dioxide into the atmosphere. Energy is one of the eight strategic research priorities areas at the University of Kentucky—its Center for Applied Energy Research has research groups working on power generation, organic electronics, materials technologies, clean fuels and chemicals, and biofuels and environmental catalysis.

The University of Louisville Conn Center for Renewable Energy Research performs renewable energy research and promotes technologies, practices, and programs that increase efficiency for energy utilization. Research themes include solar fuels and manufacturing, biofuels and biomass conversion, energy storage, advanced energy materials, and energy efficiency. Some of this research has led to commercialization activity and the creation of startups like Bert Thin Films, a University of Louisville spinoff attempting to commercialize CuBert™, a plug-and-play copper paste replacement for the more expensive silver paste in the solar cell manufacturing process. The Department of Energy–supported Industrial Assessment Center (IAC) program at the University of Louisville provides free energy productivity and waste assessments to small- and medium-sized industrial facilities.

Engineering: Kentucky engineering R&D expenditures grew from $68.2 million in 2015 to $74.7 million in 2021, with a CAGR of 1.5%. The state's most recent NSF EPSCoR award was focused on engineering. Statewide, engineering not elsewhere classified (nec), is the largest subfield, followed by civil engineering, bioengineering, and electrical and computer engineering. The University of Kentucky and University of Louisville have different engineering research strengths. The University of Kentucky's largest engineering subfield is engineering nec because of its two major multidisciplinary centers, the Center for Applied Energy and the Transportation Research Center. Civil engineering is second, followed by metallurgical and materials engineering.

The University of Louisville's largest subfield is electrical and computer engineering, followed by bioengineering and engineering, nec. Louisville leverages its Nano/Micro Technology Center and LARRI for dedicated microelectronics, microfluidics, advanced materials, and robotics research. Among the comprehensive universities, Morehead State University has strengths in aerospace engineering, while Western Kentucky University has strengths in mechanical engineering.

11 See Braincube. AI vs. Machine Learning vs. Data Science for Industry: Key Definitions, Differences, and How They Work Together. https://braincube.com/resource/manufacturing-ai-vs-machine-learning-vs-data-science/

Innovation and Startup Activity

Innovation is the introduction of new products, processes, business models, or marketing practices. Innovation is different from invention. Although invention is important and occurs across a variety of actors (individuals, government labs, higher education, nonprofit organizations, companies), companies are the conduit of innovation, i.e., the vehicle by which these new products, processes, or practices are commercialized and introduced to the marketplace.

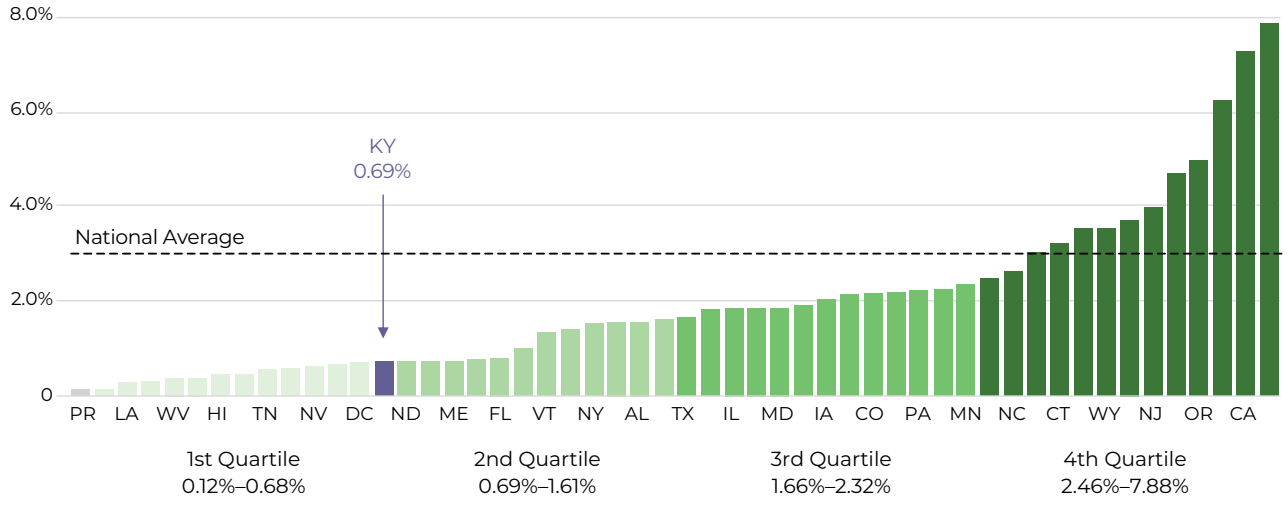
The economic impact of innovation can be seen in the revenue growth and competitiveness of (1) existing companies through the introduction of new models of an existing product, quality improvements and efficiency improvements introduced into the manufacturing process, and new tech platforms that increase connection to customers and suppliers; and (2) new companies that commercialize new products and technologies.

Indicators of business innovation activity includes business R&D expenditures, patent activity, and venture capital (VC) activity and exits (e.g., through mergers and acquisition or initial public offerings on the stock market).

Kentucky's business R&D intensity is well below the U.S. average.

In terms of business R&D intensity, Kentucky ranks in the bottom half of states with business R&D expenditures as a share of output of 0.69% compared to the national average of 2.95%. This suggests that Kentucky has significantly fewer R&D-intensive companies in its existing industry base relative to other states with strong manufacturing—e.g., Indiana at 2.46%; Ohio at 1.83%, and North Carolina at 2.61%.

Figure 10. State Ranking by Business R&D as a Percentage of Private-Industry Output, 2020



Source: National Science Board. (2023). State Science and Engineering Indicators.

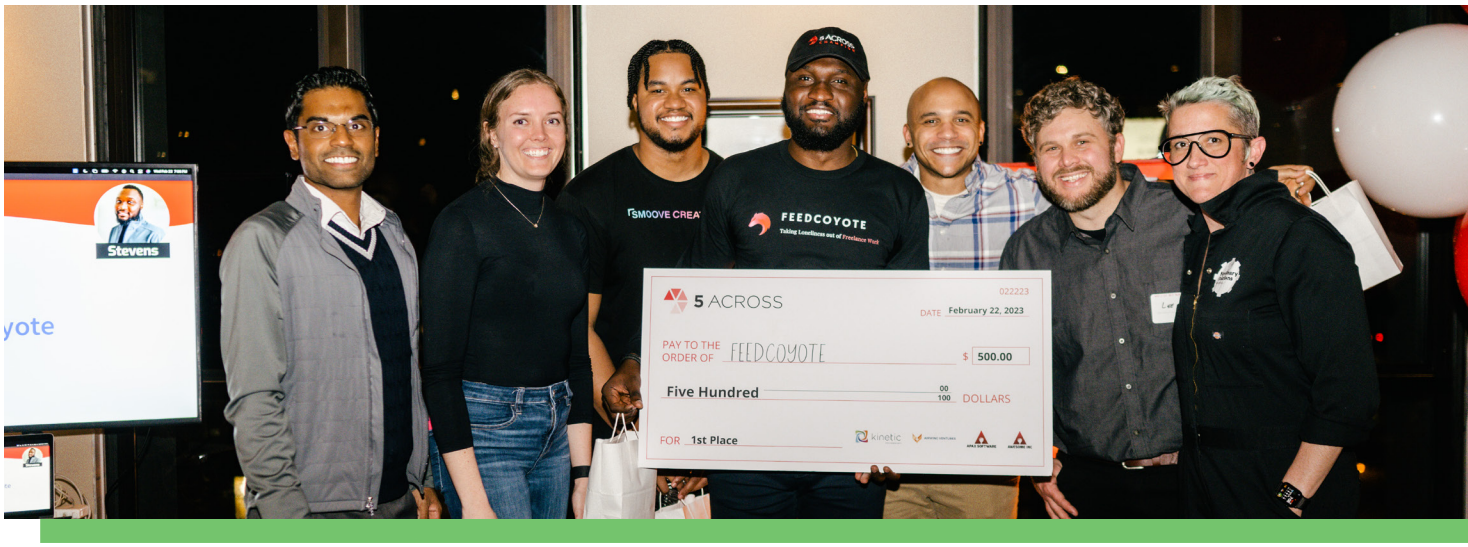
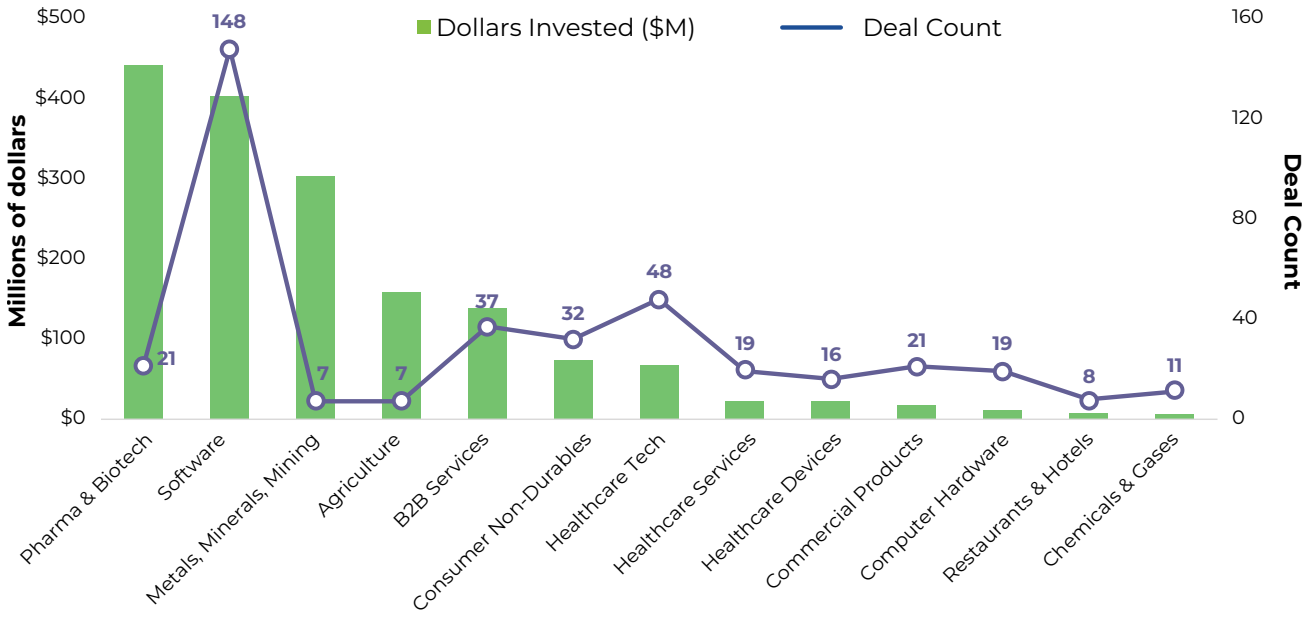


Photo credit: Awesome Inc.

Kentucky's strongest deal activity is in Software, Health Tech, and B2B Services.

Although VC-backed firms represent less than 1% of all startup companies nationally, VC activity is an indicator of high-growth potential startups based on innovation activity. Over the past 5 years, Kentucky has seen the strongest VC deal activity (represented by the line in Figure 11) in Software (148 deals), Health Tech (48 deals), and B2B Services (37 deals). The ranking by highest value of VC investment is Pharma and Biotech ($441.3 million in 21 deals), Software ($402.7 million in 148 deals), and Metals, Minerals, and Mining ($303.0 million in seven deals).

Figure 11. Count of Kentucky's VC Deals and VC Investment ($M) by Primary Industry Group, 2017–2022

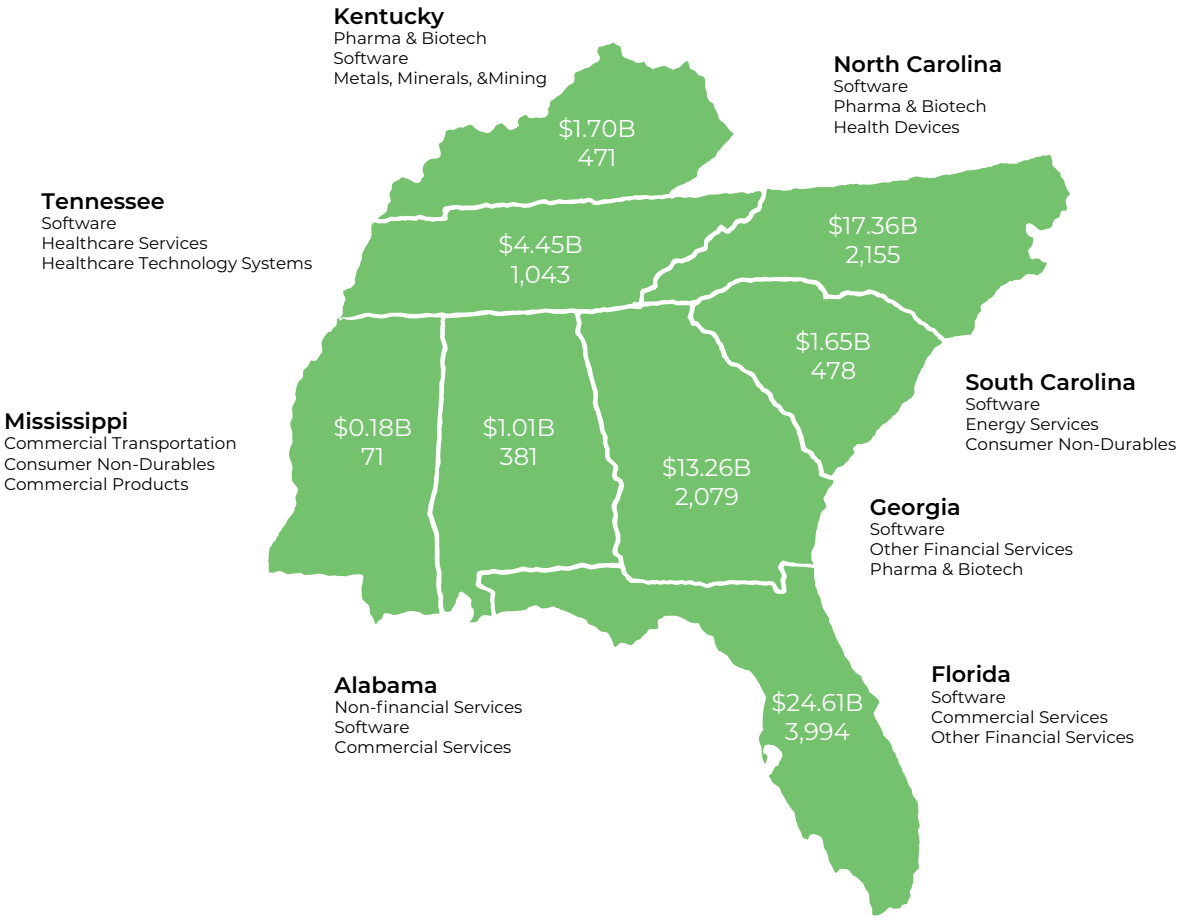


Source: Pitchbook Venture Capital and Private Equity Database.

Total VC investment in Kentucky companies is similar to South Carolina.

Over the past 5 years, Kentucky ranked fifth out of all eight Southeast states in terms of both VC investment dollars and deal flow. Kentucky is most similar to South Carolina in terms of total VC investment, but with a different mix of leading industry verticals.

Figure 12. Total VC Investment ($B), Total Number of VC Deals, and Top Three Industries by Southeast State, 2017–2022

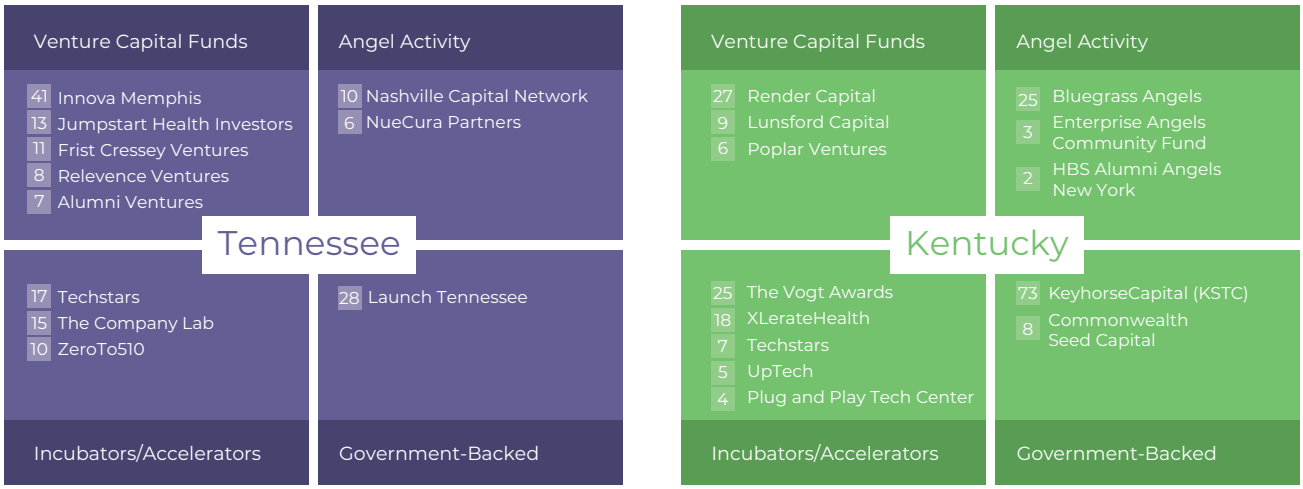


Sources: Panorama Ventures. (2023). The State of Startups in the Southeast 2022; Pitchbook Venture Capital and Private Equity Database.

What are sources of VC in Kentucky?

Kentucky has a lower level of VC deal activity and fewer private VC funds compared to five of the seven other Southeast states. Figure 13 shows the top VC investors by type of investor. Kentucky has a number of incubators/accelerators, angels, and government-supported VC firms investing in pre-seed to seed stage deals.

Figure 13. Top VC Investors by Type of Investor, 2017–2022



Sources: Panorama Ventures. (2023). The State of Startups in the Southeast 2022; Pitchbook Venture Capital and Private Equity Database.

Photo credit: Awesome Inc.

Goals and Actions

The Kentucky S&T Plan identifies four areas for action: STEM Education and Workforce, Research Competitiveness, Innovation and Entrepreneurship, and High-Tech Industry Growth. Goals and recommendations for each of the four areas are presented below.

STEM EDUCATION AND WORKFORCE

Goal 1: Increase student enrollment in STEM postsecondary education.

STEM Pipeline (Enrollment)

Action 1: *Increase the number of students attracted to and prepared to pursue STEM degrees, including first-generation college students, women, and students of color.*

1.1. Continue to pursue additional funding (state and external funds) to support STEM project-based learning in K–12 schools, especially Title 1 schools, to increase K–20 STEM pipeline.

1.2. Support and retain diverse, high-quality K-12 STEM teachers through preparation and professional development

1.3. Develop targeted degree and workforce development certificate programs for high-growth industries (e.g., automotive, computer/tech, electric power).

1.4. Increase funding available for graduate assistantships to increase number of MS and PhD STEM graduates.

1.5. Create networking events, conferences, and "collaboration hubs" to foster new and build upon existing collaborations with Kentucky State.

Goal 2: Increase number of STEM degrees awarded at all levels and among first-generation college students, women, and students of color.

STEM Pipeline (Graduates)

Action 2: *Pursue and provide additional support to retain and graduate students in STEM degrees, especially first-generation college students, women, and students of color.*

2.1. Pursue external grants (e.g., NSF INCLUDES, S-STEM, LSAMP)[12] to provide more hands-on, real-world experiential education that will help students bridge to their future professions (e.g., applied research experiences, internships, coops to retain STEM students).

2.2. Provide students support services focused on retention and STEM degree completion.

2.3. Develop training for research mentors for early-career research faculty at comprehensive universities.

2.4. Request the Kentucky EPSCoR Statewide Committee, Kentucky Academy of Sciences, or Kentucky Commercialization Ventures provide training for early-career research faculty on how to create undergraduate research experiences and sponsor an annual symposium to share success stories in creating and sustaining these programs.

12 INCLUDES is the NSF Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science. It supports the research, collaborative infrastructures, partnerships, and networks necessary to address specific STEM-inclusion challenges at a national scale. S-STEM is the NSF Scholarships in Science, Technology, Engineering, and Mathematics program. It supports institutions of higher education to fund scholarships for academically talented low-income students and to implement activities that support their recruitment, retention, and graduation in STEM. LSAMP is the Louis Stokes Alliance for Minority Participation program. It provides funding for a bridge to baccalaureate and doctorate projects and STEM pathways projects.

RESEARCH COMPETITIVENESS	
Goal 1: Increase research competitiveness through capacity-building (people, equipment, and facilities).	
People	***Action 1:*** *Invest to increase the pool of high-quality students available to support research activity across all science and engineering disciplines.*
	1.1. Increase funding available for graduate assistantships to increase the number of master's and PhD students. 1.2. Ensure graduate stipends are nationally competitive. 1.3. Increase funding to expand paid opportunities for undergraduates to participate in research, internships, and coops to develop the undergraduate-graduate pipeline. 1.4. Hire postdocs (at both research universities and comprehensive universities) who can support the research mission, train graduate and undergraduate students, and help develop proposals.
Equipment	***Action 2:*** *Increase financial support to replace and upgrade equipment in core research facilities (to help recruit and retain top research faculty).*
	2.1. Create a state investment fund to modernize equipment, instrumentation, and computing infrastructure. 2.2. Develop an inventory of research core facilities that can be accessed by researchers at universities and companies across the state (define core facility, identify them, list use costs for research universities, comprehensive universities, large companies, small companies).
Facilities	***Action 3:*** *Provide and maintain state-of-the-art facilities aligned to strategic research areas to recruit and retain top research faculty.*
	3.1. Create state investment fund to renovate, modernize, and construct buildings (benchmark investment being made by other states).
Goal 2: Increase recognition that applied and basic research are needed to tackle 21st century challenges, including economic and societal challenges.	
Promotion and Tenure Guidelines	***Action 1:*** *Identify the value of industry-driven and use-inspired research (e.g., industry-sponsored research projects, Small Business Innovation Research grants) in promotion and tenure guidelines.*
Industry Connections	**Action 2***: Continue to build industry-university connections and collaborations.*
	2.1. Work to ensure better coordination of industry liaison function across Kentucky's universities. 2.2. Invest in innovation space adjacent to research universities for companies, startups, and faculty working in high-priority industry verticals. 2.3. Invest in programming to maximize new connections, e.g., "lunch and learns"; pitch competitions; hackathons for students, companies, faculty.

INNOVATION AND ENTREPRENEURSHIP

Goal 1: Increase business R&D and innovation activity in target industries.

Business R&D

Action 1: *Provide funds that can be used to support small- and medium-sized manufacturers, biotech, and high-tech companies with applied R&D projects and access to talent.*

1.1. Create matching grant funds that can be used on applied R&D projects to solve industry-driven technical challenges. The funds will help Kentucky businesses access university and community and technical college faculty and facilities/equipment to support this applied R&D.

1.2. Create pool of funds that startups/small companies can use to "top up" or match salaries for interns or coops in both technical and business disciplines.

1.3. Create pool of funds that can be used to broker and support startup/small business proof-of-concept/pilots with potential customers (medium or large companies).

1.4. Restore funding for Kentucky's SBIR Matching Fund program.

Goal 2: Increase availability of Seed through Series B+ stage capital.

Venture Capital

Action 2: *Expand the amount of VC available to Kentucky companies that hit business and technical milestones and advance to the next stage of growth*

2.1. Expand the stage and scope of Kentucky Enterprise Fund investments (investments are currently capped at $500,000) by capitalizing new funds that can be used to invest in follow-on Series A and B+ rounds. (benchmark: Elevate Ventures in Indiana can invest up to $4M in a company and was investing $13.5M a year pre-SSBCI 2.0).

2.2. Increase capital for the Commonwealth Seed Fund to make indirect fund-of-funds investments.

HIGH-TECH INDUSTRY

Goal 1: Tell Kentucky's technology story better.

Branding

Action 1: *Develop a compelling storyline and draw on branding and communications best practices from neighboring states to communicate this story.*

1.1. Work with industry and the Cabinet for Economic Development (CED) to develop a more comprehensive and compelling storyline supported by a robust benchmarking effort against neighboring states.

1.2. Generate success stories about startup companies and faculty working on interesting problems or technologies.

Goal 2: Support corporate recruitment, expansion, and growth.

Recruitment and Retention

Action 2: *Work collaboratively across industry, higher education, and government to recruit and retain companies in target industries.*

2.1. Leverage community colleges and universities in ongoing efforts by regional economic development organizations and CED to recruit and retain high-tech companies, given that talent is a key driver of location decisions.

2.2. Encourage industry, higher education, and venture development stakeholders to continue to collaborate with CED to generate ideas and a strong business case for initiatives that will support high-tech company growth and retention.

Appendix

List of Contributing Stakeholders

Higher Education Administrators

Rodney Andrews, PhD, *Associate Vice President for Research, University of Kentucky, KY NSF EPSCoR*
Lisa Cassis, PhD, *Vice President for Research, University of Kentucky*
Blaine Ferrell, PhD, *Dean Emeritus, Western Kentucky University*
Claire Fuller, PhD, *Dean of the College of Science, Engineering, and Technology, Murray State University*
Kevin Gardner, PhD, *Executive Vice President for Research and Innovation, University of Louisville*
Samantha Langley, PhD, *Vice Provost for Graduate Education, Research and Outreach, Director of Online Education, Northern Kentucky University*
Ian McClure, JD, *Associate Vice President for Research, Innovation and Economic Impact, University of Kentucky*
Will Metcalf, JD, *Associate Vice President for Research Development and Strategic Partnerships, University of Louisville*
Jeff Mossey, MBA, *Program Manager, KY NSF EPSCoR, University of Kentucky*
Jacob Owen, MA, *Associate Director, NASA Kentucky Space Grant Consortium and NASA EPSCoR Programs*
Taunya Phillips, MBA, *Director of the Office of Technology Commercialization, University of Kentucky*
Laura Savatski, MBA, *Executive Director of Innovation and Commercialization, University of Louisville*
Cathleen Webb, PhD, *Associate Dean for Research, Western Kentucky University, KY NSF EPSCoR*

State Government

Monique Quarterman, MBA, *Executive Director for Entrepreneurship and Small Business Innovation, Cabinet for Economic Development*
Kristina Slattery, *Commissioner, Department for Business Development, Cabinet for Economic Development*

Other Education

Anthony Mires, MS, *Executive Director, AdvanceKentucky*
Lee Nimocks, MA, *Senior Vice President and Chief of Staff, Kentucky Council on Postsecondary Education*
Kristin Williams, PhD, *Chancellor, Kentucky Community and Technical College System*

Higher Education Faculty

University of Kentucky

Nelson Akafuah, PhD, *Associate Professor of Mechanical and Aerospace Engineering, Chair, Department of Engineering Technology, Director, Institute of Research for Technology Development*
John Anthony, PhD, *C.W. Hammond Professor of Chemistry*
L. Sebastian Bryson, PhD, *Hardin-Drnevich-Huang Professor of Civil Engineering, Chair, Department of Civil Engineering*
Kendall Corbin, PhD, *Assistant Professor of Horticulture*
Seth DeBolt, PhD, *Professor of Plant Science, Director, James B. Beam Institute for Kentucky Spirits*
Greg Erhardt, PhD, *Raymond-Blythe Associate Professor of Civil Engineering*
James Fox, PhD, *Raymond-Blythe Professor of Civil Engineering*
Kenneth Graham, PhD, *Associate Professor of Chemistry*
Mike McGlue, PhD, *Associate Professor of Earth and Environmental Sciences, Director of Graduate Studies*
Lindell Ormsbee, PhD, *Raymond-Blythe Professor of Civil Engineering, Earl Parker Robinson Chair of Engineering*

Kozo Saito, PhD, *Professor Emeritus of Mechanical and Aerospace Engineering, Founding Director, Institute of Research for Technology Development*
Suzanne Smith, PhD, *Professor of Mechanical and Aerospace Engineering, Director Emeritus, NASA Kentucky Space Grant and EPSCoR Programs*
Christine Trinkle, PhD, *Associate Professor of Mechanical and Aerospace Engineering, Director of Undergraduate Studies in Mechanical Engineering*
Matthew Weisenberger, PhD, *Associate Director, Center for Applied Energy Research, Adjunct Assistant Professor of Materials Engineering*
Edward Woolery, PhD, *Chair, Earth and Environmental Sciences, James S. Hudnall Professor of Geology*

University of Louisville

Lihui Bai, PhD, *Associate Professor and Director of Master of Science in Industrial Engineering, Co-Director of the Logistics and Distribution Institute*
Sabur Baidya, PhD, *Assistant Professor of Computer Science and Engineering*
Bikram Bhatia, PhD, *Assistant Professor of Mechanical Engineering and Principal Investigator of the Pyro Energy Research Laboratory*
Thomas Berfield, PhD, *Associate Professor of Mechanical Engineering*
Theodore "Thad" Druffel, PhD, *Theme Leader, Solar Manufacturing R&D, Conn Center for Renewable Energy Research*
Ayman El-Baz, PhD, *Chair of the Department of Bioengineering*
Omid Ghasemi Fare, PhD, *Associate Professor of Civil and Environmental Engineering*
Xiao-An Fu, PhD, *Professor of Chemical Engineering*
Monica Gentili, PhD, *Associate Professor of Industrial Engineering*
Cindy Harnett, PhD, *Professor of Electrical and Computer Engineering*
Sung Jin Kim, PhD, *Professor of Electrical and Computer Engineering*
Steven Koenig, PhD, *Professor of Bioengineering*
Jonathan Kopechek, PhD, *Assistant Professor of Bioengineering*
Adrian Lauf, PhD, *Associate Professor in the Computer Science & Engineering*
Tyler Mahoney, PhD, *Assistant Professor of Civil and Environmental Engineering*
Michael McIntyre, PhD, *Associate Professor of Electrical and Computer Engineering*
William McGinley, PhD, *Professor of Civil and Environmental Engineering, Endowed Chair in Infrastructure Research*
John Naber, PhD, *Professor of Electrical and Computer Engineering*
Badri Narayanan, PhD, *Assistant Professor in Mechanical Engineering*
Olfa Nasraoui, PhD, *Professor of Computer Engineering and Computer Science, Endowed Chair of E-Commerce, Founding Director, Knowledge Discovery and Web Mining Lab*
Pratik Parkih, PhD, *Department Chair and Professor of Industrial Engineering*
Dan Popa, PhD, *Endowed Chair of Advanced Manufacturing*
Thomas Roussel, PhD, *Associate Professor of Bioengineering*
Mark Running, PhD, *Professor of Biology*
Mahendra Sunkara, PhD, *Professor of Chemical Engineering, University Scholar and Director for the Conn Center for Renewable Energy Research*
Kevin Walsh, PhD, *Samuel T. Fife Endowed Professor of Electrical and Computer Engineering, Founding Director, Micro/NanoTechnology Center*
Stuart Williams, PhD, *Associate Professor of Mechanical Engineering*
Gerold Willing, PhD, *Associate Professor of Chemical Engineering*
Jagannadh Satyavolu, PhD, *Theme Leader, Biofuels and Biomass Conversion, Endowed Chair in Renewable Energy Research, Conn Center for Renewable Energy Research*
Wei Zhang, PhD, *Professor and Chair of the Department of Computer Science and Engineering*

Eastern Kentucky University

Judy Jenkins, PhD, *Associate Professor of Chemistry and Undergraduate Program Coordinator*
Laura Rowe, PhD, *Professor of Chemistry, Eastern Kentucky University*
Benjamin Wicker, PhD, *Professor of Chemistry, Eastern Kentucky University*

Kentucky State University

Alexander C.K. Lai, *PhD, Associate Professor of Biology*
Kirk Pomper, PhD, *Director Land Grant Programs, Dean and Professor College of Agriculture, Community, and the Sciences*

Morehead State University

Jen O'Keefe, PhD, *Professor of Geology and Science Education*

Murray State University

Christopher Lennon, PhD, *Assistant Professor of Microbiology*
Bassil el Masri, PhD, *Associate Professor of Earth and Environmental Studies, Graduate Program Coordinator*
Kevin Miller, PhD, *Professor of Organic and Polymer Chemistry*
Jessica (J.B.) Moon, PhD, *Assistant Professor of Wetland Ecology*
Michael Ramage, PhD, *Director of the Cyber Education and Research Center*

Northern Kentucky University

Lily Ma, PhD, *Professor of Chemistry and Biochemistry*
Erin Strome, PhD, *Professor and Chair of Biological Sciences*
Dirk Grupe, PhD, *Associate Professor of Physics and Department Chair*
Mark Bardgett, PhD, *Regents Professor and Director of the Interdisciplinary Minor in Neuroscience*

Western Kentucky University

Lawrence Hill, PhD, *Assistant Professor of Chemistry, Graduate Coordinator*
Matthew Nee, PhD, *Professor of Chemistry*
Bangbo Yan, PhD, *Professor of Chemistry, Director, Advanced Materials Institute, Thermal Analysis Labs*

Industry

Fred Allen, PhD, *Technical Director, Estron Chemical*
Kyle Barnette, *Corporate Recruiter, Lexmark*
Paul Boccieri, *Corporate Recruiter and Student Program Manager, Lexmark*
Liz Caras, *Director, Global Recruiting, Lexmark*
Brian Cobb, *Chief Innovation Officer, CVG Airport*
Kimberley Cooke, *Business Operations Manager, MEMStim*
Justin Henkel, *Public Affairs, UPS*
Rowyn Hosler, *Human Resources, Alltech*
Elijah Robert Jensen, PhD, *Founder and CEO, BlackBox Energy*
Joe Karrer, *Director of Corporate Strategy, Lexmark*
Vijay Kamineni, MBA, *CEO, Metals Innovation Initiative (MI2), Logan Aluminum*
Naashom Marx, *Director of Strategic Innovation, Advanced Mobility, CVG Airport*
Dan Seevers, *Director of Analytics and Development Operations, Lexmark*
Ann Thompson, *Workforce Development Manager, Ford*
Josh Williams, MBA, *Vice President, Strategic Initiatives, Louisville Healthcare CEO Council*
Tammy York Day, *President and CEO, Louisville Healthcare CEO Council*

Venture Capital

Robert LaMothe, MBA, *President, Commonwealth Seed Capital*
Kelby Price, *Executive Director of Venture Finance and Managing Partner, Keyhorse Capital, Kentucky Science & Technology Corporation*
John Wilmoth, MBA, *Founder and Managing Partner, Poplar Ventures*
Chris Young, *Chair and Lead Manager of Bluegrass Angels Funds*

Venture Development Organizations

Lisa Bajorinas, MBA, *Executive Director, Kentucky, Innovation Hubs, Kentucky Science & Technology Corporation*
Monica Bilak, MS, *Regional Director, GroWestKY and Sprocket Paducah, Kentucky Innovation Hub*
Sam Ford, *Executive Director, AccelerateKY, Innovation & Culture Fellow, Central Region Ecosystem for Arts, Technology, and Entrepreneurship and Western Kentucky University Innovation Campus*
Larry Horn, MBA, *Executive Director, Amplify Louisville, Kentucky Innovation Hub*
Kayla Meisner, MS, *Executive Director of Kentucky Commercialization Ventures, Kentucky Science & Technology Corporation*
Maria Labreveux, PhD, *Executive Director of Kentucky Science and Engineering Foundation, Kentucky Science & Technology Corporation*
Terry Samuel, MBA, *President, Kentucky Science & Technology Corporation*
Buddy Steen, *CEO, Western Kentucky University Innovation Campus, Programs Director, Central Region Ecosystem for Arts, Technology, and Entrepreneurship*
Sabrina McWhorter, *Manager of Business and Innovation, Shaping our Appalachian Region*

Chambers of Commerce/Economic Development Organizations

Kevin Atkins, *Chief Development Officer, Office of the Mayor, City of Lexington*
Candance Brake, MPA, *CEO, Greater Owensboro Chamber of Commerce*
Ron Bunch, CEcD, *President and CEO, Bowling Green Area Chamber of Commerce*
Brad Davis, *Vice President of Business Development, Greater Owensboro Economic Development Corporation*
Gina Greathouse, *Executive Vice President, Commerce Lexington, Inc.*
Colby Hall, *Executive Director, Shaping our Appalachian Region*
Bob Quick, *President and CEO, Commerce Lexington, Inc.*
Dean Schlader, *Vice President, Business Outreach and Investor Development, Greater Louisville, Inc.*
Clark Welch, *Director of Economic Development, Greater Louisville, Inc.*

High-Tech Industry

Figure 1

Knowledge- and technology-intensive industries (in this report, high-tech and advanced manufacturing industries) are defined by an industry's research and development (R&D) expenditures relative to value-added output (i.e., R&D intensity). High- and medium-high R&D intensity manufacturing and services industries are presented in below.

High and Medium-High Research and Development-Intensive Industries

INDUSTRY TITLE	R&D INTENSITY	NAICS 2012
High R&D Intensity: Manufacturing		
Aerospace product and parts mfg.	31.69%	3364
Pharmaceutical and medicine mfg.	27.98%	3254
Computer and electronic products mfg.	24.05%	334
Optical instrument and lens mfg.	24.05%	333314
Medium-High R&D Intensity: Manufacturing		
Motor vehicle mfg.	15.36%	3361-3363
Medical equipment and supplies mfg.	9.29%	3391
Other fabricated metal products mfg.	7.89%	332913, 332991
Machinery mfg. (agricultural, industrial, metalworking, HVAC, power transmission)	7.89%	3331, 3332, 3334, 3335, 3336, 3339
Photographic and photocopying equipment mfg.	7.89%	333316
Other commercial and service industry machinery mfg.	7.89%	333318
Electrical equipment, appliance, and component mfg.	6.22%	335
Chemical mfg., excluding pharmaceuticals	6.52%	3251, 3252, 3253, 3255, 3256, 3259
Railroad and other transportation equipment mfg.	5.72%	3365, 3369
High R&D Intensity: Services		
Software publishers	28.94%	5112
Scientific research and development services	30.39%	5417
Medium-High R&D Intensity: Services		
Computer systems design and related services	5.92%	5415
Data processing, hosting, and related services	5.92%	518
Other information services	5.92%	519

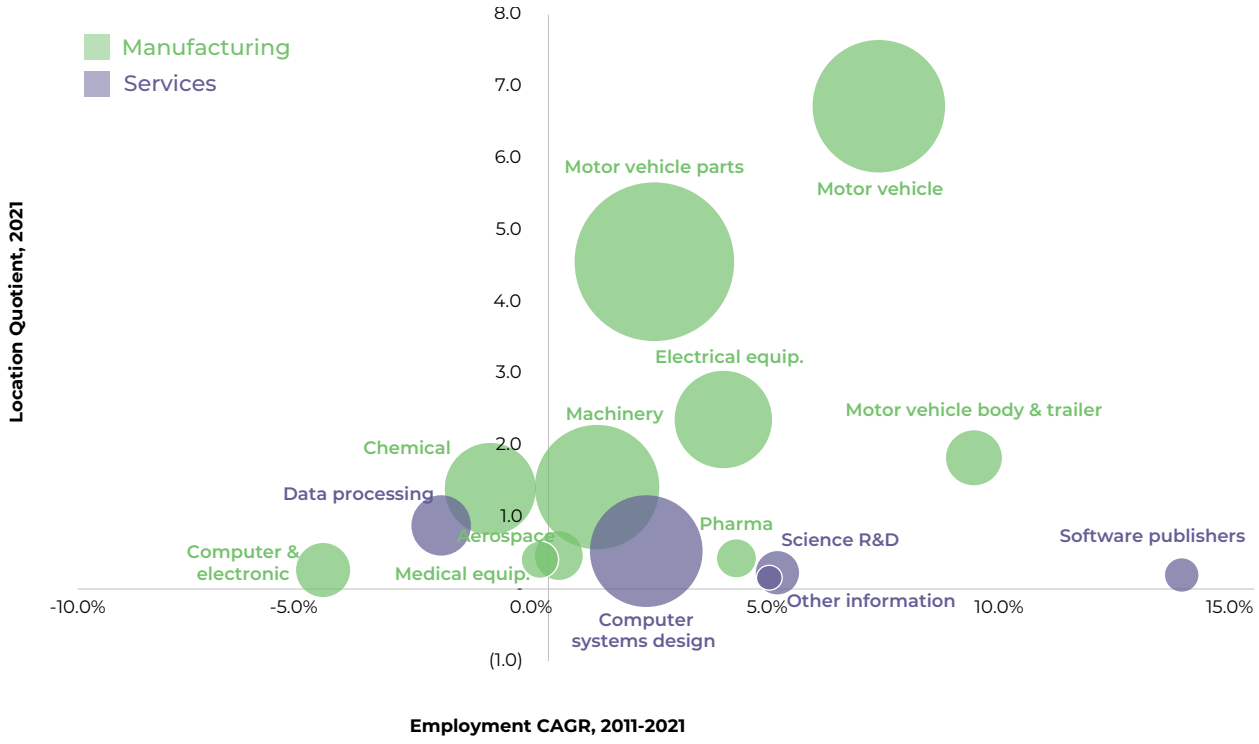
NAICS = North American Industry Classification System; Mfg. = Manufacturing

Source: Galindo-Rueda, F. & Verger, F. (2016). OECD Taxonomy of Economic Activities Based on R&D Intensity. OECD Science, Technology, and Industry Working Papers. OECD Publishing. National Science Board. (2022). "SAKTI-3 Concordance for Knowledge and Technology Intensive Industry Employment" Science and Engineering Indicators.

Figure 2

Most of Kentucky's high-tech industries grew over the past 10 years. They are shown in the top right quadrant and include motor vehicles and motor vehicle parts, machinery, electrical equipment, aerospace, and pharma/biotech manufacturing. On the services side, these industries include computer systems design, scientific R&D, and software. The size of the industry's bubble in the figure indicates the number of employees in the industry. The x-axis shows the compound annual growth rate (CAGR), while the y-axis shows the concentration of employment in Kentucky relative to in the United States.

Kentucky High-Tech Industry Segment Employment Growth and Employment Concentration (i.e., Location Quotient), 2011–2021



Source: Bureau of Labor Statistics. (2011, 2021). Quarterly Census of Employment and Wages.

Figure 3

Over the past 10 years, Kentucky's high-tech sector grew by 2.2% per year, adding 25,920 jobs in total. Manufacturing of motor vehicles (including parts and bodies), electrical equipment and appliances, and machinery each added more than 2,000 jobs. On the high-tech services side, computer systems design, software, and scientific R&D added more than 1,000 jobs each. Computer and electronic product manufacturing, chemical manufacturing, and data processing had the steepest employment declines.

Size and Growth of Kentucky High-Tech Industry Segments, 2011 and 2021

NAICS	INDUSTRY TITLE	2011	2021	10-YEAR CHANGE	10-YEAR CAGR	LQ
3361	Motor vehicle mfg.	11,177	22,043	10,866	7.0%	6.73
3363	Motor vehicle parts mfg.	25,405	31,738	6,333	2.3%	4.56
335	Electrical equipment, appliance, component mfg.	8,255	11,888	3,633	3.7%	2.36
5415	Computer systems design and related services	12,746	15,665	2,919	2.1%	0.53
3362	Motor vehicle body and trailer mfg.	1,626	3,866	2,240	9.0%	1.83
333	Machinery mfg.	17,399	19,312	1,913	1.0%	1.42
5112	Software publishers	401	1,418	1,017	13.5%	0.20
5417	Scientific research and development services	1,497	2,409	912	4.9%	0.23
3254	Pharmaceutical and medicine mfg.	1,236	1,830	594	4.0%	0.43
519	Other information services	495	783	288	4.7%	0.16
3364	Aerospace parts mfg.	2,826	2,891	65	0.2%	0.47
3391	Medical equipment, supplies mfg.	1,738	1,708	(30)	-0.2%	0.41
518	Data processing, hosting, and related services	5,617	4,461	(1,156)	-2.3%	0.89
3251-53, 3255-56, 3259	Chemical mfg., excluding Pharmaceuticals	11,760	10,395	(1,365)	-1.2%	1.40
334	Computer, electronic product mfg.	5,956	3,647	(2,309)	-4.8%	0.27
	TOTAL	**108,134**	**134,054**	**25,920**	**2.2%**	

NAICS = North American Industry Classification System; CAGR = Compound annual growth rate; LQ = Location quotient; Mfg. = Manufacturing

Notes: The LQ shows Kentucky's concentration of employment in an industry relative to the national average. The higher the concentration, the higher Kentucky's specialization in this industry.

Under NAICS 333 machinery manufacturing, NAICS 3334 HVAC and refrigeration equipment manufacturing lost 241 jobs (2021 total employment: 2,546) and NAICS 3336 turbine and power transmission equipment manufacturing lost 953 jobs (2021 total employment: 384) over this 10-year period.

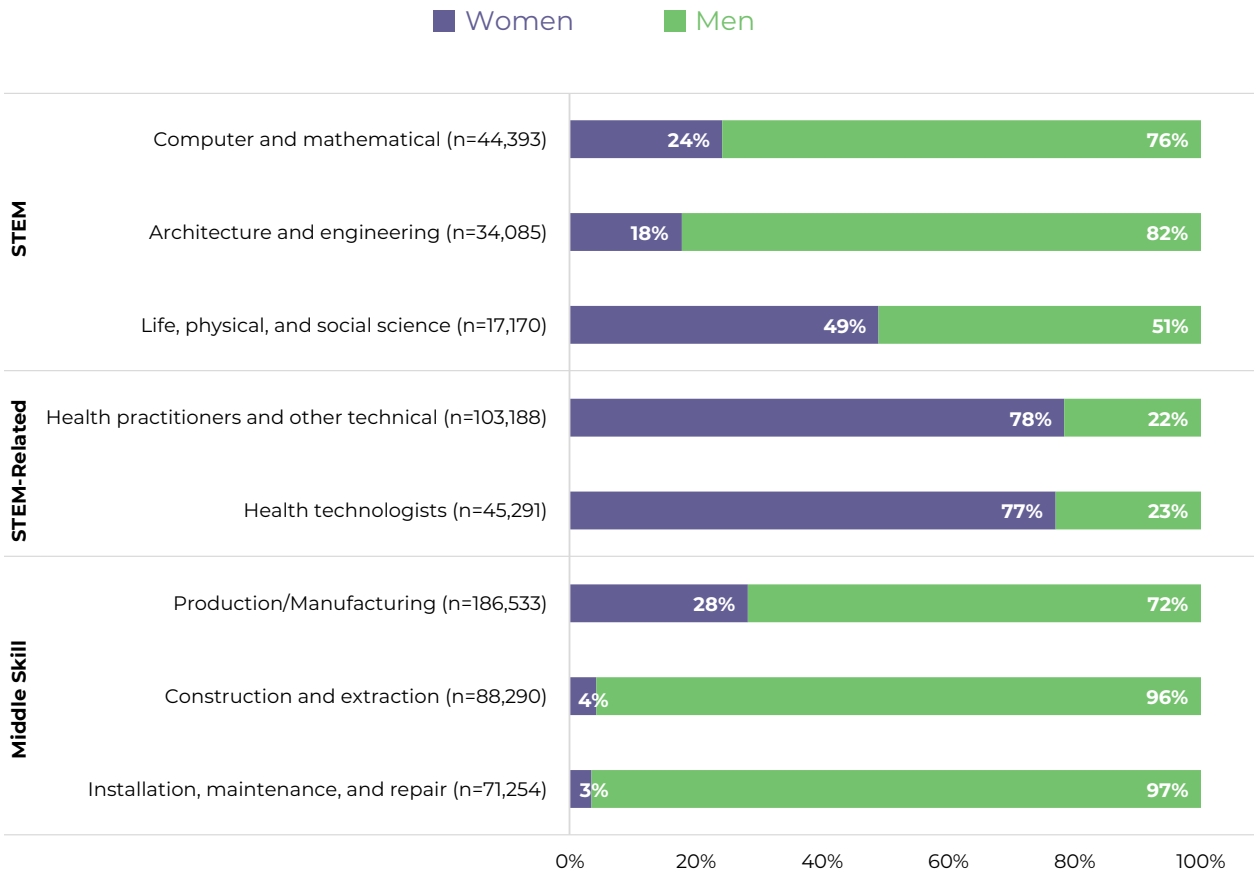
Source: Bureau of Labor Statistics. (2011, 2021). Quarterly Census of Employment and Wages.

STEM Workforce

Figure 4

In Kentucky, men are overrepresented in STEM jobs (first category in figure), while women are overrepresented in STEM-related health jobs (second category). Men and women are nearly equally represented in life, physical and social sciences jobs. Men are overrepresented in all major segments of middle-skill occupations (third category): manufacturing; construction; and installation, maintenance, and repair.

Breakdown of Kentucky Employment in STEM, STEM-Related, and Middle-Skill Jobs



Source: U.S. Census Bureau. (2021). American Community Survey.

Figure 5

Kentucky's population is less racially diverse than the United States as a whole. Black Kentuckians represent 8.6% of the population and 7.1% of the employed workforce. Kentuckians who identify as two or more races represent 2.2% of the population (5.7% of workforce). Asian people represent 1.7% of the population (1.7% of the workforce). Hispanic and Latino Kentuckians of any race represent 4.2% of the population (3.8% of the workforce).

Breakdown by Race and Ethnicity of Kentucky's Population and Employed Workforce, 2021

	UNITED STATES POPULATION 2022	KENTUCKY POPULATION 2022	KENTUCKY EMPLOYED WORKFORCE 2021
Total	**333,287,557**	**4,512,310**	**1,992,331**
White	75.8%	87.1%	83.8%
Black or African American	13.6%	8.6%	7.1%
Two or more races	2.9%	2.2%	5.7%
Asian	6.1%	1.7%	1.7%
American Indian and Alaska Native	1.3%	0.3%	-
Native Hawaiian and Other Pacific Islander	0.3%	0.1%	-
Other/not reporting	-	-	1.8%
TOTAL	**100%**	**100%**	**100%**
Hispanic or Latino*	18.9%	4.2%	3.8%

Note: Hispanic or Latino is an ethnicity. Hispanic or Latino people can be any race, so ethnicities are not included in the percentage of total to avoid double-counting.

Source: U.S. Census Bureau. (2022). Population Estimates Program and 2021 American Community Survey.

Figure 6

Black Kentuckians are at or above workforce parity (7.1% of all jobs) in life, physical, and social science jobs and manufacturing jobs. In all other STEM, STEM-related, and middle-skill occupations, Black Kentuckians are below parity. Employment growth has been stronger in engineering and installation, maintenance, and repair jobs and weaker in computer and construction jobs. Health technician job employment is below parity and has declined.

Black Kentuckians Employed in STEM Occupations: Total Number, 2011 and 2021, and 10-Year CAGR

	2011	2021	% OF TOTAL 2021	2011–21 CAGR
STEM Occupations				
Computer and mathematical	1,392	1,606	3.6%	1.4%
Architecture and engineering	745	1,242	3.6%	5.2%
Life, physical, and social sciences	263	1,291	7.5%	17.2%
STEM-Related Occupations				
Health diagnosing and treating practitioners	2,626	3,165	3.1%	1.9%
Health technologists and technicians	2,256	2,135	4.7%	-0.5%
Middle-Skill Occupations				
Installation, maintenance, and repair	2,296	3,158	4.4%	3.2%
Construction and extraction	2,526	2,700	3.1%	0.7%
Production/manufacturing	16,505	21,181	11.4%	2.5%

Note: In 2021, Black Kentuckians represented 7.1% of Kentucky's total employed workforce.

Source: U.S. Census Bureau. (2021). American Community Survey.

Figure 7

Hispanic or Latino Kentuckians are at or above workforce parity (3.8% of all jobs) in life, physical, and social science jobs, construction jobs, and manufacturing jobs. In all other STEM, STEM-related, and middle-skill occupations, Hispanic Kentuckians are below parity. Their employment growth is strongest in computer jobs and health practitioner jobs. Employment in engineering jobs and health technician jobs is below parity, with negative employment growth.

Hispanic or Latino Kentuckians Employed in STEM Occupations: Total Number, 2011 and 2021, and 10-Year CAGR

	2011	2021	CURRENT SHARE	2011–21 CAGR
STEM Occupations				
Computer and mathematical	104	763	1.7%	22.1%
Architecture and engineering	989	834	2.4%	-1.7%
Life, physical, and social sciences	258	681	4.0%	10.2%
STEM-Related Occupations				
Health diagnosing and treating practitioners	753	1,337	1.3%	5.9%
Health technologists and technicians	735	416	0.9%	-5.5%
Middle-Skill Occupations				
Installation, maintenance, and repair	809	1,153	1.6%	3.6%
Construction and extraction	4,741	8,182	9.3%	5.6%
Production/manufacturing	8,253	9,373	5.0%	1.3%

Note: In 2021, Hispanic or Latino Kentuckians represented 3.8% of Kentucky's total employed workforce.

Source: U.S. Census Bureau. (2021). American Community Survey.

Figure 8

White Kentuckians are at or above workforce parity (83.8% of all jobs) across all STEM, STEM-related, and middle-skill occupations, except production/manufacturing and life, physical, and social science jobs.

Figure 8. White Kentuckians Employed in STEM Occupations: Total Number, 2011 and 2021, and 10-Year CAGR

	2011	2021	% OF TOTAL 2021	2011–21CAGR
STEM Occupations				
Computer and mathematical	26,133	36,939	83.2%	3.5%
Architecture and engineering	22,626	29,744	87.3%	2.8%
Life, physical, and social sciences	7,360	13,757	80.1%	6.5%
STEM-Related Occupations				
Health diagnosing and treating practitioners	75,260	92,571	89.7%	2.1%
Health technologists and technicians	40,183	40,009	88.3%	0.0%
Middle-Skill Occupations				
Installation, maintenance, and repair	64,389	63,505	89.1%	-0.1%
Construction and extraction	91,453	73,727	83.5%	-2.1%
Production/manufacturing	138,077	143,763	77.1%	0.4%

Note: In 2021, White Kentuckians represented 83.8% of Kentucky's total employed workforce.

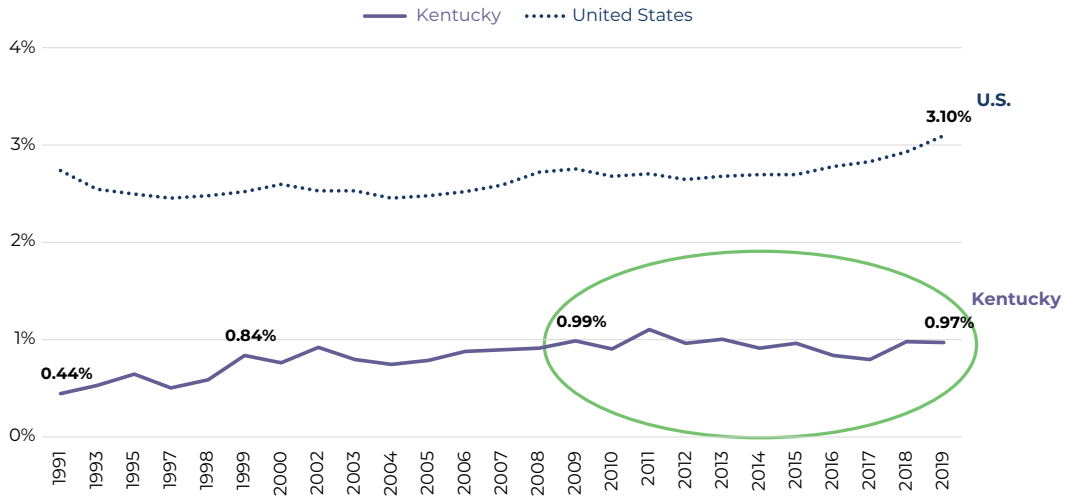
Source: U.S. Census Bureau. (2021). American Community Survey.

Research Competitiveness

Figure 9

Total R&D expenditures include business, academic, government, and nonprofit R&D. The higher the R&D intensity (i.e., total expenditures relative to gross domestic product [GDP]), the more industrialized and technology-intensive an economy is. Kentucky's total R&D intensity of 1.0% has been flat the past 10 years and below the U.S. R&D intensity of 3.1%.

Kentucky and U.S. Total R&D Intensity (R&D Expenditures as a Percentage of GDP)

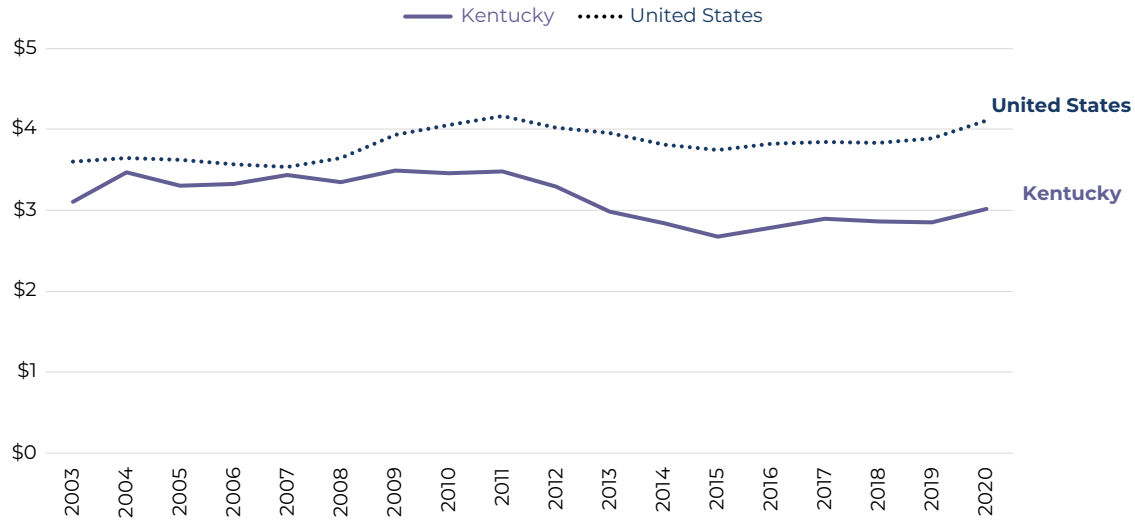


Source: National Science Board. (2023). State Science and Engineering Indicators.

Figure 10

Since the 2008–2010 recession, Kentucky's academic R&D expenditures per $1,000 of GDP have diverged from the U.S. average and widened.

Kentucky and U.S. Academic R&D per $1,000 of GDP, 2003–2020



Source: National Science Board. (2023). State Science and Engineering Indicators.

Figure 11

The average annual rate of growth drives a state's academic R&D expenditures ranking. Compared to other Established Program to Stimulate Competitive Research (EPSCoR) states, Kentucky's past 10-year growth rate (1.0% CAGR) has been slow, widening the gap between it and South Carolina, Kansas, and other higher-ranking states and closing the gap between it and lower-ranking states Oklahoma and Nebraska.

Total Academic R&D Expenditures in EPSCoR States and Territories, FY2011, FY2016, and FY2021

	RANK	TOTAL R&D EXPENDITURES ($M)			CAGR	
STATE	2021	2011	2016	2021	2011–21	2016–21
Alabama	1	898	945	1,272	3.5%	6.1%
Iowa	2	725	814	931	2.5%	2.7%
Louisiana	3	728	683	831	1.3%	4.0%
Kansas	4	511	559	785	4.4%	7.0%
South Carolina	5	621	687	753	2.0%	1.9%
Kentucky	6	596	547	655	1.0%	3.7%
Oklahoma	7	445	489	623	3.4%	5.0%
Nebraska	8	413	481	576	3.4%	3.7%
New Hampshire	9	360	380	499	3.3%	5.6%
Mississippi	10	461	455	491	0.6%	1.5%
New Mexico	11	405	367	473	1.6%	5.2%
Rhode Island	12	459	463	426	-0.8%	-1.7%
Arkansas	13	283	298	388	3.2%	5.4%
Montana	14	195	195	330	5.4%	11.1%
Nevada	15	165	191	309	6.4%	10.1%
North Dakota	16	211	227	308	3.8%	6.3%
Hawaii	17	331	318	295	-1.1%	-1.5%
Delaware	18	189	198	255	3.0%	5.2%
West Virginia	19	211	199	231	0.9%	3.0%
Vermont	20	137	120	198	3.7%	10.5%
Alaska	21	186	167	197	0.6%	3.3%
Idaho	22	142	155	166	1.5%	1.4%
Maine	23	140	100	165	1.7%	10.5%
Puerto Rico	24	164	121	124	-2.8%	0.5%
South Dakota	25	136	107	101	-3.0%	-1.2%
Wyoming	26	58	112	93	4.9%	-3.6%
Guam	27	6	7	18	12.1%	19.0%
Virgin Islands	28	22	21	15	-3.6%	-6.4%

Note: The National Science Foundation's EPSCoR program is limited to states and territories that received 0.75% or less of total NSF research funding over the most recent 3-year period. The program helps institutions in eligible states build infrastructure and research capacity, and train students to enable them to compete more successfully for open federal R&D funding awards. This table is ranked by total academic R&D expenditure of EPSCoR states in 2021.

Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 12

Anchored by the medical schools at University of Kentucky and the University of Louisville, life sciences is Kentucky's largest R&D field. The six primarily undergraduate institution (referred to as comprehensive universities) all perform life sciences R&D. Although engineering R&D is the second-largest field, total engineering R&D makes up between one-sixth and one-seventh of life sciences R&D expenditures. Outside of the life sciences, each comprehensive university has strengths in different fields relative to the others.

Kentucky Science and Engineering R&D Expenditures and Rank by Institution: Total and by Major Field ($M), FY2021

INSTITUTION	TOTAL S&E	LIFE SCIENCES		ENGINEERING		OTHER SCIENCES	PHYSICAL SCIENCES		GEO, ATMOS, OCEAN SCIENCES		COMPUTER & INFORMATION SCIENCES		MATHEMATICS & STATISTICS	
		RANK	$M	RANK	$M	$M	RANK	$M	RANK	$M	RANK	$M	RANK	$M
Univ. of Kentucky	$418.8	51	$323.0	70	$52.4	$25.8	127	$8.7	138	$3.4	124	$4.0	105	$1.5
Univ. of Louisville	$187.8	90	$157.7	135	$21.0	$4.0	199	$3.2	308	$0.2	378	$0.1	161	$0.7
Kentucky State Univ.	$8.8	247	$8.6	-	-	$0.0	-	-	420	$0.0	443	$0.0	242	$0.2
W. Kentucky Univ.	$6.1	349	$2.3	306	$0.6	$0.9	261	$1.2	206	$1.0	-	-	400	$0.0
Murray State Univ.	$3.8	328	$3.1	-	-	$0.0	415	$0.2	327	$0.1	-	-	214	$0.3
N. Kentucky Univ.	$3.3	368	$2.0	-	-	$0.6	313	$0.7	-	-	417	$0.0	327	$0.1
Morehead State Univ.	$1.7	451	$1.0	296	$0.8	$0.2	525	$0.0	416	$0.0	-	-	-	-
E. Kentucky Univ.	$0.9	501	$0.5	381	$0.1	$0.2	445	$0.1	412	$0.0	-	-	-	-
Total	**$631.1**		**$498.0**		**$74.7**	**$32.5**		**$14.2**		**$4.7**		**$4.1**		**$2.8**

S&E = Science and engineering; Geo, Atmos, Ocean Sciences = Geosciences, Atmospheric, and Ocean Sciences.

Note: The rank is based on all U.S. higher education institutions that report R&D expenditures of more than $150,000 on the Higher Education Research and Development Survey.

Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 13

University of Kentucky Total Science and Engineering Research Expenditures by Field ($M), FY2011–FY2021

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	CAGR 2011–21	CAGR 2016–21
All Sciences	**312.2**	**298.3**	**279.1**	**277.3**	**276.6**	**289.5**	**322.5**	**335.2**	**347.6**	**359.2**	**366.4**	**1.6%**	**4.8%**
Life Sciences	257.4	247.5	230.3	231.2	232.8	250.6	275.8	294.8	314.5	322.1	323	2.3%	5.2%
Physical Sciences	10.9	10.5	10.5	9	7.2	8.3	7.5	7.1	8.2	8.6	8.7	-2.2%	1.1%
Computer Sciences	4	3.3	3.3	3.1	2.1	2.9	3	3.1	3.2	4.1	4	0.1%	6.8%
Mathematics & Statistics	2.5	2	2.1	1.8	1.1	0.8	0.9	0.8	1.7	1.3	1.5	-5.0%	12.8%
Other Sciences	37.5	35	32.9	32.2	33.4	26.9	35.3	29.4	20.1	23.1	29.2	-2.5%	1.6%
All Engineering	**52**	**55.8**	**53.3**	**45**	**49**	**50.8**	**45.4**	**47.8**	**50.7**	**47**	**52.4**	**0.1%**	**0.6%**
Civil	9.6	10.6	11.8	10.1	11.7	10.4	9.9	9.9	10.1	8.8	10.2	0.6%	-0.2%
Metallurgical & Materials	3.8	4.7	4.3	3.5	2.9	2.6	2.8	4.3	5.3	4.6	4.5	1.7%	11.4%
Mechanical	2.9	3.9	3.4	3.7	3.8	4.6	3.6	1.3	2.6	3.5	3.8	2.7%	-3.6%
Chemical	4.2	3.8	2.5	2.6	1.5	3.5	4.1	4.3	4.7	3.5	3.4	-2.3%	-1.0%
Bioengineering & Biomedical	1.8	1.2	2.1	1.4	1.1	1	1.3	1.1	0.9	1.8	2.5	3.7%	21.5%
Electrical & Computer	3.8	4.7	4.5	3.4	1.9	2.1	2.1	1.4	1.7	2.5	2.4	-4.7%	2.6%
Aerospace & Aeronautical	0.8	2	2.2	2.2	3	4.4	5.2	4.7	3.7	2.7	2.6	12.5%	-10.0%
Industrial & Manufacturing	0	0	0	0	0	0.3	0.6	0.6	0.3	0.2	0.8	N/A	19.1%
Engineering, nec	25	25	22.3	18.2	23	21.9	15.7	20.1	21.4	19.5	22.1	-1.2%	0.2%

Nec = Note elsewhere classified

Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 14

University of Louisville Total Science and Engineering Research Expenditures by Field ($M), FY2011–FY2021

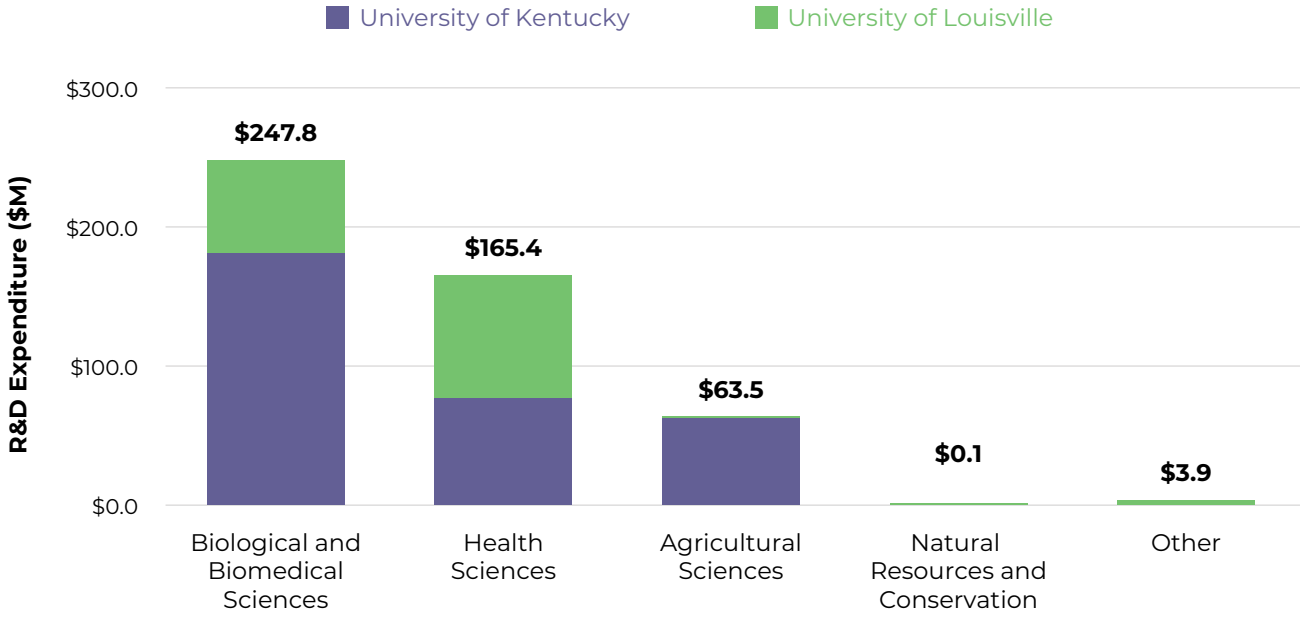
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	CAGR 2011–21	CAGR 2016–21
All Sciences	**139.2**	**141.5**	**136.8**	**138.6**	**137.4**	**145.4**	**151.4**	**151.1**	**149.8**	**166.8**	**166.8**	**1.8%**	**2.8%**
Life Sciences	131.6	134.1	129.7	132.3	130.7	138.7	144.9	144.6	141.4	158.7	157.7	1.8%	2.6%
Physical Sciences	2.8	2.4	2.7	2.5	2.1	1.7	1.7	1.8	3.1	3.0	3.3	1.4%	14.2%
Computer Sciences	1.0	0.7	0.5	0.5	0.3	0.2	0.2	0.3	0.3	0.1	0.1	-23.0%	-21.5%
Mathematics & Statistics	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	33.4%	38.7%
Other Sciences	3.8	4.3	3.9	3.3	4.2	4.7	4.4	4.3	5.0	4.5	5.0	3.0%	1.5%
All Engineering	**27.7**	**23.9**	**23.6**	**24.6**	**17.2**	**18.9**	**17.5**	**17.3**	**16.3**	**18.1**	**21.0**	**-2.7%**	**2.1%**
Bioengineering & Biomedical	5.8	6.2	5.8	6.6	5.8	7.1	5.4	4.5	4.8	4.5	5.8	0.0%	-4.0%
Electrical and Computer	5.2	4.3	3.6	2.8	1.9	2.7	3.2	3.7	3.6	4.4	5.5	0.5%	15.6%
Mechanical	0.9	0.9	0.9	1.0	0.6	1.4	1.4	1.7	1.5	1.1	1.9	8.4%	7.1%
Chemical	1.5	2.3	0.9	1.8	1.3	1.3	1.1	1.1	1.3	0.8	1.6	0.9%	4.4%
Civil	2.9	3.0	2.7	2.4	2.0	1.9	1.7	1.4	1.5	2.0	1.5	-6.2%	-4.3%
Industrial and Manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.8	1.6	1.0	N/A	N/A
Aerospace and Aeronautical	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-43.2%	N/A
Metallurgical and Materials	0.2	0.2	0.4	0.7	0.6	0.2	0.0	0.1	0.1	0.0	0.0	-100.0%	-100.0%
Engineering, nec	11.0	6.9	9.2	9.4	5.0	4.4	4.2	4.3	2.7	3.8	3.7	-10.4%	-3.8%

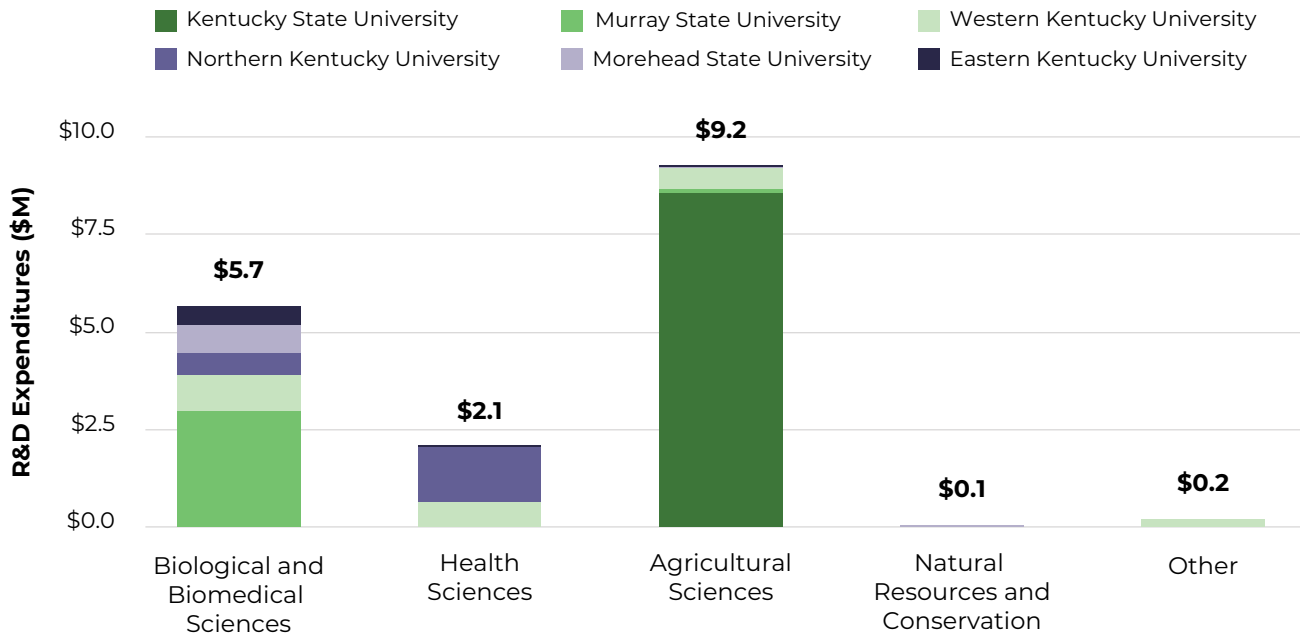
Nec = Not elsewhere classified; N/A = Not applicable.

Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 15

Life Science R&D Expenditures, by Institution, by Field, FY2021

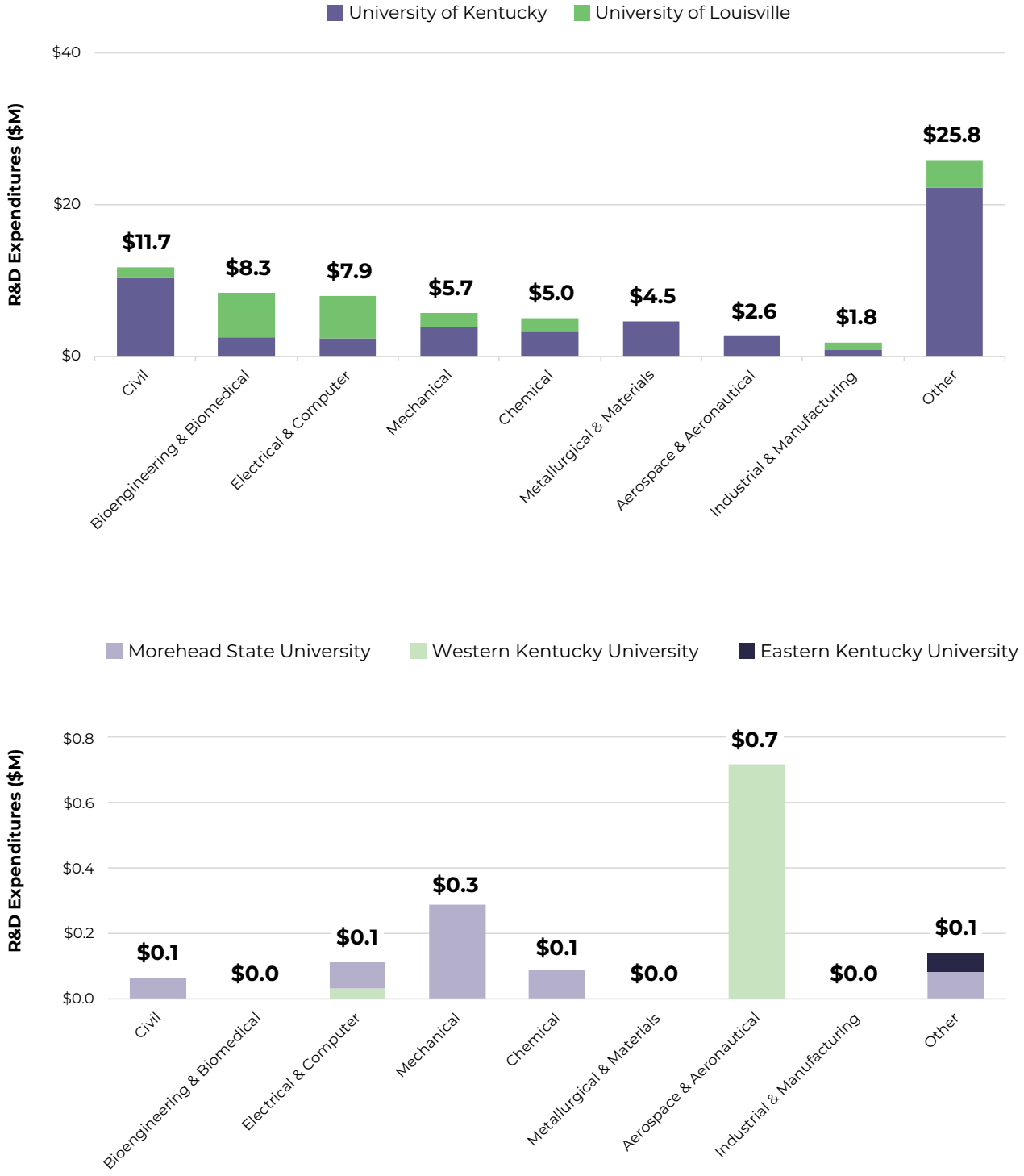




Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 16

Engineering R&D Expenditures, by Institution, by Field, FY2021



Note: "Other Engineering" is the University of Kentucky's largest engineering subfield, due to the interdisciplinary nature of the Center for Applied Energy Research and the Kentucky Transportation Center.

Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

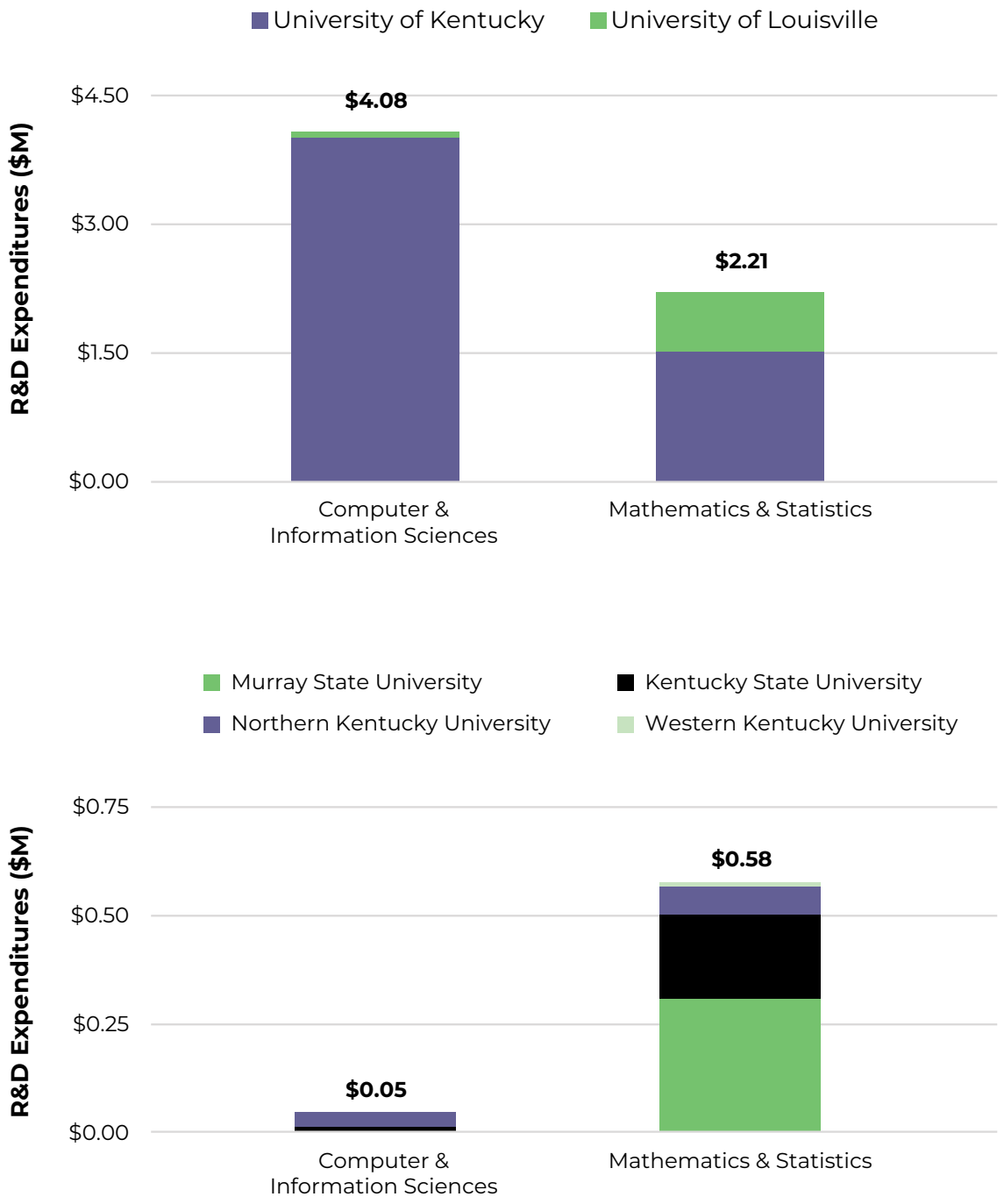
Figure 17

Physical Sciences R&D Expenditures, by Institution, by Field, FY2021

Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 18

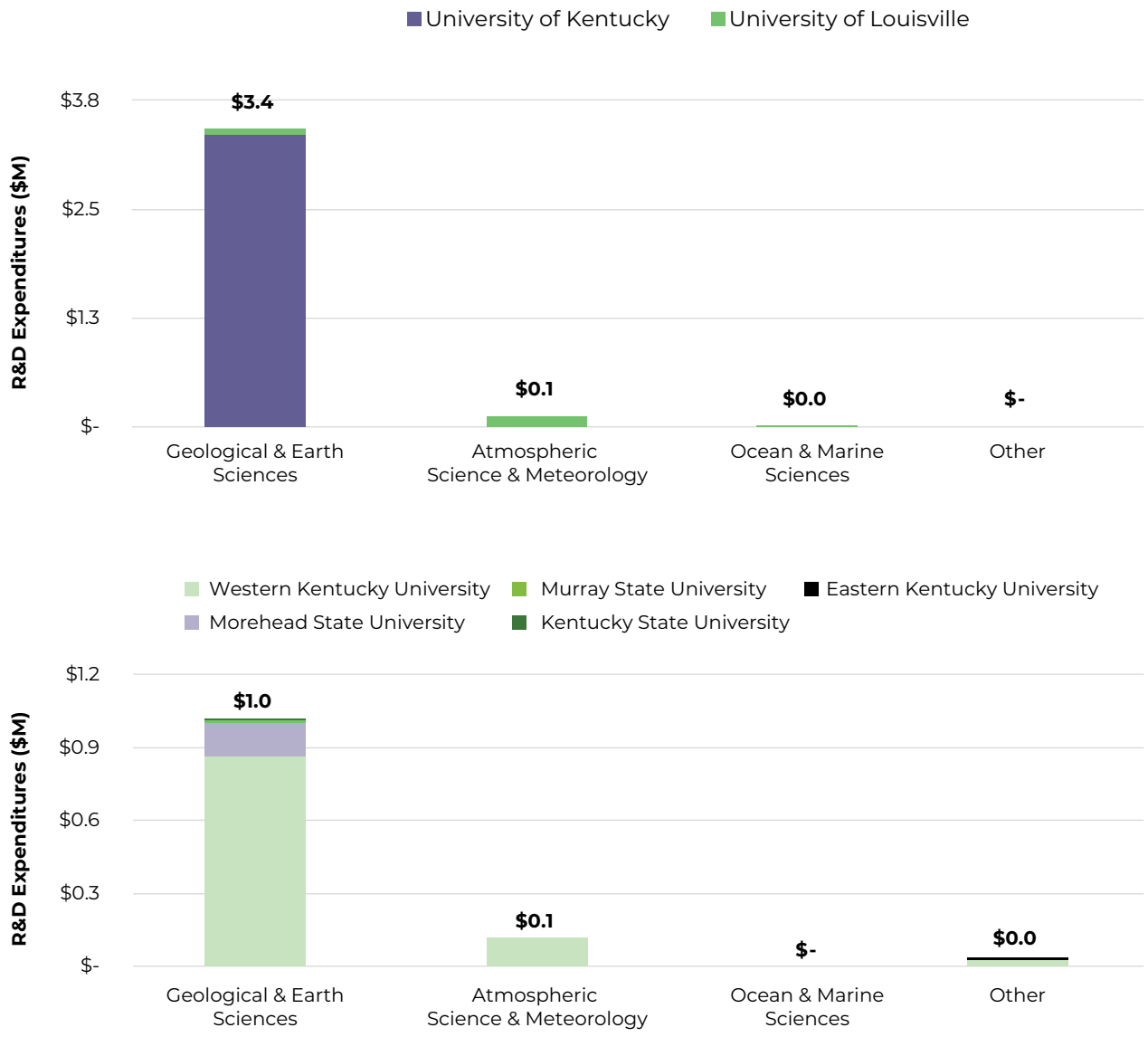
Computer Sciences and Mathematics R&D Expenditures, by Institution, by Field, FY2021



Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Figure 19

Geosciences, Atmospheric, and Ocean Sciences R&D Expenditures, by Institution, by Field, FY2021



Source: National Science Foundation. (2023). Higher Education Research and Expenditures Survey.

Innovation & Entrepreneurship

Figure 20

Over the past 5 years, venture capital (VC) investment has been highest in Kentucky pharma and biotech, software, and metals, minerals, and mining industries. With the exception of software, the number of deals in these industries has actually been relatively small. In terms of number of VC deals, software leads, followed by health tech and business-to-business (B2B).

Kentucky VC Deals and VC Investment ($M) by Primary Industry Group, 2017–2022

PRIMARY INDUSTRY	DEAL COUNT	ALL DEALS ($M)	AVERAGE ($M)	MINIMUM ($M)	MAXIMUM ($M)
Pharma & Biotech	21	$441.3	$27.6	$0.01	$115.0
Software	148	$402.7	$3.7	$0.01	$161.4
Metals, Minerals, Mining	7	$303.0	$50.5	$0.03	$200.0
Agriculture	7	$159.6	$26.6	$0.55	$97.0
B2B (Commercial Services)	37	$138.8	$6.3	$0.03	$100.0
Consumer Non-Durables	32	$74.0	$3.0	$0.03	$34.0
Health Tech	48	$67.9	$2.0	$0.03	$13.0
Healthcare Services	19	$23.4	$1.8	$0.03	$9.5
Healthcare Devices	16	$22.9	$1.8	$0.03	$7.0
Commercial Products	21	$17.4	$1.0	$0.03	$3.3
Computer Hardware	19	$11.3	$0.8	$0.02	$4.0
Restaurants & Hotels	8	$7.7	$1.9	$0.17	$5.0
Chemicals & Gases	11	$5.5	$0.9	$0.54	$1.7
TOTAL	**451**	**$1,689.9**			

Source: PitchBook Venture Capital and Private Equity Database

Figure 21

Over the past 10 years, Kentucky has had 31 successful exits of formerly VC-backed companies: Eight exits from 2013 to 2017 and 23 from 2018 to 2022. Exits return to founders and investors capital that can be reinvested, supporting growth of the entrepreneurial ecosystem.

Successful Exits of Kentucky's Formerly Venture Capital-Backed Companies, 2013–2022

EXIT YEAR	EXIT TYPE	COMPANY	INDUSTRY	ACQUIRING COMPANY
2013	IPO	LogicMark	Healthcare Devices	-
2013	M&A	FirstMile Technologies	Communications & Networking	Inside Connect Cable
2014	M&A	Fellon-McCord & Associates	Energy Services	Ingersoll-Rand
2014	M&A	Jacobs Automation	Consumer Durables	Rockwell Automation
2016	M&A	HealthWarehouse	Specialty Retail	Rx Investor Value
2016	M&A	Enviroflight	Agriculture	Precigen and Darling Ingredients
2017	M&A	PGxl Laboratories	Healthcare Services	Prescient Medicine
2017	M&A	Photizo Group	Commercial Services	Virtulytix
2018	M&A	CitiLogics	Software	Xylem
2018	M&A	Football Outsiders	Software	EdjSports
2018	M&A	Horse Network	B2C	Wrigley Media
2018	M&A	Eyechronic	Software	Enlighten Technologies
2018	M&A	HomeHero	Healthcare Services	Family Directed
2018	M&A	MakeTime	Software	Xometry
2019	M&A	3DR (Diagnostic Equipment)	Healthcare Devices	Accumen
2019	M&A	Mobilemedtek	Healthcare Devices	Lifelines Neuro
2020	M&A	Halcyon Thruput	Agriculture	Generation Hemp
2020	M&A	CrossCoat Medical	Healthcare Devices	IntralinkSpine
2020	M&A	Onovative	Software	Main Street, Inc.
2020	M&A	Wyzerr	Software	PopCom
2021	SPAC	AppHarvest	Agriculture	Novus Capital Corp.
2021	IPO	Talaris Therapeutics	Pharma & Biotech	-
2021	M&A	Gem + Jewel	Specialty Retail	Jewelers Mutual Group
2021	M&A	SuperFan	Software	PrestoSports
2021	M&A	Vita-Stat	Health Tech	Glennis Solutions
2022	SPAC	Rubicon Technologies	Software	Founder SPAC
2022	M&A	Enlighten Technologies	Commercial Services	Weedmaps
2022	M&A	Cuddle Clones	B2C	Dianthus
2022	M&A	IntralinkSpine	Healthcare Devices	Spinal Simplicity
2022	M&A	Podchaser	Commercial Services	Acast
2022	M&A	T2 Software	Software	Sonos

Note: Types of exits of VC-backed companies that return investment to investors include mergers and acquisitions (M&A), initial public offerings (IPO), and special-purpose acquisition company (SPAC), which enables investors to pool their capital to acquire a "public-market ready" business with the intent of taking it public.

Source: PitchBook Venture Capital and Private Equity Database

Figure 22

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are the federal government's seed funds that support technology commercialization spurred by federal R&D. Phase 1 awards are $50,000 to $250,000 for up to a year and Phase 2 awards are up to $1.5 million over 2 years. Kentucky's SBIR/STTR award counts and value have fluctuated, with stronger performance in Phase 2 awards since 2016.

Kentucky SBIR/STTR Total Award Count by Phase, 2014–2022

PHASE	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Phase 1	30	23	27	23	24	33	19	25	24	20
Phase 2	9	10	10	17	15	9	13	14	8	16
Total Count	**39**	**33**	**37**	**40**	**39**	**42**	**32**	**39**	**32**	**36**

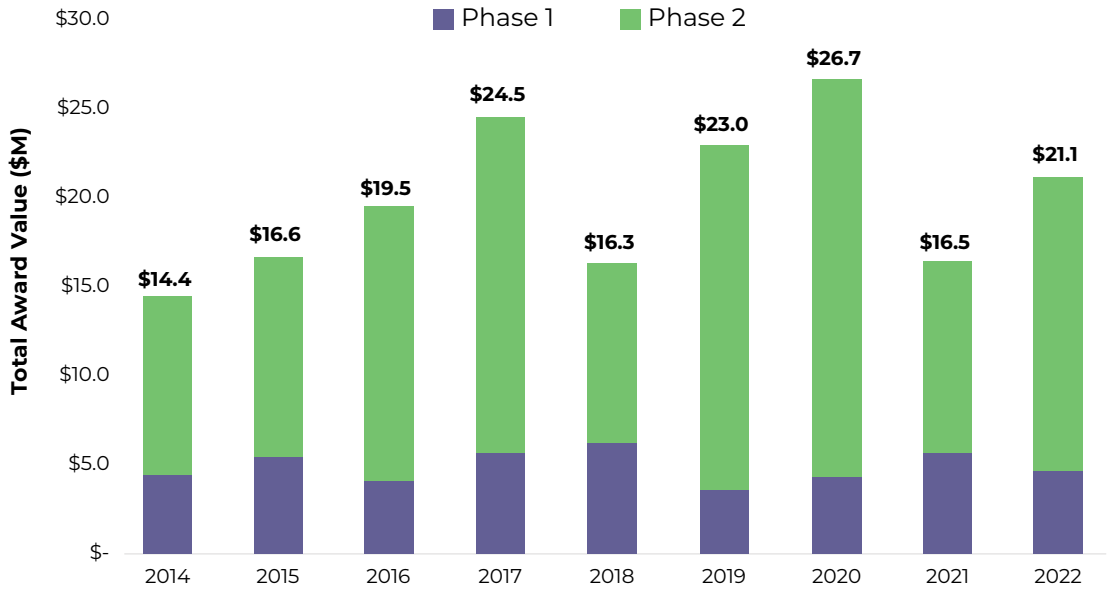
Kentucky SBIR/STTR Total Award Value, 2014–2022

PHASE	2014	2015	2016	2017	2018	2019	2020	2021	2022
Phase 1	$4.40	$5.42	$4.09	$5.64	$6.21	$3.55	$4.27	$5.67	$4.66
Phase 2	$10.05	$11.22	$15.43	$18.89	$10.11	$19.41	$22.39	$10.78	$16.48
Total Value	**$14.4**	**$16.6**	**$19.5**	**$24.5**	**$16.3**	**$23.0**	**$26.7**	**$16.5**	**$21.1**

Source: SBIR/STTR Award Database

Figure 23

Kentucky SBIR/STTR Total Award Value by Phase, 2014–2022



Source: SBIR/STTR Award Database

STEM Degrees

Figure 24

In 2020, Kentucky awarded 1,847 science and technologies associate degrees, 7,197 science and engineering (S&E) bachelor's degrees, 6,209 S&E master's degrees, and 302 S&E doctoral degrees. The table shows the breakdown of degrees conferred by race, ethnicity, and temporary visa status. The demographic groups are closest to population parity at the associate and bachelor's degree levels and most underrepresented at the master's and doctoral levels.

Kentucky S&E Degrees:
Share of Total Degrees by Race, Ethnicity, and Temporary Visa Status 2020

	TOTAL	WHITE	BLACK	ASIAN	LATINO	OTHER	TWO+ RACES	TEMP VISA
Associate Degrees								
Science	**519**	**78%**	**10%**	**2%**	**3%**	**3%**	**4%**	**0%**
Math and Computer Sciences	392	80%	8%	3%	3%	2%	4%	0%
Social Sciences	127	74%	15%	0%	2%	6%	4%	0%
Technologies	**1,328**	**83%**	**7%**	**1%**	**3%**	**2%**	**3%**	**0%**
Health Tech	982	82%	8%	1%	3%	2%	3%	0%
Engineering Tech	291	86%	5%	1%	3%	2%	2%	0%
Science Tech	55	95%	2%	0%	0%	0%	4%	0%
Total	**1,847**	**82%**	**8%**	**2%**	**3%**	**2%**	**3%**	**0%**
Bachelor's Degrees								
Science	**6,094**	**76%**	**7%**	**3%**	**4%**	**4%**	**4%**	**3%**
Life Sciences	1,832	81%	4%	4%	3%	3%	3%	2%
Math and Computer Sciences	982	74%	5%	3%	4%	4%	4%	6%
Physical Sciences	290	77%	4%	3%	6%	1%	4%	6%
Other Sciences	2,990	73%	9%	2%	4%	5%	4%	2%
Engineering	**1,103**	**80%**	**2%**	**4%**	**4%**	**2%**	**3%**	**5%**
Total	**7,197**	**76%**	**6%**	**3%**	**4%**	**4%**	**4%**	**3%**

	TOTAL	WHITE	BLACK	ASIAN	LATINO	OTHER	TWO+ RACES	TEMP VISA
Master's Degrees								
Science	**5,887**	**15%**	**2%**	**2%**	**0.5%**	**4%**	**0%**	**77%**
Math and Computer Sciences	4,679	2%	0.1%	2%	0.04%	1%	0%	95%
Life Sciences	238	71%	6%	5%	3%	4%	1%	9%
Physical Sciences	86	29%	0%	8%	0%	2%	0%	60%
Other Sciences	884	65%	8%	0%	2%	19%	1%	5%
Engineering	**322**	**67%**	**6%**	**4%**	**6%**	**1%**	**3%**	**14%**
Total	**6,209**	**17%**	**2%**	**2%**	**1%**	**4%**	**1%**	**74%**
Doctoral Degrees								
Science	**237**	**48%**	**5%**	**4%**	**1%**	**5%**	**1%**	**35%**
Life Sciences	88	50%	6%	6%	0%	3%	2%	33%
Math and Computer Sciences	41	37%	0%	2%	5%	0%	0%	56%
Physical Sciences	25	24%	4%	0%	0%	0%	0%	72%
Other Sciences	83	59%	8%	4%	1%	11%	0%	17%
Engineering	**65**	**20%**	**0%**	**2%**	**2%**	**6%**	**2%**	**69%**
Total	**302**	**42%**	**4%**	**3%**	**1%**	**5%**	**1%**	**43%**

Notes: In National Center for Education Statistics data, all races and ethnicities sum to 100%. Degrees conferred to students include both in- and out-of-state students.

Source: National Center for Education Statistics. (2021). Integrated Postsecondary Education System, Completions Survey.

Figure 25

Kentucky S&E Degrees Conferred to White Students:
Total Number in 2010 and 2020, Share of Total S&E Degrees, and 2010–2020 CAGR

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Associate Degrees				
Science	**475**	**407**	**78%**	**-1.5%**
Math and Computer Sciences	454	313	80%	-3.7%
Social Sciences	21	94	74%	16.2%
Technologies	**1,796**	**1,107**	**83%**	**-4.7%**
Health Tech	1,412	804	82%	-5.5%
Engineering Tech	367	251	86%	-3.7%
Science Tech	17	52	95%	11.8%
Bachelor's Degrees				
Science and Engineering				
Science	**3,696**	**4,614**	**76%**	**2.6%**
Life Sciences	1,167	1,482	81%	2.42%
Social Sciences	1,129	1,125	73%	-0.04%
Psychology	745	1,003	73%	3.0%
Math and Computer Sciences	403	727	74%	6.1%
Physical Sciences	191	222	77%	1.5%
Geosciences	61	55	89%	-1.0%
Engineering	**561**	**880**	**80%**	**4.6%**
Mechanical	184	297	85%	4.9%
Electrical	131	185	77%	3.5%
Civil	104	140	88%	3.0%
Chemical	59	105	76%	5.9%
All Other	**83**	**153**	**72%**	**6.3%**
Master's Degrees				
Science and Engineering				
All Science	**687**	**858**	**15%**	**2.2%**
Psychology	303	377	62%	2.2%
Social Sciences	182	186	69%	0.2%
Life Sciences	116	169	71%	3.8%
Math and Computer Sciences	52	93	2%	6.0%
Physical Sciences	18	25	29%	3.3%
Geosciences	16	8	80%	-6.7%
Engineering	**187**	**215**	**67%**	**1.4%**

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Doctoral Degrees				
Science and Engineering				
All Science	**120**	**114**	**48%**	**-0.5%**
Life Sciences	50	44	50%	-1.3%
Psychology	30	25	66%	-1.8%
Social Sciences	20	21	50%	0.5%
Math and Computer Sciences	8	15	37%	6.5%
Physical Sciences	10	6	24%	-5.0%
Geosciences	2	3	100%	4.1%
Engineering	**9**	**13**	**20%**	**3.7%**

Notes: White Kentuckians represented 83.8% of Kentucky's employed workforce in 2021. Degrees conferred to students include both in- and out-of-state students.

Source: National Center for Education Statistics. (2021). Integrated Postsecondary Education System, Completions Survey.

Figure 26

Kentucky S&E Degrees Conferred to Black Students: Total Number in 2010 and 2020, Share of Total S&E Degrees, and 2010–2020 CAGR

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Associate Degrees				
Science	**54**	**52**	**7%**	**-0.4%**
Math and Computer Sciences	53	33	8%	-4.6%
Social Sciences	1	19	5%	34.2%
Technologies	**315**	**92**	**7%**	**-11.6%**
Health Tech	270	76	8%	-11.9%
Engineering Tech	44	15	5%	-10.2%
Science Tech	1	1	2%	0.0%
Bachelor's Degrees				
Science and Engineering	**289**	**434**		
Science	**273**	**412**	**7%**	**4.2%**
Life Sciences	48	77	4%	4.8%
Social Sciences	110	137	9%	2.2%
Psychology	89	139	10%	4.6%
Math and Computer Sciences	18	47	5%	10.1%
Physical Sciences	7	11	4%	4.6%
Geosciences	1	1	2%	0.0%
Engineering	**16**	**22**	**2%**	**3.2%**
Mechanical	4	4	1%	0.0%
Electrical	6	6	2%	0.0%
Civil	0	2	1%	-
Chemical	2	4	3%	7.2%
All Other	**4**	**6**	**3%**	**4.1%**
Master's Degrees				
Science and Engineering	**61**	**107**	**2%**	**5.8%**
All Science	**52**	**89**	**2%**	**5.5%**
Psychology	16	45	7%	10.9%
Social Sciences	24	23	9%	-0.4%
Life Sciences	9	15	6%	5.2%
Math and Computer Sciences	3	5	0%	5.2%
Physical Sciences	0	0	0%	-
Geosciences	0	1	10%	-
Engineering	**9**	**18**	**6%**	**7.2%**

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Doctoral Degrees				
Science and Engineering	**10**	**13**	**4%**	**2.7%**
All Science	**9**	**13**	**5%**	**3.7%**
Life Sciences	5	5	6%	0.0%
Psychology	2	2	5%	0.0%
Social Sciences	2	5	12%	9.6%
Math and Computer Sciences	0	0	0%	-
Physical Sciences	0	1	4%	-
Geosciences	0	0	0%	-
Engineering	**1**	**0**	**0%**	**-**

Notes: Black Kentuckians represented 7.1% of Kentucky's employed workforce in 2021. Degrees conferred to students include both in- and out-of-state students.

Source: National Center for Education Statistics. (2021). Integrated Postsecondary Education System, Completions Survey.

Figure 27

Kentucky S&E Degrees Conferred to Hispanic or Latino Students: Total Number in 2010 and 2020, Share of Total S&E Degrees, and 2010–2020 CAGR

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Associate Degrees				
Science	**13**	**14**	**3%**	**0.7%**
Math and Computer Sciences	13	12	3%	-0.8%
Social Sciences	0	2	2%	-
Technologies	**31**	**44**	**3%**	**3.6%**
Health Tech	20	34	3%	5.4%
Engineering Tech	11	10	3%	-0.9%
Science Tech	0	0	0%	-
Bachelor's Degrees				
Science and Engineering	**81**	**277**	**4%**	**13.1%**
Science	**72**	**235**	**4%**	**12.6%**
Life Sciences	17	52	3%	11.8%
Social Sciences	25	56	4%	8.4%
Psychology	17	72	5%	15.5%
Math and Computer Sciences	8	37	4%	16.5%
Physical Sciences	4	17	6%	15.6%
Geosciences	1	1	2%	0.0%
Engineering	**9**	**42**	**4%**	**16.7%**
Mechanical	3	17	5%	18.9%
Electrical	2	8	3%	14.9%
Civil	2	3	2%	4.1%
Chemical	2	4	3%	7.2%
All Other	**0**	**10**	**5%**	**-**
Master's Degrees				
Science and Engineering	**17**	**48**	**1%**	**10.9%**
All Science	**13**	**28**	**1%**	**8.0%**
Psychology	4	14	2%	13.3%
Social Sciences	3	5	2%	5.2%
Life Sciences	4	7	3%	5.8%
Math and Computer Sciences	2	2	0%	0.0%
Physical Sciences	0	0	0%	-
Geosciences	0	0	0%	-
Engineering	**4**	**20**	**6%**	**17.5%**

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Doctoral Degrees				
Science and Engineering	**9**	**4**	**1%**	**-7.8%**
All Science	**8**	**3**	**0%**	**-9.3%**
Life Sciences	5	0	0%	-100.0%
Psychology	2	1	3%	-6.7%
Social Sciences	1	0	0%	-100.0%
Math and Computer Sciences	0	2	5%	-
Physical Sciences	0	0	0%	-
Geosciences	0	0	0%	-
Engineering	**1**	**1**	**2%**	**-**

Notes: Latino Kentuckians represented 3.8% of Kentucky's employed workforce in 2021. Degrees conferred to students include both in- and out-of-state students.

Source: National Center for Education Statistics. (2021). Integrated Postsecondary Education System, Completions Survey.

Figure 28

Kentucky S&E Degrees Conferred to Asian Students: Total Number in 2010 and 2020, Share of Total S&E Degrees, and 2010–2020 CAGR

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Associate Degrees				
Science	**8**	**11**	**2%**	**3.2%**
Math and Computer Sciences	8	11	3%	3.2%
Social Sciences	0	0	0%	-
Technologies	**24**	**17**	**1%**	**-3.4%**
Health Tech	16	14	1%	-1.3%
Engineering Tech	8	3	1%	-9.3%
Science Tech	0	0	0%	-
Bachelor's Degrees				
Science and Engineering	**113**	**216**	**3%**	**6.7%**
Science	**94**	**168**	**3%**	**6.0%**
Life Sciences	48	73	4%	4.3%
Social Sciences	17	30	2%	5.8%
Psychology	18	29	2%	4.9%
Math and Computer Sciences	5	28	3%	18.8%
Physical Sciences	6	8	3%	2.9%
Geosciences	0	0	0%	-
Engineering	**19**	**48**	**4%**	**9.7%**
Mechanical	7	10	3%	3.6%
Electrical	5	17	7%	13.0%
Civil	0	3	2%	-
Chemical	3	6	4%	7.2%
All Other	**4**	**12**	**6%**	**11.6%**
Master's Degrees				
Science and Engineering	**30**	**118**	**2%**	**14.7%**
All Science	**16**	**105**	**2%**	**20.7%**
Psychology	5	1	0%	-14.9%
Social Sciences	1	3	1%	11.6%
Life Sciences	4	11	5%	10.6%
Math and Computer Sciences	6	83	2%	30.0%
Physical Sciences	0	7	8%	-
Geosciences	0	0	0%	-
Engineering	**14**	**13**	**4%**	**-0.7%**

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Doctoral Degrees				
Science and Engineering	**16**	**10**	**3%**	**-4.6%**
All Science	**14**	**9**	**4%**	**-4.3%**
Life Sciences	6	5	6%	-1.8%
Psychology	3	2	5%	-4.0%
Social Sciences	2	1	2%	-6.7%
Math and Computer Sciences	1	1	2%	0.0%
Physical Sciences	2	0	0%	-100.0%
Geosciences	0	0	0%	-
Engineering	**2**	**1**	**2%**	**-6.7%**

Notes: Asian Kentuckians represented 1.7% of Kentucky's employed workforce in 2021. Degrees conferred to students include both in- and out-of-state students.

Source: National Center for Education Statistics. (2021). Integrated Postsecondary Education System, Completions Survey.

Figure 29

Kentucky S&E Degrees Conferred to Female Students, All Races and Ethnicities: Total Number in 2010 and 2020, Share of Total S&E Degrees, and 2010–2020 CAGR

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Associate Degrees				
Science	**155**	**188**	**36%**	**1.9%**
Math and Computer Sciences	142	79	20%	-5.7%
Social Sciences	13	109	86%	23.7%
Technologies	**1671**	**868**	**65%**	**-6.3%**
Health Tech	1610	824	84%	-6.5%
Engineering Tech	58	41	14%	-3.4%
Science Tech	3	3	5%	0.0%
Bachelor's Degrees				
Science and Engineering	**2470**	**3740**	**52%**	**4.2%**
Science	**2361**	**3494**	**57%**	**4.0%**
Life Sciences	739	1128	62%	4.3%
Social Sciences	673	858	55%	2.5%
Psychology	680	1096	79%	4.9%
Math and Computer Sciences	141	242	25%	5.6%
Physical Sciences	105	148	51%	3.5%
Geosciences	23	22	35%	-0.4%
Engineering	**109**	**246**	**22%**	**8.5%**
Mechanical	29	48	14%	5.2%
Electrical	15	28	12%	6.4%
Civil	26	33	21%	2.4%
Chemical	24	58	42%	9.2%
All Other	**15**	**79**	**37%**	**18.1%**
Master's Degrees				
Science and Engineering	**628**	**1917**	**31%**	**11.8%**
All Science	**582**	**1829**	**31%**	**12.1%**
Psychology	302	476	79%	4.7%
Social Sciences	124	140	52%	1.2%
Life Sciences	92	134	56%	3.8%
Math and Computer Sciences	35	1040	22%	40.4%
Physical Sciences	21	34	40%	4.9%
Geosciences	8	5	0%	-4.6%
Engineering	**46**	**88**	**27%**	**6.7%**

DEGREE	2010	2020	CURRENT SHARE	2010–2020 CAGR
Doctoral Degrees				
Science and Engineering	**120**	**121**	**40%**	**0.1%**
All Science	**113**	**104**	**44%**	**-0.8%**
Life Sciences	47	47	53%	0.0%
Psychology	34	23	61%	-3.8%
Social Sciences	16	13	31%	-2.1%
Math and Computer Sciences	7	12	29%	5.5%
Physical Sciences	9	7	28%	-2.5%
Geosciences	0	2	67%	-
Engineering	**7**	**17**	**26%**	**9.3%**

Notes: Women represented 47.9% of Kentucky's employed workforce in 2021. Degrees conferred to students include both in- and out-of-state students.

Source: National Center for Education Statistics. (2021). Integrated Postsecondary Education System, Completions Survey.