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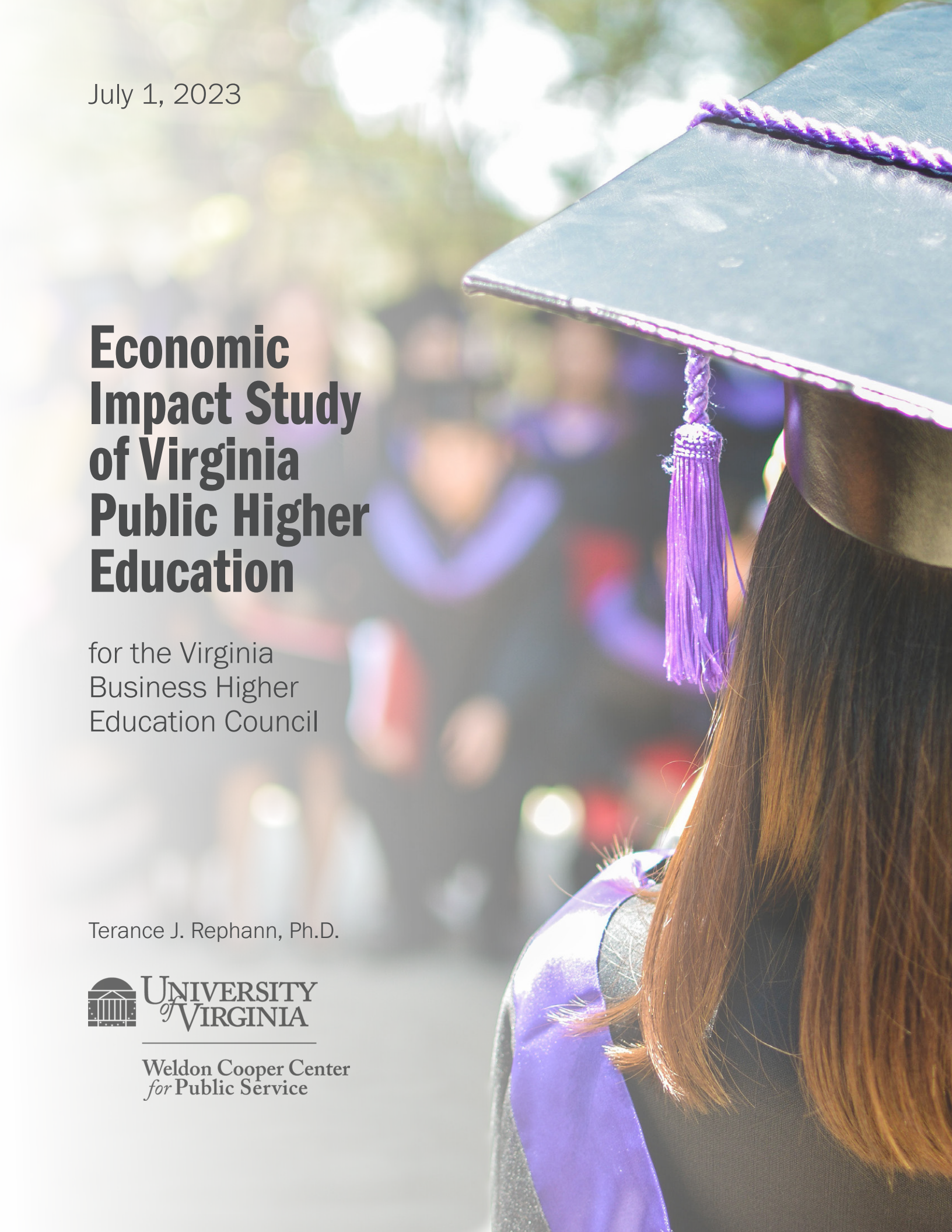
Economic Impact Study of Virginia Public Higher Education

for the Virginia Business Higher Education Council

Terance J. Rephann, Ph.D.

University of Virginia

Weldon Cooper Center for Public Service



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STUDY HIGHLIGHTS

- The total economic activity attributable to Virginia public higher education operations in FY 2021 is $52.431 billion in Virginia gross domestic product expressed in terms of 2021 dollars and 188,379 jobs. State public higher education each year accounts for $3.874 billion in long-term state revenue.
- Every dollar spent on public higher education by the state is associated with an additional $1.89 in state revenue and an increment of $25.59 to Virginia gross domestic product.
- The medical centers at Virginia Commonwealth University and the University of Virginia make significant contributions to the state economy. Together, they account for 45,626 jobs, $4.581 billion in GDP, and $356 million in state revenues in FY 2021.
- Research expenditures by higher education are responsible for nearly 13,510 jobs, $1.091 billion in GDP, and $96 million in state revenues in FY 2021.
- An estimated 54 percent of higher education research funds are derived from out-of- state sources, primarily the federal government.
- University startups directly employed 842 workers at the end of FY 2021. The total economic impact of these firms was 1,779 full- and part-time jobs and $209 million in GDP. These enterprises generated an estimated $13 million in state revenues during FY 2021.
- An estimated 31.2 percent of Virginia public higher education institutions' revenue is derived from out-of-state sources such as federal grants and contracts, out-of-state tuition, and private gifts.
- The expenditure of out-of-state funds, plus the expenditures of out-of-state students and visitors on local goods and services, results in an economic impact of $3.032 billion and 39,340 Virginia jobs for FY 2021. The state revenue impact is $240 million.

EXECUTIVE SUMMARY

Virginia's public higher education system plays a key role in providing educational access to citizens across the commonwealth. Thirty-nine colleges and universities serve the state, including 15 four-year institutions, one junior college, and 23 community colleges. Their geographical reach is extended through more than 70 branch campuses and centers and numerous other off-campus clinical locations and agricultural or environmental research stations. These institutions also provide access to community members through continuing education, business and industry training, online and distance learning opportunities, and high school dual enrollment.

Virginia's public higher education institutions also play a vital role in the commonwealth's economy. College, university, and community college spending on employee payroll, supplies and services, and capital projects injects billions of dollars annually into the economy. Student and visitor spending on goods and services also generates significant economic activity. Most important, these institutions prepare the commonwealth's workforce and develop future community and business leaders. Of all degrees issued by higher education institutions in the state, Virginia's public colleges and universities award 80 percent of all associate's degrees, 65 percent of bachelor's degrees, 43 percent of master's degrees, and 49 percent of doctor's degrees. College graduates earn significantly more than high school graduates, and they improve the productivity of Virginia businesses. In addition, Virginia's colleges and universities foster entrepreneurial ventures such as startups connected to university-licensed technologies that generate new, high earning employment opportunities.

This study examines the effect of the public higher education sector on Virginia's economy. It provides a full accounting of the current flow of economic activity in Virginia that can be directly tied to the spending, educational activities, and research commercialization of publicly supported institutions of higher education. Economic effects for the three components are measured using a regional economic impact model, the Regional Economic Models, Inc. Policy Insight Plus (REMI PI+) model, that was designed for Virginia's economy. Outputs of the REMI PI+ model include calculation of the amount of Virginia gross domestic product, personal income, industrial output, and employment attributable to public higher education.

Following the terminology used by other economic impact studies, the term "economic footprint" is used to denote all measurable economic activity that results from activities related to public higher education. In this study, the economic activity can be traced to expenditures (termed the "expenditure effect") made as the colleges and universities increase the skills of students. Economic activity can also be attributed to improved workforce educational levels (termed the "human capital effect"). The term "human capital" refers here to the increased productivity and earnings that results from a student's acquisition of skills and knowledge. Lastly, new firms and the resulting economic output and employment that are generated as a result of research and development commercialization activities (termed "university startups") are counted as part of the economic footprint.

The major findings of the study are as follows:

- The total economic footprint attributable to Virginia public higher education operations in FY 2021 is $52.431 billion in Virginia gross domestic product, expressed in terms of 2021 dollars, and 188,379 jobs. State public higher education each year accounts for $3.874 billion in long-term state revenue.
- Every dollar spent on public higher education by the state is associated with an additional $1.89 in state revenue and an increment of $25.59 to Virginia gross domestic product.
- The medical centers at Virginia Commonwealth University and the University of Virginia make significant contributions to the state economy. Together they account for 45,626 jobs, $4.581 billion in GDP, and $356 million in state revenues. These economic impact estimates form part of the larger public higher education footprint.
- Research expenditures by higher education are responsible for nearly 13,510 jobs, $1.091 billion million in GDP, and $96 million in state revenues. An estimated 54 percent of higher education research funds are derived from out-of-state sources, primarily the federal government. Once more, these economic impacts represent a portion of the total economic footprint.
- University startups directly employed 842 workers at the end of FY 2021. The total economic impact of these firms was 1,779 in employment and $209 million in GDP. These enterprises generate an estimated $13 million in state revenues during the year.
- An estimated 31.2 percent of Virginia public higher education institutions' revenue is derived from out-of-state sources such as federal grants and contracts, out-of-state tuition, and private gifts. The expenditure of these out-of-state funds plus the expenditures of out-of-state students and visitors on local goods and services results in an economic impact of $3.032 billion and 39,186 Virginia jobs for FY 2021. The state revenue impact is $240 million. The expenditures associated with out-of-state students alone (i.e., tuition payments, student spending on goods and services, and visitor expenditures) generated 18,337 jobs, $1.486 billion in GDP, and $106 million in state revenues. These impact estimates, again, are part of the public higher education footprint.

INTRODUCTION

This study measures the contribution of Virginia's public higher education sector to the state economy. The definition of public will include those institutions governed by boards whose members are appointed by the Governor and that receive regular public financial support. They include 15 public four-year institutions, one junior college, and 23 community colleges. Although public higher education produces many other outputs besides economic activity and higher earnings for its graduates, it has become increasingly important in an era of fiscal limitations to demonstrate the economic contributions of public institutions and show how the state receives a return on its investment of state funds.

The study provides a full accounting of the of economic activity in Virginia that can be directly tied to the expenditures and activities of publicly supported institutions of higher education. Direct spending by the institutions, spending by students and visitors, the flow of new degree recipients into the workforce, and the employment of university startups are used to compute direct, indirect, and induced contributions to state economic activity. In undertaking this work, the study uses REMI PI+ regional economic modeling software. Outputs of the REMI model include calculation of the amount of gross domestic product, personal income, industrial output, and employment.

The study is divided into three sections. The first section examines the characteristics of Virginia's public higher education sector with special focus on recent changes. These features include enrollment patterns, financial characteristics, degree production, research and development spending, and university commercialization activities. The second section describes the approach to modeling the economic contribution of higher education, presents important features of the REMI PI+ regional economic impact model, and explains how input data were assembled. The third section introduces modeling scenarios used in estimating state economic footprint and presents model scenario results.

SECTION 1: VIRGINIA'S PUBLIC HIGHER EDUCATION SECTOR

Through its network of 39 public higher education institutions, including 15 four-year institutions, one junior college (Richard Bland College), and 23 community colleges (see **Appendix A.1 and Appendix A.2**), Virginia public higher education touches every region of the state. These institutions support over 70 branch campuses and centers. In addition, community colleges offer dual enrollment at local high schools, distance learning, and contract training opportunities to schools, homes, and workplaces. These growing offerings have expanded geographical access to higher education.[1]

Virginia public higher education enrollment peaked following the Great Recession at over 413,000 students in 2011. It declined every year to 2021, with enrollment losses concentrated at community colleges. Two-year college enrollment decreased 18.3 percent from fall 2015 to fall 2021 and four-year institution enrollment grew modestly at 3.5 percent over the same period (see **Figure 1.1**). This declining total enrollment is linked to slowing population growth, higher proportions of high school graduates drawn from more disadvantaged social backgrounds who are less likely to attend college, and labor shortages exacerbated by the COVID-19 rebound that were accompanied by higher compensation and better job flexibility for workers without college degrees (Torry 2023; Grawe 2018). While some four-year institutions had been able to recruit more international students to offset slowing domestic enrollment growth, the COVID-19 pandemic and international travel restrictions have recently impeded these efforts as well.

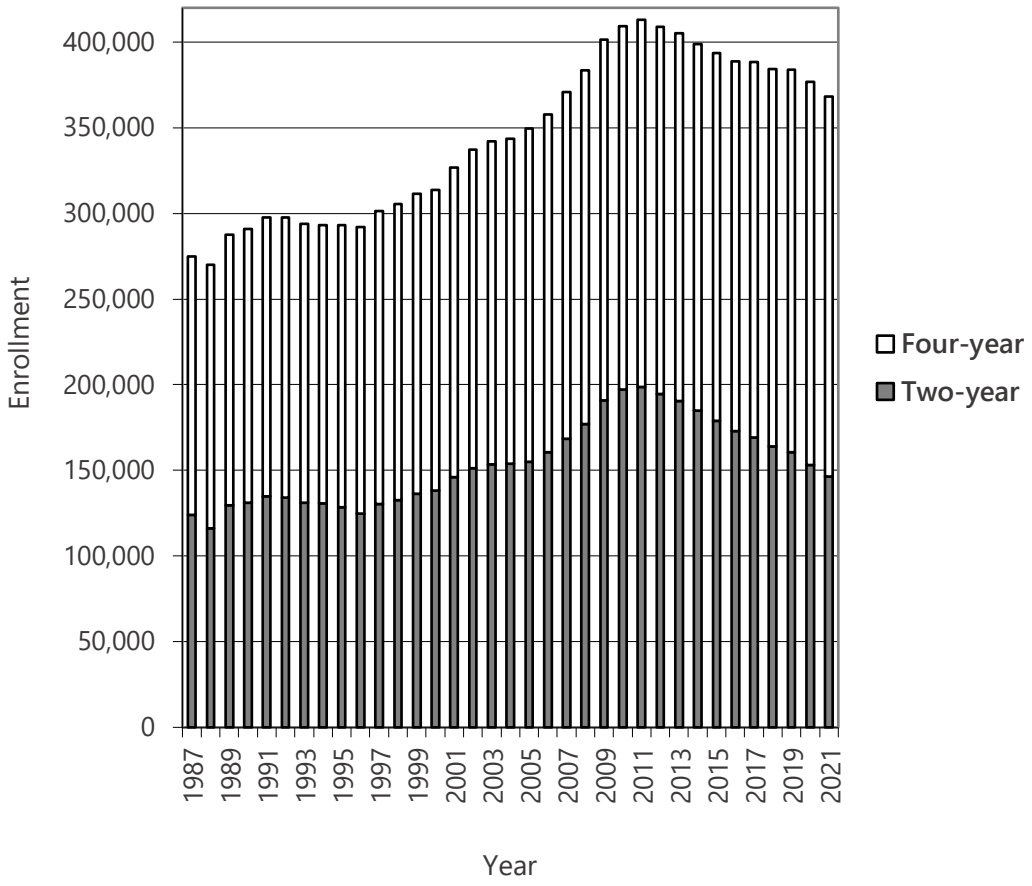
Public perceptions of the value of a college degree relative to its cost have also shifted notably in recent years. Gallup polling data of 18-29 year olds showed that 74 percent reported that obtaining a degree was important in 2013 compared to just 41 percent in 2019 (Selingo and Sigelman 2023). This perception is more widely held despite evidence that, although the college wage premium has decreased slightly because of increasing college attendance costs, the rate of return remains high (Abel and Dietz 2019). Returns for both bachelor's degree and associate's degree are close to 14 percent, which far exceeds the rate of return available from most private investments. College educated workers are also less likely to be unemployed.

Long-term structural changes in the economy, including technological changes such as digitization and automation, can be expected to lead to employment attrition for vocations that involve routine activities and basic cognitive skills and reward those requiring more advanced technological and interpersonal skills (Rephann 2021). The former usually require few skills while the latter typical require postsecondary education. Although some employers (including the Commonwealth of Virginia) have begun to scale back postsecondary educational credentials requirements for some positions to aid job recruitment and improve equity, recent data from Georgetown's Center for Workforce and Education indicate that 70 percent of all jobs will require some postsecondary education by 2030 (Carnevale 2021). Moreover, if young people hope to realistically obtain a "good

[1] Virginia's public colleges and universities also operate numerous other off-campus clinical locations and agricultural or environmental research stations that conduct research, provide patient care, and offer educational experiences.

job" (defined as a job that pays $57,000 for workers aged 25 to 35), higher education is a virtual necessity. Eighty percent of such workers with a bachelor's degree and 56 percent of those with some college or an associate's degree have such jobs but only 42 percent of those with a high school diploma do (Carnevale et al. 2022).

Figure 1.1 Virginia Public Higher Education Fall Enrollment, 1987-2021

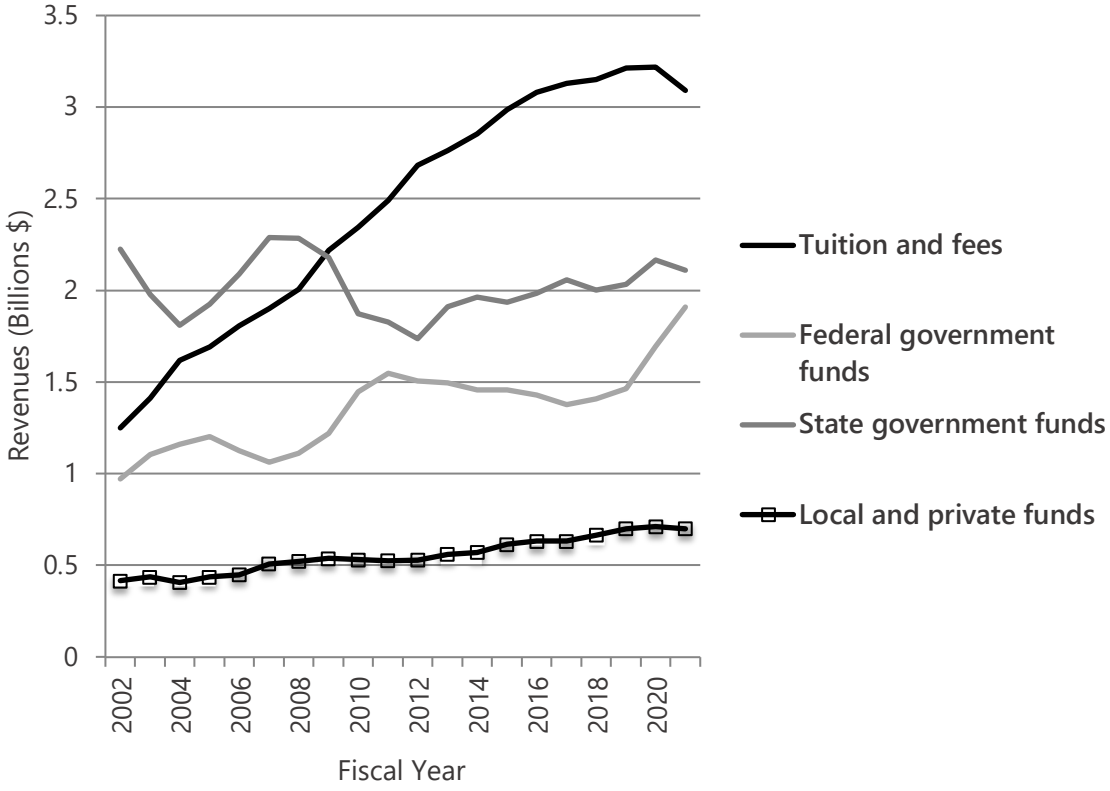


Source: State Council for Higher Education in Virginia, E02: Fall Headcount Enrollment
http://research.schev.edu/enrollment/E2_Report.asp

State appropriations and grants to higher education in Virginia increased 21.5 percent over the last decade (see **Figure 1.2** and **Table 1.1**). Because of declining FTE enrollments over the same period, real state appropriations and grants per FTE increased at a faster rate of 32 percent. However, at $6,998 per FTE in FY 2021, state funding was still significantly lower than the FY 2008 level of $8,036 per FTE in real dollars. This funding rebound is similar to other U.S. states, though Virginia funding lags well below the national average in per student state support (SHEEO 2023). Moreover, while inflation adjusted state funding for higher education on an FTE basis at a national level exceeded the 2008 funding level for the first time in FY 2022, this watershed has not yet been realized in Virginia according to preliminary data (SHEEO 2023). Federal government grants have also recently

started to become a more significant share of public higher education revenues. Because of higher education funds allotted as part of pandemic relief efforts such as the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) of 2020, federal government grants grew 30 percent from FY 2019 to FY 2021. However, it should be noted that most of these federal funds are one-time infusions of emergency aid and are unlikely to recur.

Figure 1.2 Virginia Public Higher Education Operating and Non-operating Revenues (Billions of 2021 Dollars) by Source, FY 2002- FY 2021



Source: U.S. Department of Education, Integrated Post-Secondary Data System, Finance Survey, 2002-2021
Note: Funds include grants, contracts, appropriations, and gifts.

Table 1.1 Virginia Public Higher Education Operating and Non-operating Revenues ($) by Source, FY 2021

Revenue Source	Four-year	Two-year	Total
Tuition and fees	2,771,497,971	320,221,537	3,091,719,508
Federal government grants, contracts and appropriations	1,579,885,861	330,030,267	1,909,916,128
State government grants, contracts and appropriations	1,696,936,882	413,663,174	2,110,600,056
Local and private grants, contracts, appropriations and gifts	675,086,871	26,036,631	701,123,502
Auxiliary enterprises sales and services	1,145,383,850	18,133,909	1,163,517,759
Other sources	6,172,331,035	36,966,431	6,209,297,466
Total revenue	10,046,318,224	1,143,861,130	11,190,179,354
Estimated out-of-state revenue			
Amount	**3,319,297,293**	**367,705,823**	**3,687,003,116**
Percent of total revenue	*33.0%*	*32.1%*	*32.9%*

Source: U.S. Department of Education, Integrated Post-Secondary Data System, Finance Survey, 2021

State public higher education has a broad mission to educate students, conduct research and development, and provide a public service, and this mission is reflected in its expense patterns (see **Table 1.2**). In FY 2021, Virginia's public colleges and universities allotted about 28 percent of total spending on instruction, 22 percent on academic support (i.e., activities that support the institution's academic mission such as academic administration, libraries, and academic computing), student services (i.e., noninstructional student support activities such as admissions and registration, student activities, counseling), and institution support (i.e., general administrative support services for institutional operations such as general administrative services, financial operations, human resources, and procurement), and 12 percent on research. Institutions spent 11 percent on auxiliary services—activities such as residence halls, meal plans, and bookstores that are funded by student fees. Nineteen percent of four-year expenses were incurred for hospital services (reflecting UVA and VCU medical center activities), which rely mainly on patient fees for funding.

Virginia public higher education expenses in constant (real) dollars grew 17 percent from FY 2012 to FY 2021. There was marked variation in growth among functional categories. For example, instructional expenses grew just 14 percent while auxiliary enterprise expenses actually fell because

of residual COVID-19 effects on student housing rental, cafeteria, and other revenue generating activities. In contrast, scholarships and fellowships expenses grew 38 percent, reflecting the increasing tendency for colleges and universities to offset higher tuitions with financial aid to improve access for students with financial need (Cook and Turner 2022; Grawe 2018).[2] Also, hospital services expenses grew by 51 percent, reflecting the growing medical services footprint of UVA and VCU.[3]

Table 1.2 Virginia Public Higher Education Expenses ($) by Type, FY 2021

Type of Expense	Four-year	Two-year	Total
Instruction	2,738,016,948	469,050,807	3,207,067,755
Research	1,355,920,844	0	1,355,920,844
Public service	229,755,119	11,833,468	241,588,587
Academic support	815,276,403	100,586,754	915,863,157
Student services	280,815,792	110,454,973	391,270,765
Institutional support	893,827,886	232,774,409	1,126,602,295
Scholarships and fellowships	369,524,390	141,092,116	510,616,506
Auxiliary services	1,273,966,917	11,608,760	1,285,575,677
Hospital services	1,894,868,624	0	1,894,868,624
Independent operations	934,986	0	934,986
Other expenses	286,080,694	59,330,401	345,411,095
Total	**10,138,988,603**	**1,136,731,688**	**11,275,720,291**

Source: U.S. Department of Education, Integrated Post-Secondary Data System, Finance, 2021

Despite stagnating enrollment, Virginia public higher education degree production continues to increase, albeit at a slower pace than when enrollment growth was more robust. Virginia public higher education degree production grew by 20.1 percent from 2008-2009 to 2014-2015, slowing

[2] More disaggregated financial aid Information from the IPEDS Student Financial Aid report data further supports this observation. The percentage of Virginia public higher education financial aid for first-time full-time students provided by institutional grants was 40.3 percent in 2020-21 compared to 26 percent in 2014-2015.

[3] The state's third medical school, Virginia Tech-Carillion School of Medicine, became a college of Virginia Tech in 2018. However, it does not provide hospital services. These are provided by its private partner, Carilion Clinic.

to 6.3 percent from 2014-15 to 2020-21. Degree production lags enrollment by several years, and it does not yet fully capture more recent enrollment attrition. Also, cohort graduation rates have been trending higher, helping to offset the effect of enrollment decline to some extent. Six-year graduation rates for Virginia four-year public institutions, already among the highest nationally, rose from 70 percent for cohort year 2008 to 72 percent for cohort year 2016. Three year graduation and transfer rates for two-year public institutions increased from 18.4 percent for cohort year 2008 to 25.5 percent for cohort year 2019.[4]

Public institutions have also experienced some modest attrition in state market share in areas of degree production.[5] Of all degrees issued by higher education institutions in the state, public institutions awarded 62 percent in 2020-21, down slightly from 63 percent in 2014-15. Virginia's public colleges and universities awarded 80 percent of all state associate's degrees, 65 percent of bachelor's degrees, 43 percent of master's degrees, and 49 percent of doctor's degrees in 2020-21. Virginia public higher education institutions confer a majority of degrees in all programmatic areas except for health professions, legal professions, and education.[6] They awarded 97 percent of architecture and construction program degrees. They were responsible for 86 percent of engineering and technologies degrees and 76 percent of natural sciences and mathematics degrees, thus generating a pool of talent that helps to maintain state scientific competitiveness and meet workforce needs.

Demand for high skilled workers in the commonwealth is projected to outpace supply for many industries and regions. The VEDP Office of Education Economics has identified 156 "Top Jobs" based on job quality and demand such as high entry level earnings, opportunities for advancement within the occupation, forecasted number of jobs, and strategic importance to Virginia's economic development strategy (VOEE 2021). According to the most recent 2021-2022 high demand occupations list, 91 of 156 occupations (58 percent) typically require an associate's degree or higher for entry level employment while half of the projected annual openings for these occupations do. Virginia public higher education will play a key role in preparing this future workforce.

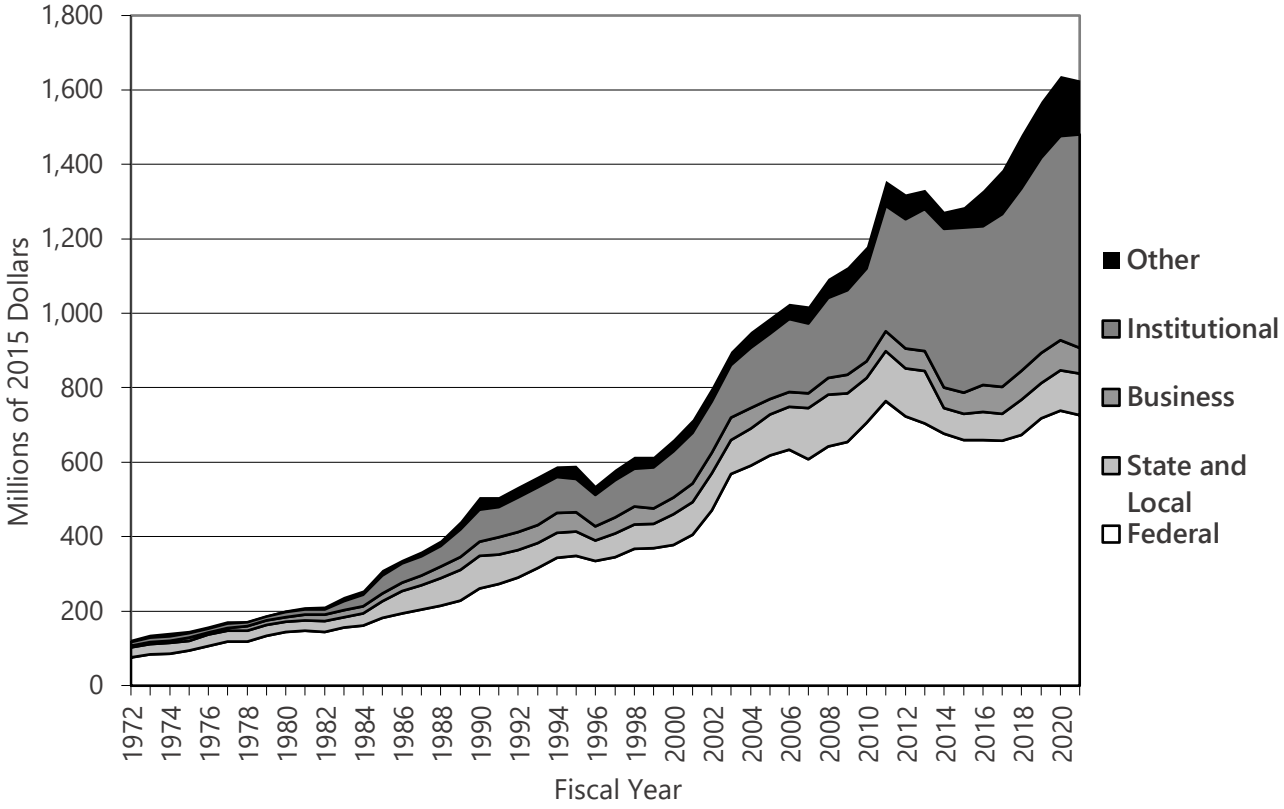
[4] This information is based on U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Graduation Rates data.

[5] The for-profit higher education sector has continued to shrink in Virginia (as elsewhere in the U.S.), in part because of federal government sanctioning of some for-profit companies. For example, ITT Technical Institute had schools in Chantilly, Norfolk, Richmond, Springfield, and Salem, which were shuttered as part of a national bankruptcy. However, private college graduate degree production, largely because of the expansion of Liberty University programs, has continued to grow.

[6] Summary fields examined were: Agriculture, natural resources, family/food science, and recreation (CIP 2-digit codes 1, 3, 12, 16, and 31), Architecture and construction (4, 46), Legal professions (22), Natural sciences and mathematics (26, 27, 40), Human services and public administration (43, 44), Communication and information technologies (9, 10, 11), Engineering and technologies (14, 15, 19, 41, 47, 49), Liberal arts, humanities, religion and performing arts (5, 23, 24, 30, 38, 39, 50, 54), Social sciences (42, 45), Health professions (51), Education (13), and Business (52).

Virginia's economic competitiveness also depends on its public higher education research and development capacity. Supported by increased federal, state and local, and institutional contributions, R&D expenditures expressed in terms of 2012 dollars increased by a factor of 10 from 1972 to 2015 (see **Figure 1.3**). Increases in federal funds accounted for over half of that increase. From 2015 to 2021, R&D expenditures also increased, albeit at a slower annualized rate of 4 percent compared to the earlier 5.6 percent rate. However, institutional expenditures from endowments and other institutional funds (38 percent) and other sources (primarily nonprofit organizations and gifts) at 26 percent have formed the largest part of the increase. Such funding is important for generating scientific discoveries that contribute to basic scientific knowledge as well as translational research that results in intellectual property such as patents and leads to commercialization activity such as university startups.

Figure 1.3 Virginia Public Higher Education Academic R&D Expenditures by Source of Funding, Millions of 2012 Dollars



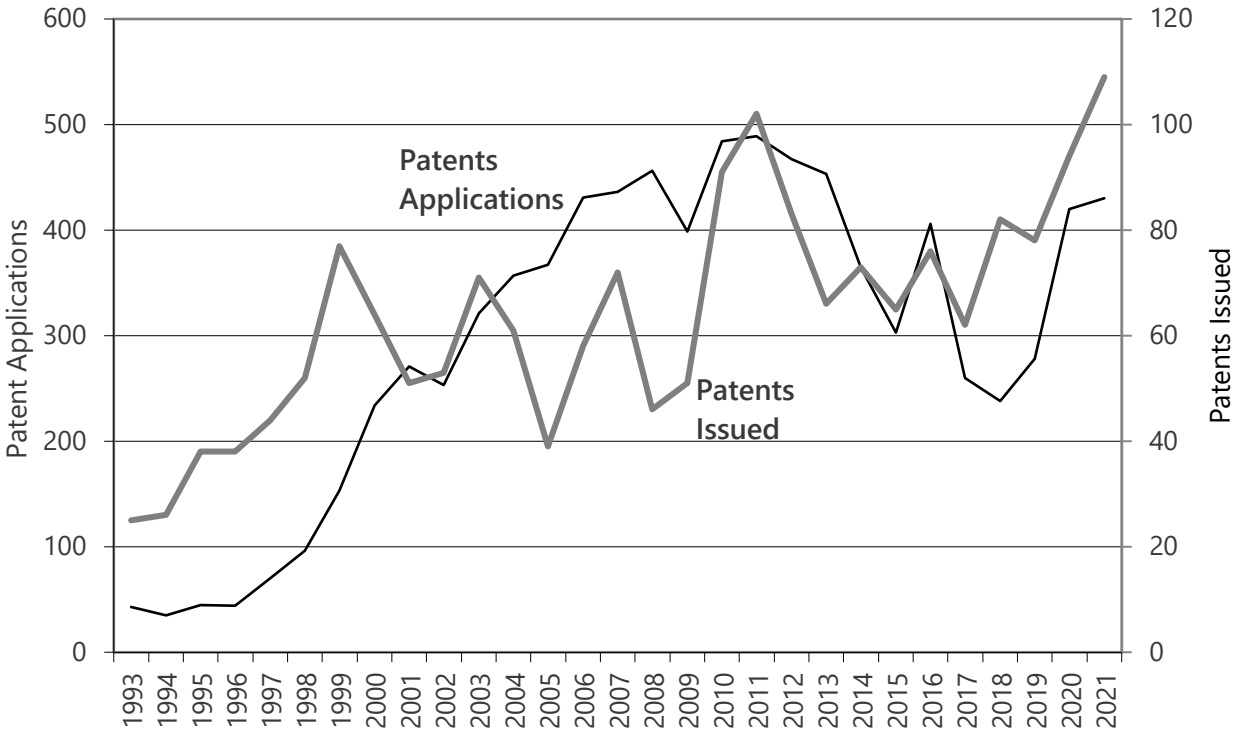
Source: National Science Foundation Higher Education Research and Development (HERD) Survey. https://www.nsf.gov/statistics/srvyherd/

Note: Expenditures before 2003 include only R&D expenditures in Science and Engineering fields

University research expenditures are tied closely to university innovation activities such as patenting activity. **Figure 1.4** indicates that new patent applications and awards had been trending upwards through 2011 but began to slip at the same time that research expenditures started to stagnate in 2012. However, patent activity growth resumed in 2018, shortly after research

expenditures started to recover. It is unknown to what extent this correlation is causal or whether it merely reflects shifts in research expenditure funding sources, fluctuations in the rate at which researchers are able to turn research expenditures into patented discoveries, or some other factor.[7]

Figure 1.4 Virginia Public University Patent Applications and Patents Issued, 1985-2021



Source: Association of University Technology Managers, Statistics Access for Tech Transfer (STATT)

Virginia's public colleges and universities have also generated scores of business startups over the years. Although data on the entire universe of such firms started and jobs created is unavailable, information can be constructed easily for a subset of such firms: firms that were established as a result of licensed university technologies, which are termed "university startups." This definition is used by the Association of University Technology Managers (AUTM) in soliciting information from university technology transfer offices about university-generated startups as part of its annual Licensing Activity Survey.[8]

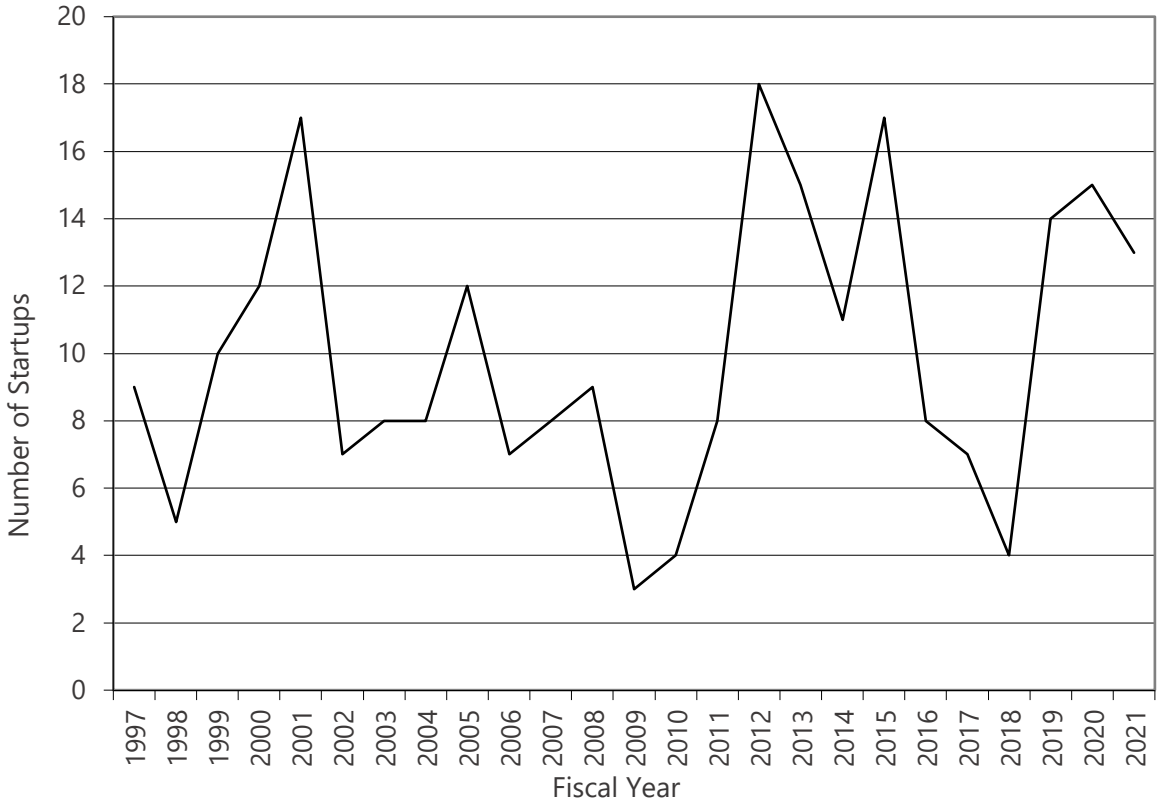
AUTM data indicates that Virginia public higher education institutions generated 320 startups from 1997 to 2021, which represents a creation rate of 13 startups per year (see **Figure 1.5**). Seventy-eight percent of these startups were initially located in Virginia. Although not all of these startups

[7] For example, one study of 16 U.S. universities indicates that federal life sciences funding is an important determinant of university drug and medical patenting activity (Blume-Kohout 2022). Some studies suggest that cuts in state appropriations decrease university patent production (Bound et al. 2019; Zhao 2018).

[8] This definition excludes licenses were owned by other entities such as the Virginia Innovation Partnership Corporation and enterprises that were generated by other university startups.

are still operating or located in Virginia, information collected from university technology transfer offices and matched with employment records from the Virginia Employment Commission Quarterly Census of Employment and Wages (QCEW) for the 2nd quarter of 2021 indicate that about 27 percent of the 249 original firms reported payroll employment for the period. These 67 university startups had 842 employees. Sixty-two percent of university startup employment is in the "professional, scientific, and technical services" industry, a sector whose employees require a high level of expertise and training, and supports jobs that pay well above average wages. The remaining employment includes 16 percent in computer and electronic manufacturing, 13 percent in educational services, 5 percent in chemical manufacturing, and 4 percent in other industries.

Figure 1.5 Number of Virginia Public University Startups Located in Virginia by Year, 1997-2021



Source: Association of University Technology Managers, Statistics Access for Tech Transfer (STATT)

The AUTM survey does not capture university spin-off companies. By spin-off companies, we mean companies that were created as a consequence of faculty, student, and alumni Virginia public higher education experiences or exposure to entrepreneurial support services but not with university licensed technologies. Numbers available from selected public institutions suggest the size and economic significance of these other companies is even more consequential. For example, Virginia public research university students generated 96 startups in FY 2016 (Center for Innovative Technology 2018); very few of these were connected to university-licensed technology. Public higher education faculty and staff also generate income from business, publishing, and consulting activities. While a definitive count of the extent of this faculty activity is not available, a study for

George Mason University is suggestive. It found that full-time faculty earned supplemental income equivalent to 24 percent of their university income through such independent activities (Fowler and Fuller 2005).

It also does not capture the effect of university innovation on larger incumbent or entrant firms. These effects derive from university innovation spillover effects to the region, originating as a result of the expertise or licensed technologies they obtained from higher education institutions, collaborating through business-university partnerships, hiring university graduates, or general face-to-face sharing of research and diffusion of ideas in forums and through local industry networks. Recent research suggests that the principal effect of university research expenditures on patenting activity transmits through these types of firms (Schoellman and Smirnyagin 2021). For example, many existing Virginia-based firms benefit from university technology transfer through partnerships with universities facilitated by independent nonprofit centers of excellence such as the Commonwealth Center for Advanced Logistics Systems, the Commonwealth Cyber Initiative, and the Commonwealth Center for Advanced Manufacturing. Also, patenting activity has been observed to stimulate local employment in proportion with how closely area industries align with university technology strengths (Hasuman 2012). Hausman estimates a total local employment effect of 13 workers per patent on average. With the reservoir of 1,847 Virginia patents issued to Virginia public higher education institutions over the 1993-2021 period that would translate into over 24,000 jobs. This figure dwarfs the total estimated number of Virginia startup employees (842).

Virginia's public higher education institutions also foster entrepreneurship through programming and providing financial resources for new firm ventures. Many colleges and universities offer formal degree programs in entrepreneurship. Several have created entrepreneurial development centers that offer extensive educational opportunities and business development services. At least seven institutions provide incubation or accelerator programs for startups, including the William & Mary (Launchpad), George Mason University (Mason Enterprise Center), James Madison University (Gilliam Center for Entrepreneurship), Old Dominion University (Strome Entrepreneurial Center Incubator), the University of Mary Washington (Eagleworks Business Incubation Center), the University of Virginia (i.Lab Incubator, Catalyst Accelerator, and I-Corps Discovery), and Virginia Tech (Apex Center for Entrepreneurs). Institutions have also become more active in furnishing seed and/or proof-of concept funds for new ventures. In FY 2021, at least six institutions offered such funds including George Mason University (Mason Innovation Fund), James Madison University (Madison Trust), Old Dominion University (Catalyzing Entrepreneurship and Economic Development Fund), University of Virginia (UVA LVG Seed Fund), Virginia Commonwealth University (VCU Commercialization Fund), Virginia Tech (VTC Innovation Fund and VTC Seed Fund).

Virginia's college and university alumni are also a major source of entrepreneurial ventures. One study found that University of Virginia alumni started 2,944 companies within the commonwealth that employed an estimated 371,000 workers and generated $395 billion in revenue (Lenox et al. 2014).

SECTION 2: METHODOLOGY AND DATA

Modeling Issues

Colleges and universities can affect a state, regional, or local economy in a variety of ways. These channels include the expenditures of the institutions and their students, improvements to human capital, knowledge creation through research, knowledge dissemination from extension and outreach, entrepreneurship, commercialization of university research, industry location decisions, improvements to quality of life, expenditures of tourists, and the provision of regional leadership on economic development matters. Rephann, Knapp, and Shobe (2009) provides a more complete discussion of these issues. This study restricts its attention to the most easily quantifiable features of higher education, expenditures on educational inputs, additions to human capital, and university startups. In this sense, it is fair to say that this study provides more conservative estimates than some other assessments.

College and university economic impact studies usually focus on the role of expenditures in stimulating economic activity. They are among the most easily measured features of higher education, being either publicly available or easily estimated. They include items such as employee payrolls, outlays on goods and services, capital purchases, student expenditures, and visitor expenditures. These expenditures can be entered into an economic impact model to measure the economic activity that results when money spent by higher education changes hands in the state economy. Input-output models trace expenditures backwards through the industrial supply chain to identify the additional business volume that results as funds re-circulate through the economy. The cumulative sum of multiple rounds of spending and re-spending results in a "multiplier effect." Allowance must be made in the model for expenditure leakages that occur when the initial expenditure is made outside the state (e.g., office furniture purchased from a manufacturer based in Michigan) and for in-state purchases where the locally merchandized item is actually produced by an out-of-state manufacturer. **Table 2.1** shows the values of the gross expenditures of higher education by major category.

Table 2.1 Virginia Public Higher Education Expenditure and Employment, FY 2021

Item	Total
Employee compensation, including fringe benefits	$7,857,874,253
Outlays on goods and services	$3,667,568,660
Capital expenditures	$1,372,179,581
Buildings and infrastructure	$1,081,261,819
Equipment	$270,094,480
Software	$9,362,652
Books and art	$11,460,631
Student expenditures	$2,946,831,668
Visitor expenditures	$139,203,235
Total institution related expenditures	**$15,983,657,397**
Employment	**80,403**

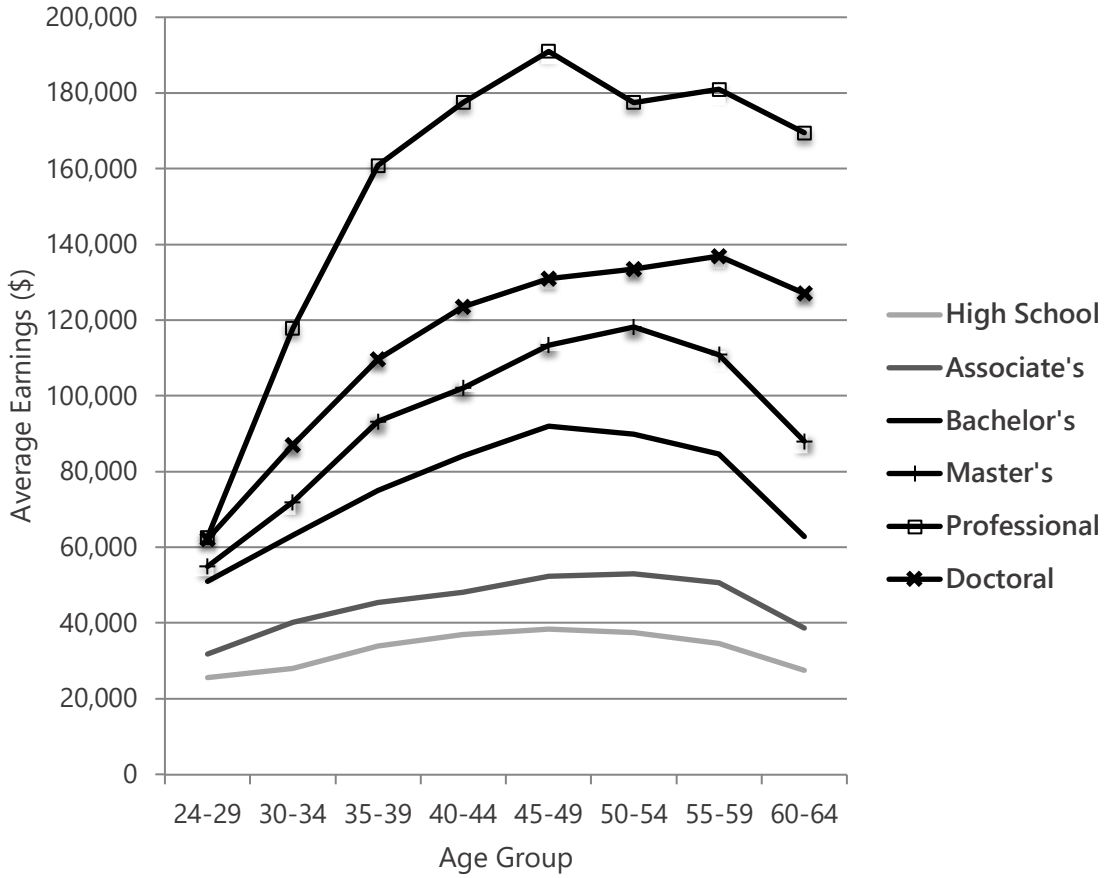
The primary mission of colleges and universities is to produce educated citizens and skilled workers. Not surprisingly, human capital additions are correspondingly much more important in determining the overall economic impact of public higher education than college and university expenditures. However, gauging this feature of economic impact also requires obtaining reasonable imputations of the additions of human capital for the commonwealth economy. Two steps are used to determine these additions in this study. First, the effect of various types of college degrees on worker earnings and productivity is computed. Second, the stream of graduates that enter the Virginia workforce and are retained within the state over time is estimated.

Figure 2.1 shows average earnings by educational achievement level for different age groups computed from recent U.S. Census data for Virginia.[9] The cumulative differences between various

[9] Abel and Dietz (2019) suggests that the premium earned by college graduates decreased slightly between 2015 and 2019. This is consistent with other studies which show a college wage premium flattening or slightly declining for bachelor's degrees but rising for graduate/professional degrees (Valletta 2018; Ashworth and Ranson 2019). Possible explanations for this recent phenomenon include "polarization" (a decrease in middle-skilled occupational demand due to technological change), "skill downgrading" (a deceleration in business IT investments that has driven high skill workers into lower skill positions), declining labor force participation rates, and decreased business dynamism (Valletta 2016; Ashworth and Ransom 2019).

degree average earnings and high school graduate average earnings provide one measure of the economic gains that accrue to individuals over a lifetime from higher education. The potential downside of using these differentials is that confounding individual, family, and community characteristics account for parts of the difference. For instance, if differences in the innate abilities of individuals help to explain some portion of educational achievement, one should reduce the assigned earnings differential by that amount. Some researchers argue that this "ability bias" is important with estimates from twin studies suggesting that the bias ranges from 6-12 percent, while others argue that there are equal and offsetting errors and biases such as comparative advantage, credit constraints, and measurement error that render such averages usable (Bartik, Hershbein and Lachowska 2016; McMahon 2009).

Figure 2.1. Virginia Average Earnings by Age Group and Educational Attainment, 2017-2021

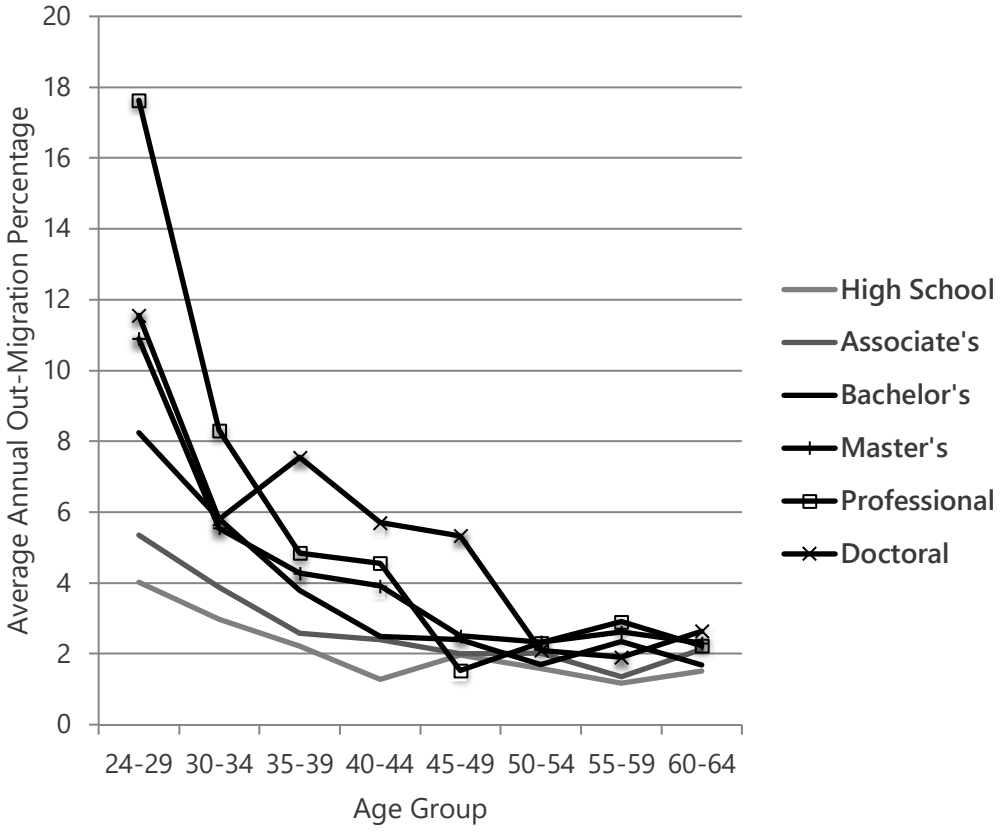


Source: American Community Survey Public Use Microdata Sample (PUMS), 2017-2021

Recent research indicates that a boost in the number of college enrollees and graduates can have a significant long-term impact on state human capital stocks (Winters 2018, 2020; Kennan 2015). However, human capital additions are gradually lost through time through the lifecycle processes of migration, retirement, and death. Individuals with higher levels of education are even more likely to migrate because their more specialized skills command a larger geographical market and

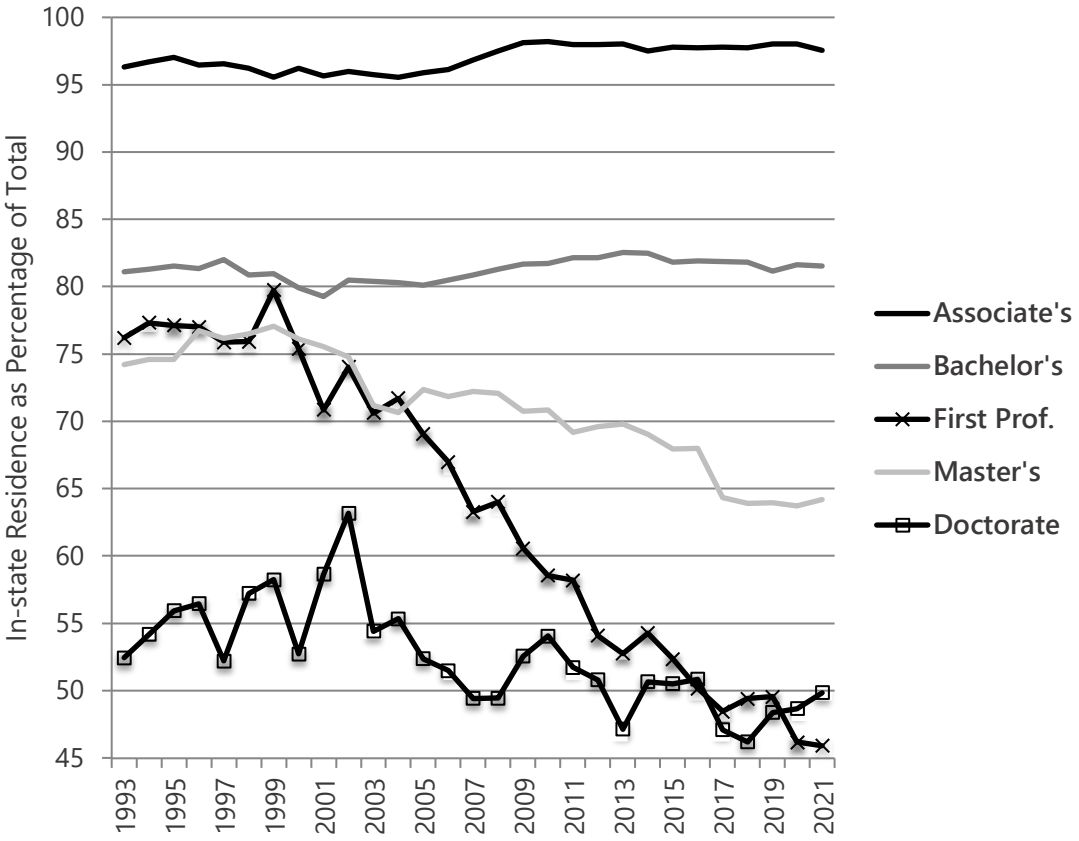
regional wage differentials are larger (see **Figure 2.2**). Also, their costs of moving may be lower because of a greater likelihood of receiving employer moving cost assistance, greater tax savings for higher earners when itemizing moving expenses for their income taxes, and lower psychic costs of moving due to expanded personal networks, exposure to different cultures, and travel to other regions as part of their educational experiences. Therefore, states do not necessarily reap the full rewards in terms of resident educational attainment by increasing the production of college graduates. The extent that states are able to retain graduates depends on the robustness of area labor markets (Abel and Deitz 2012) and the propensity to migrate based an individual's regional attachments (represented by whether graduate was born in the state, attended high school there, or resided there before matriculating) (Gottlieb and Joseph 2006; Tornatzky et al. 2002). **Figure 2.3** shows that the origin of Virginia public higher education graduates varies markedly by degree level. About 98 percent of associate's public higher education degree graduates and 81 percent of bachelor's degree graduates are state residents, whereas only 48 percent of doctoral and professional graduates are state residents. Thus, one would expect that far more of the former degree recipients would be retained in the state workforce than the latter. As a result, it is important to account for degree wage premia as well as outmigration propensities in estimating the contributions that public higher education institutions make to state human capital stocks.

Figure 2.2 Virginia Average Annual Out-Migration Percentage by Age Group and Educational Attainment, 2017-2021



Source: American Community Survey Public Use Microdata Sample (PUMS), 2017-2021

Figure 2.3 Percentage of Completions by Degree Level by In-state Residents, 1993-2021



Source: State Council for Higher Education in Virginia, C01: Completions Summary by Domicile
http://research.schev.edu/completions/C1_Domicile.asp

The most recent generation of economic research highlights the role of higher education research and development activities in regional economic development. Colleges and universities produce both basic and applied research. The former produces social benefits that are geographically diffuse. Applied research has a high potential for catalyzing regional economic development through knowledge transfers to local businesses and entrepreneurs. However, fully measuring these local innovation spillovers has proven elusive (Bartik and Erickcek 2008). One obvious avenue of economic impact is through university-related startups and spinoffs. Although much recent scholarship suggests that the overall contribution of such activities to the university economic footprint is relatively small outside of a handful of successful university corridors such as Silicon Valley, Route 128 in Boston, and the Research Triangle in North Carolina (Bartik and Erickeck 2008), including these university commercialization activities will provide a more accurate gauge of the university contribution to the state economy. As noted in the previous section, Virginia public higher education generates an average of 13 Virginia-based university startups each year. In 2021, a total of 67 university startups reported 842 payroll employees.

REMI PI+ Model

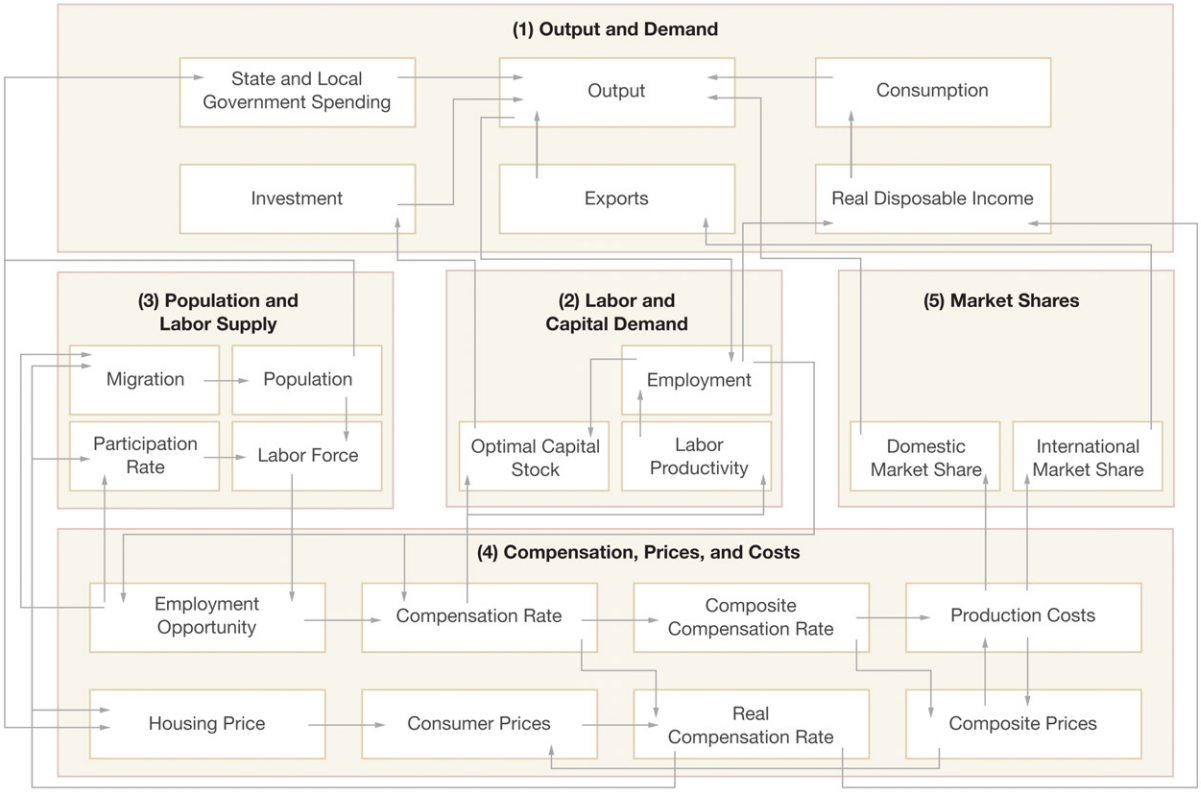
REMI PI+ (Policy Insight Plus) is a dynamic, multi-sector regional economic simulation model used for economic forecasting and measuring the impact of public policy changes on economic and population variables. It combines economic modeling methods such as input-output analysis, and econometric forecasting to characterize the mechanics and path of a regional economy (Treyz, Rickman, and Shao 1991). The model used for this analysis was customized for the state of Virginia. REMI PI+ and earlier versions of the software have been used in thousands of national and regional economic studies, including at least five other studies of state public higher education systems.

The model offers several key advantages over static input-output models such as IMPLAN and RIMS II,[10] which are often used in higher education impact studies and restrict attention to expenditure impacts. Some of these advantages include the ability to (a) more accurately depict the functioning of a market economy through the equilibrating forces of wages and prices and their effects in product, labor, and capital markets, (b) represent the effects of complex national and regional public policy initiatives by allowing a much wider variety of policy variables to be adjusted, (c) show the dynamic adjustments that occur in individual variables over time, and (d) illustrate responses for a large number of economic and demographic variables.

The model contains five major modules or blocks (see **Figure 2.4**), which interact simultaneously. The Output block determines expenditures for final demand, including consumption, investment, government, imports, and as well as demand for intermediate inputs. Final demand responds to changes in other model blocks. This module contains a key engine in the model, an input-output model based on the Bureau of Economic Analysis (BEA) benchmark transactions table that shows flows of goods and services among industries. The Labor and Capital Demand block determines employment, capital, and fuel demand as well as labor productivity. The Population and Labor force block determines the population characteristics of the region, including age, race, and sex composition. Labor force participation changes in response to wages and employment opportunities. A key driver of state population changes is migration, which is influenced by relative wage levels as well as amenities. The Wage, Price, and Costs block is where the prices of factor and housing and product price levels are determined. The Market Shares block helps to measure exports to and imports to the region. Changes in market share are driven by production costs, demand characteristics, distance to markets, and output.

[10] IMPLAN®, which stands for Impact Analysis for Planning, is maintained by IMPLAN Group, LLC. RIMS II refers to an enhanced version of the Regional Industrial Multiplier System developed by the federal government's Bureau of Economic Analysis.

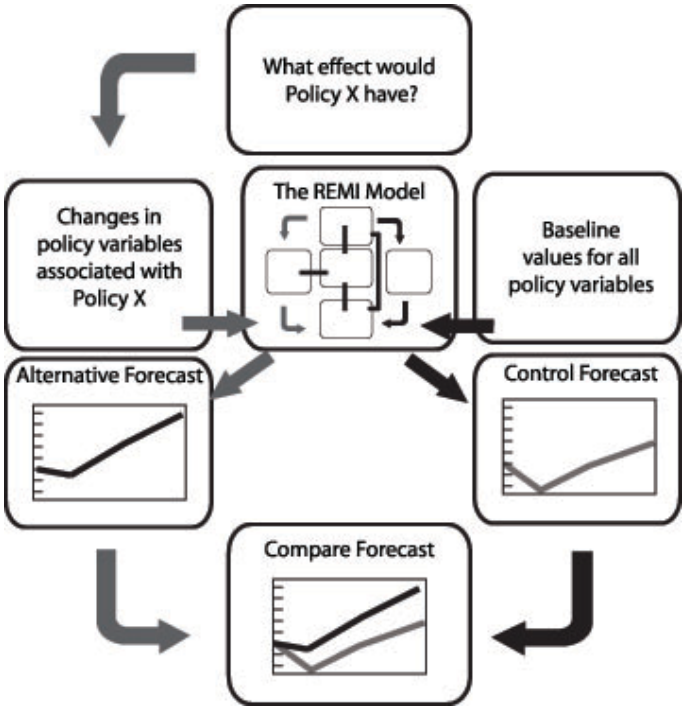
Figure 2.4. Simplified Economic Structure of the Key Interactions in Regional Economies Based on the REMI PI+ Model



Source: Regional Economic Models, Inc.

The basic procedure used to obtain Virginia public higher education economic impacts is illustrated in **Figure 2.5** and briefly summarized here. A control forecast for the Virginia economy was generated using REMI PI+. An alternative forecast was then run in which the expenditures associated with Virginia public higher education, its flow of graduates and associated higher earnings and productivity, and university startup employment were removed from the state economy. That is to say, the expenditures, graduate earnings/productivity input data, and university startup employment were entered as negative values. The difference between the baseline control forecast and the alternative forecast provides an estimation of the economic impact. Since these impacts are negative, the signs were reversed from negative to positive for presentation purposes to illustrate the positive contribution that Virginia public higher education makes to the state economy.

Figure 2.5 REMI PI+ Model Simulation Flow



Source: Regional Economic Models, Inc.

Input Data

This study divides economic effects into three distinct components. The expenditure component refers to the economic effect of expenditures related to institutional operations and capital purchases. Public higher education expenditures are divided into several different categories, including employee compensation, outlays on goods and services, capital expenditures, student expenditures, and visitor expenditures. The human capital component represents the economic effect of enhanced graduate earnings and productivity to the state during the time when graduates enter and participate in the state workforce. It is assumed that only graduates who are Virginia residents enter the Virginia workforce. Thus, the approximately 19 percent of total graduates from out-of-state are not reflected in any state earnings and productivity improvements. The method for calculating the human capital additions to the Virginia workforce makes use of Public Use Microdata (PUMS) from the U.S. Census Bureau American Community Survey. Earnings differentials are computed by age and educational attainment for different occupational groups to ascertain the added value of a college degree. These differentials are aligned with the degree field and level for the graduating 2020-21 cohort. Accounting for the field of degrees as well as the level of degree is important because there is considerable variation in employee compensation across fields of study. Once the earnings differentials are determined, the resident graduate workforce is reduced by an outmigration rate based on age and degree level to reflect attrition due to migration out of the state. Workforce attrition due to out-migration from the state is based on Virginia outmigration rates by age and educational attainment computed from Public Use Microdata (PUMS) from the U.S. Census Bureau's American Community Survey PUMS. Lastly, the average graduate is assumed

to work for 30 years before retiring. In accordance with previous studies, we make a slight (10 percent) reduction in graduate earnings to reflect the presence of ability bias. No effort is made to capture productivity improvements or other beneficial effects that might occur within the wider Virginia workforce because of human capital spillover effects that have been identified in other economic analyses (Bartik, Hershbein and Lachowska 2016; Moretti 2012). The final component accounts for university startups—the most easily identifiable university-related entrepreneurial business ventures in the state that were created as the result of licensing university intellectual property. Once again, no attempt is made to capture the full effect of innovation spillovers on the state economy, although it is recognized that these economic effects may be several magnitudes as large as university startups.

The goal of the analysis was to capture the most pertinent features of public higher education for which credible data could readily be constructed. However, several categories of spending were not available or were available in a form that would have created double counting. Therefore, the results of this analysis should be considered understated, or, in common parlance, conservative. A few caveats are in order.

First, the study includes information on the operational and capital expenditures of higher education institutions from the U.S. Department of Education and public higher education Comprehensive Audited Financial Reports. However, detailed information on the expenses of university-related foundations were not available from these sources. There are several different types of university foundations connected to Virginia higher education institutions: (a) scholarship foundations that exist primarily to provide financial assistance to students, (b) real estate foundations that manage and operate student housing and other properties, (c) economic development foundations that manage economic development properties such as research parks and business incubators and provide economic development services, (d) technology transfer foundations that manage the patenting and licensure of university intellectual property, (e) departmental or school foundations that solicit funds to sponsor particular programs, schools, departments, or alumni activities and (f) other foundations, such as health services foundations, which exist to administer university medical services. Some foundations at smaller institutions combine several of these functions in a single organization.

There are two reasons that some foundation spending is not incorporated in this study. First, including many foundation expenditures would have resulted in double-counting. For example, scholarship expenditures on tuition, fees, books, housing and transportation are already included as model data input. The scholarship expenditures used to finance tuition will be reflected in university expenditures on payroll and goods and services. Payments to students for educationally related expenses will be reflected in student expenditures. Another example of the potential for double counting occurs when foundations lease space and contract for services with the educational institutions. These “pass through” expenses will already be reflected in college and university budgets. Second, foundation expenditure data were not readily available from public sources in a standardized, consistent format for use in the model. However, an analysis of earlier data showed that two university health care component units, the University of Virginia Health

Services Foundation (now the University of Virginia's Physician's Group) and the VCU Medical Center, accounted for two-thirds of state higher education foundation spending (Rephann, Knapp, and Shobe 2009). Therefore, their expenses were obtained from their respective financial offices for this study as they were in previous studies.

Second, the study also does not capture the economic impact of affiliated enterprises. They include companies for which universities have partial or full equity ownership such as hospitals, ambulatory care firms, and laboratory services enterprises connected to the UVA and VCU Health Systems. Examples include Culpeper Regional Hospital and HealthSouth, LLC located in the Fontaine Research Park in Charlottesville for the UVA Health System. It also does not include the economic impact of independent institutions created as joint or cooperative ventures such as the Edward Via College of Osteopathic Medicine in Blacksburg. Moreover, although the recently established Virginia Tech Carilion School of Medicine does not provide hospital services, faculty, staff, and students are compensated for services rendered to its private partner, Carilion Clinic, which are not accounted for in this study.

Third, the study does not account for state spending and economic impacts of selected higher education organizations that receive state financial support. Most notably, it does not include the Eastern Virginia Medical School (EVMS). Although EVMS receives some state appropriations, it has a unique governance structure in which state officials select a minority of its Board of Visitors. Nor does the study include the operations at the five state supported higher education centers (i.e., New College Institute in Martinsville, Roanoke Higher Education Center, Institute for Advanced Learning and Research in Danville, Southern Virginia Higher Education Center in South Boston, and Southwest Virginia Higher Education Center in Abington). Only spending associated with two-year and four-year public higher education institutions programming at those locations is counted.

Fourth, the study makes only a limited effort to capture spending connected with university related visitations and tourism. Once again, data limitations played a role here. Higher education institutions do not collect information in a consistent format on the types of university visitors. These visitors may include campus visitations by prospective students; visitors of faculty, staff and students; visitors for cultural and sporting events; conference attendees; and patients and family members who temporarily relocate for medical treatment.

Fifth, the full human capital effects of higher education are not captured. For instance, the productivity and earnings gains for completers of credit program diploma and certificate programs and for all program non-completers are not included. Studies suggest that these individuals who are categorized by the U.S. Census Bureau as having an educational achievement level of "some college" still realize economic gains better than high school graduates (Greenstone and Looney 2013). Additional evidence indicates that certificate and diploma program completion is associated with higher earnings than those who do not obtain these credentials (Dadgar and Trimble 2015; Jepsen, Troske and Coomes 2014). In addition, the earnings and productivity effects from college and university non-credit training continuing education, workforce credentials, contract training and adult basic education are excluded.

Sixth, the effects of some university research and development, entrepreneurship assistance, and economic development activities are not captured. Economic activity generated by university business start-ups relying on university intellectual property licenses are included. However, other university spinoffs are not counted, nor is income resulting from faculty consulting and other employment. The study does not attempt to estimate economic activity related to business creation, relocations, and expansions that can be attributed to higher education activities such as extension, business counseling, technology transfer and collaborative research projects, nor does it attempt to capture business creation, relocations and expansions due to the availability of more skilled workers and research and development activities. New businesses started by college and university alumni are similarly not counted.

Lastly, the study does not attempt to estimate the economic effects resulting from additional regional amenities. These amenities would include "creative class" lifestyle amenities associated with college communities that are an important factor in attracting and retaining a skilled workforce as well as some retirees. Such amenities include community design characteristics, university services such as visual and performing arts and a more open, tolerant, diverse and experimental cultural milieu.

Table 2.2 shows the specific sources used to compute input data. The U.S. Department of Education's Integrated Post-secondary Education Data System (IPEDS) database serves as the main source of data. IPEDS collects information through annual surveys of institutional characteristics, student expenses, awards, enrollments, employee characteristics, and financial characteristics. Supplemental financial information not available from IPEDS was obtained from Comprehensive Annual Financial Reports (CAFR) for each institution. Detailed enrollment and degree level information by place of residence was obtained from the State Council on Higher Education in Virginia's (SCHEV) website. Information on student and visitor expenditures was imputed using information from a survey of students conducted as part of a University of Virginia impact study (Knapp and Shobe 2007) and visitor expenditure information from the Virginia Tourism Council (2021). University startup data was obtained from university technology transfer offices and matched with confidential enterprise-level employment data obtained from the Virginia Employment Commission's Quarterly Census of Employment and Wages (QCEW).

This study largely replicates the methodology and utilizes most of the same data sources as the last Virginia public higher education study (Rephann 2017). **Appendix A.3** describes in detail how each data element was assembled in order to use for input in the REMI PI+ model.

Table 2.2 REMI PI+ Model Input Data Sources

Category	Data Sources
Employment	IPEDS employees by assigned position; Medical Center employment from UVA and VCU
Employee compensation	Comprehensive Annual Financial Reports by Institution; University of Virginia Physicians Group; VCU Medical Center
Capital expenditures	Comprehensive Audited Financial Reports by Institution; University of Virginia Physicians Group
Student expenditures	IPEDS institutional characteristics; IPEDS employees by assigned position; Survey data from Knapp and Shobe UVA impact study (2007)
Visitor expenditures	Virginia Tourism Corporation
Graduate earnings	IPEDS completions; U.S. Census Bureau American Community Survey; National Center for Education Statistics (SOC/CIP crosswalk), Bureau of Labor Statistics (Occupational Employment Projections by Educational Attainments and Occupational Employment Statistics)
Productivity	REMI, Inc. (Value-added to earnings ratios by industry)
University Startups	Data on university startups from university technology transfer offices and individual establishment employment records from the Virginia Employment Commission Quarterly Census of Employment and Wages (QCEW)

SECTION 3: ECONOMIC FOOTPRINT ANALYSIS

This section reports the results of three analyses of Virginia public higher education. The results indicate that there are substantial positive short-term and long-term economic effects for the commonwealth regardless of how public higher education activities are measured. A full accounting of public higher education related expenditures, graduate workforce participation, and university startup employment results in an estimated 188,379 jobs, a total gross domestic product effect of $52.411 billion, and $3.874 billion in state revenues. When state appropriations, grants and contracts to public higher education are compared to the state revenues and economic activity generated, results indicate that every dollar spent by the state is associated with an additional $1.89 in state revenue and an increment of $25.59 of Virginia gross domestic product.

Following the terminology used by the previous Virginia public higher education studies and other economic impact studies, the term "economic footprint" is used to denote the economic consequences of all activities related to public higher education.[11] An "economic footprint" analysis traces the gross economic activity that results from public higher education. It does not consider whether the funds used to generate higher education might have been used elsewhere in the economy to generate economic activity and gauge the comparative effect of that alternative activity. The term "export" is used to denote expenditures that are funded by monies that originate from outside the state. It is argued that expenditures that come from outside the state would not have occurred without the existence of public higher education. Therefore, export expenditures provide a more conservative estimate of the expenditure "economic impact" of public higher education.

This section consists of four parts. The first part presents the assumptions behind each analysis (or "scenario"). In the next three parts, the results of each scenario are discussed. The section concludes by commenting on the range of economic estimates provided and listing a few caveats for interpreting and comparing the results of these analyses.

Higher Education Simulation Scenarios

Three different higher education scenarios are presented (see **Table 3.1**) in order to examine different facets of public higher education's mark on the state economy. The analysis attempts to answer several questions. First, what overall effect do all the activities associated with the higher education sector have on the Virginia economy? Second, what is the economic effect of publicly funded higher education most closely connected to current operations in the areas of education, research, and public service? Third, what is the net contribution of Virginia public higher education? By this is meant, what does Virginia public higher education add in the form of expenditures that are new to the state, the productivity of graduates who remain in the state workforce, and from business startups?

[11] This previous Virginia public higher education studies reported FY 2007, (Rephann, Shobe, and Knapp 2009), FY 2011 (Rephann 2013) and FY 2015 (Rephann 2017) economic impact results.

The first, a so-called economic footprint analysis, examines the economic effect of university related inputs, regardless or source of funding, including hospital and capital expenditures. It also captures the effect of education on workforce earnings and productivity and the effect of university startups. The second scenario ("Current Higher Education Operations") is the same as the first except that capital and hospital expenditures are removed. Thus, the focus of this scenario is operational expenditures to support education, research, and public service activities of higher education. The third scenario ("Export") examines the net contribution of public higher education. Since expenditures derived from in-state sources (including state government, students, and donors) could have been spent elsewhere, they are not represented as an expenditure injection. This scenario includes only the portion of university payroll and procurement financing that can be attributed to out-of-state sources. For all three scenarios, the effect of the earnings and productivity of resident graduates who join the Virginia workforce and effect of university startups is captured.

In order to summarize and compare the results of these alternative scenarios, the economic effects over time are converted to present values and summed. Present value indicates the value now of dollars that accrue in the future. Dollars received in the future are worth less than dollars received today. Therefore, they are deflated by a discount rate that is assumed to be three percent. This real discount rate reflects the public/social cost of funds.[12]

Economic activity is represented by several variables including: (1) employment, (2) value added, (3) industrial output, and (4) personal income. Employment includes full-time and part-time workers and the self-employed and is measured by place-of-work rather than place-of-residence. Industrial output reflects the total value of industry production during a period, including the value of intermediate input purchases. Value-added reflects only the value of production for final demand and is measured by gross domestic product (GDP). All values are expressed in terms of 2021 dollars. In addition, state revenue is included as a state fiscal measure. It is compared to state public higher education spending for the purpose of computing a rate of return for state funds. State revenues are calculated at state average rates using the ratio of selected state revenues (i.e., taxes, miscellaneous revenues, liquor store revenue, and insurance trust revenue reported in the U.S. Census Bureau's State Government Finances report) to personal income for FY 2021.

[12] It is also similar to those used in other educational impact and benefit cost studies that report present values (Bartik, Hershbein and Lachowska 2016; EMSI 2013).

Table 3.1 Assumptions Behind Scenario Model Runs

Item	*Scenario 1* Economic Footprint: All Operations	*Scenario II* Economic Footprint: Current Higher Education Operations	*Scenario III* Exports
Institution spending	All	All	Out-of-state
Hospital spending	All	None	None
Student spending	Full-time in-state for four-year and out-of-state full-time for all institutions	Full-time in-state for four-year and out-of-state full-time for all institutions	Out-of-state full-time
Visitor spending	Out-of-state	Out-of-state	Out-of-state
Capital spending	All	None	None
Graduate Earnings	In-state with outmigration and retirement after 30 years	In-state with outmigration and retirement after 30 years	In-state with outmigration and retirement after 30 years
Productivity	In-state with outmigration and retirement after 30 years	In-state with outmigration and retirement after 30 years	In-state with outmigration and retirement after 30 years
University Startups	In-state	In-state	In-state

Economic Footprint and Impact Analysis

Results indicate that the economic footprint of Virginia public higher education activities are substantial. During the first year, 2021, when the expenditures are made, the economic effect is over $15.7 billion in GDP. This result represents the expenditure-related effect. The effect of higher education operations from 2021 falls to $2.4 billion the following year when the expenditures are discontinued under the simulation and in-state graduates are added to the Virginia workforce. At that point, the economic effects are attributable to the added earnings and productivity of the newly educated workforce. This result is called the human capital related effect. The additional economic activity decreases or increases in any given year thereafter depending on whether the added earnings with growing work experience through much of the graduates' work life outweighs

the effect of earnings and productivity losses to the commonwealth that occur because of graduate outmigration from the state. The human capital becomes zero in year 2052 when all graduates are assumed to have retired from the workforce.

Figure 3.1 illustrates the cumulative present value GDP impact by year. It shows that when the discounted values are added up over a 31-year period, the total GDP effect is over $52 billion. **Table 3.2** divides the economic variables into expenditure, human capital and university startup related components. The present value of expenditure and university startup-related GDP effect is $15.720 billion, human-capital related effect is $36.502 billion, and university startup effect is $209 million. The total economic footprint attributable to Virginia public higher education for the period of analysis is $52.431 billion. Virginia's GDP in FY 2021 was $579.598 billion.[13] Therefore, the expenditure effect accounts for 2.72 percent of GDP. The human capital effect would represent 6.31 percent, and the university startup effect would constitute 0.04 percent of GDP. The total effect is 9.06 percent. The expenditure related employment effect is 186,600 and the university startup employment effect is 1,779. This amounts to 3.53 percent and 0.03 percent respectively of estimated FY 2021 Virginia employment of 5,287,886 for a total effect equivalent to 3.56 percent (or roughly 1 in 28 Virginia jobs).[14,15] The present value of state revenues generated by public higher education activities during the FY21 year is $3.874 billion.

[13] Bureau of Economic Analysis. 2022. Quarterly Gross Domestic Product by State, 2022. https://www.bea.gov/data/gdp/gdp-state (Accessed June 2, 2023).

[14] Bureau of Economic Analysis. 2022. State Annual Personal Income and Employment. https://www.bea.gov/data/employment/employment-by-state (Accessed December 28, 2016). FY 2021 employment is estimated as average of 2020 and 2021 calendar year employment figures.

[15] In FY 2015, the public higher education employment economic impact was 167,277 (Rephann 2017). For comparison purposes, this figure represented just 3.3 percent of an estimated 5,005,693 jobs statewide in FY 2015.

Figure 3.1 Cumulative Present Value of Economic Footprint on Virginia GDP, By Year

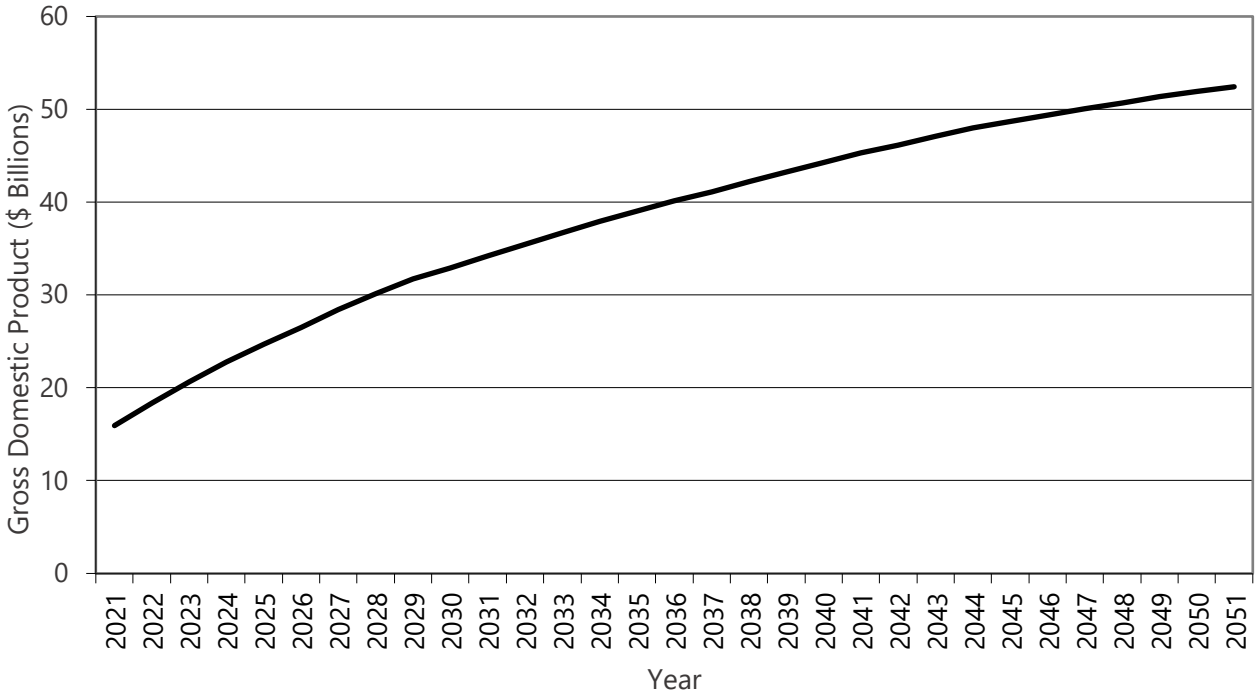


Table 3.2 Economic Footprint of Virginia Public Higher Education (Dollar Denominated Values Expressed in Present Value, Billions of 2021 Dollars)

Economic Variable	Expenditure Related	Human Capital Related	University Startup Related	Total
GDP	15.720	36.502	0.209	52.431
Industrial output	26.016	59.129	0.331	85.476
Personal income	12.371	27.461	0.135	39.968
State revenues	1.199	2.662	0.013	3.874
Employment	186,600	N/A	1,779	188,379

N/A=not available

Approximately 70 percent Virginia's public higher education GDP economic footprint can be attributed to human capital impacts that take place over a long-run time horizon (see **Figure 3.2**). Around 30 percent is accounted for by higher education expenditures. Less than one percent depends on university startups. This result suggests that focusing on the short-term impacts of higher education expenditures, as most studies do, dramatically understates the true economic contribution of higher education. When the expenditure effect for GDP is disaggregated (see **Figure 3.3**), almost half of the economic effect can be traced to higher education payroll and other

outlays. Another twenty-nine percent can be attributed to hospital activity at VCU and UVA. Fourteen percent is accounted for by student expenditures and the remainder, seven percent and one percent respectively, to capital and visitor expenditures.

Figure 3.2 Source of Economic Footprint

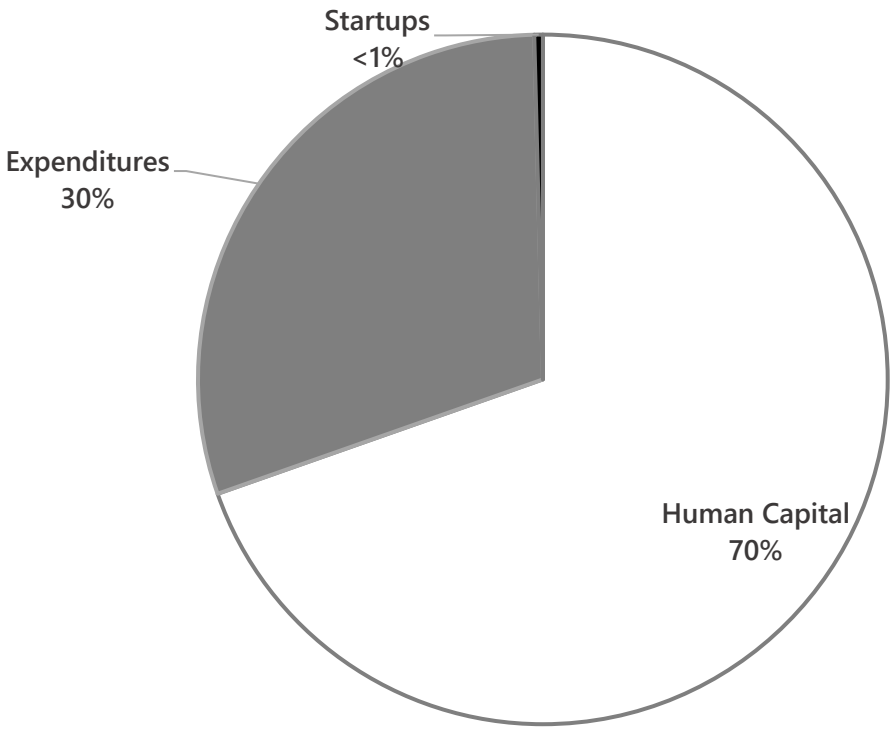


Figure 3.3 Source of Expenditure-related Economic Footprint

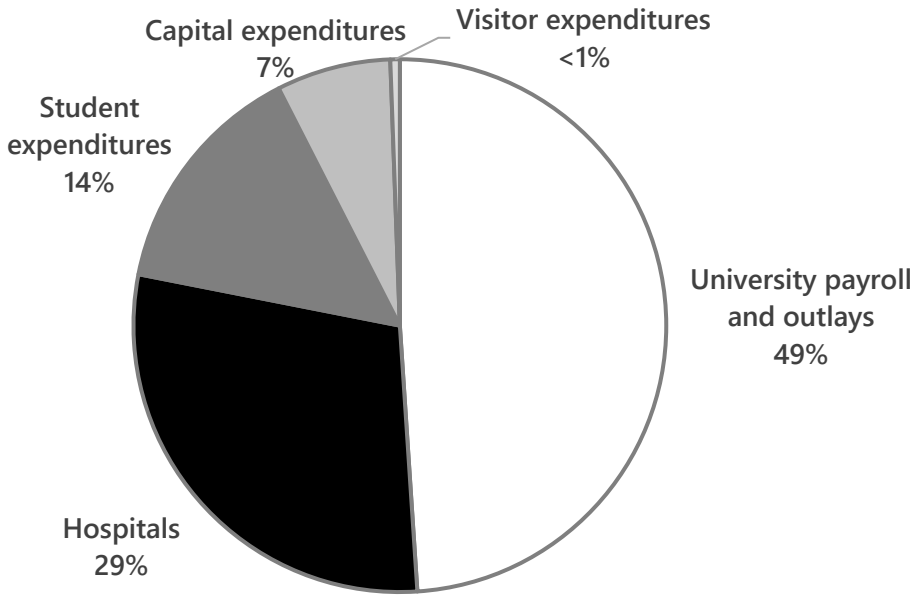


Table 3.3 provides another breakdown by expenditure function and funding source. It shows that the medical centers at Virginia Commonwealth University and the University of Virginia make a sizeable contribution to Virginia's economy. Together they account for 45,626 jobs, $4.581 billion in GDP, and $356 million in state revenues. Higher education research activities are responsible for almost 13,510 jobs, $1.015 billion in GDP, and $96 million in state revenues. An estimated fifty-four percent of these higher education research funds are derived from out-of-state sources, primarily the federal government.[16] Out-of-state students are also a source of substantial economic stimulus. Economic activity attributable to out-of-state students through the effect of tuition revenues, student expenditures on state goods and services and student visitor expenditures totals 18,425 jobs, $1.493 billion in GDP, and $106 million in state revenues.

Comparison of Scenarios 1, 2, and 3

Table 3.4 shows the results of all three economic impact scenarios. The second scenario, which removes hospital and capital expenditures, shows an expenditure effect of $10.049 billion for GDP and 130,001 for employment. The present value of the effect on GDP, including expenditure. human capital, and university startup components, is $46.759 billion. $36.502 billion of this effect or

[16] A breakdown of research funding by geographical origin was not available from the IPEDS Finance data. Therefore, data from the National Science Foundation (2021) were used to estimate the portion of expenditure derived from out of state. Funds from the federal government, industry, and nonprofit foundations are counted as out-of-state. Institutional funds may also depend on endowment income that is largely derived from out-of-state donors. But no attempt was made to apportion these funds by geographical origin, and they are counted entirely as in-state contributions.

78 percent of the total is human capital related. In addition, these activities generate $3.452 billion in total state revenue.

According to IPEDS, state appropriations combined with state grants and contracts were $2.049 billion in FY 2021. The state general fund appropriation was $2.015 billion, which includes operating support, student financial assistance, and assistance for sponsored programs. State grants and contracts, which include revenues for training programs, research contracts and the like, make up the remaining $34 million. Although state appropriations for operating support provide the most accurate figure for computing tuition amounts, total state payments are used as a measure of general state support for public higher education activities. Using this measure, every dollar that the state spends on public higher education is associated with an additional $1.89 in state revenue and an increment of $25.59 to Virginia gross domestic product for all operations. If one focuses on just state appropriations, these leveraging figures for each dollar of support are $1.92 for state revenue and $26.02 for GDP. Alternatively, if the focus is restricted to current higher education operations (subtracting hospitals and capital spending), public higher education is associated with an additional $1.68 in state revenue and $22.82 of incremental gross domestic product for all state support and $1.71 in state revenue and $23.21 for GDP for state appropriations.

Another way of representing the effectiveness of the state's investment in public higher education is the internal rate of return (IRR) for state funds. The internal rate of return for state funds is the discount rate (r) that equates the present value of all tax revenue flows to the amount of state support for public higher education. This rate provides the yield on state spending in terms of state revenues received over the 31-year time horizon used to compute present values (i.e., the initial year of 2021 when higher education spending occurs and the subsequent 30 years when graduates participate in the state workforce). The IRR for state appropriations and grants and contracts is 7.8 percent for current higher education operations. If one focuses on just state appropriations for operating support, the IRR increases to 8.1 percent.

The third scenario provides a conservative estimate of the economic activity that results from the presence of public higher education. Public higher education is different from some other state sponsored activities because money spent by the state attracts additional funds from outside the state in the form of federal grants and contracts, private gifts, spending by students who reside outside the state, and visitor spending. The funds are "new" to the state. In effect, state public higher education exports these services. Table 3.3 indicates that the expenditures of these funds results in an economic impact approximately equal to $3.039 billion in GDP or 39,340 jobs. The state revenue effect is $240 million. The total economic effect resulting from human capital improvements is equivalent to $36.502 billion, contributing to a total economic effect of $39.749 billion for this scenario.

Table 3.3 Breakdown of Economic Footprint by Function and Source (Dollar Denominated Values Expressed in Present Value, Billions of 2021 Dollars)

	GDP	Industrial output	Personal income	State revenues	Employ-ment
Human capital effect	36.502	59.129	27.461	2.662	N/A
University Startups	0.209	0.331	0.135	0.013	1,779
Total expenditures effect	15.720	26.016	12.371	1.199	186,600
• Capital	1.091	1.950	0.675	0.065	10,973
• Hospitals	4.581	8.130	3.677	0.356	45,626
• Research	1.015	1.594	0.993	0.096	13,510
o Portion attributable to out-of-state funds	0.546	0.858	0.536	0.052	7,264
• Other institutional expenditures	6.680	10.424	5.974	0.579	90,660
o Portion attributable to out-of-state student tuition	0.855	1.340	0.806	0.078	11,461
o Portion attributable to other out-of-state funds	0.999	1.556	0.846	0.082	13,651
• Student expenditures	2.263	3.765	1.002	0.097	24,635
o Portion attributable to out-of-state students	0.548	0.909	0.238	0.023	5,769
• Visitor expenditures	0.090	0.153	0.050	0.005	1,195
Total attributable to out-of-state revenues	**3.039**	**4.815**	**2.475**	**0.240**	**39,340**

Table 3.4 Economic Effects of Virginia Public Higher Education by Scenario (Dollar Denominated Values Expressed in Present Value, Billions of 2021 Dollars)

Economic Variable	Scenario I	Scenario II	Scenario III
Expenditure			
GDP	15.720	10.049	3.039
Industrial output	26.016	15.936	4.815
Personal income	12.371	8.019	2.475
State revenues	1.199	0.777	0.240
Employment	186,600	130,001	39,340
Human Capital			
GDP	36.502	36.502	36.502
Industrial output	59.129	59.129	59.129
Personal income	27.461	27.461	27.461
State revenues	2.662	2.662	2.662
Employment	N/A	N/A	N/A
University Startups			
GDP	0.209	0.209	0.209
Industrial output	0.331	0.331	0.331
Personal income	0.135	0.135	0.135
State revenues	0.013	0.013	0.013
Employment	1,779	1,779	1,779
Total			
GDP	52.431	46.759	39.749
Industrial output	85.476	75.396	64.275
Personal income	39.968	35.616	30.071
State revenues	3.874	3.452	2.915
Employment	188,379	131,780	41,119

One might ask how much of the human capital economic effect is a true "economic impact." That is to say, how much of the effect would be lost to Virginia's economy if Virginia's public higher education system were eliminated. One way to answer this question is to estimate the percentage of resident students who would be able to receive education in private institutions or outside Virginia if publicly funded institutions were not available in the state. Based on calculations reported in the 2013 report (Rephann 2013), 64.4 percent of Virginia resident students would not attend college in the absence of Virginia public higher education.[17] Assuming that the non-attendees are representative of graduates, this percentage would translate into the loss of $23.507 billion in GDP and $1.714 billion in state revenue in terms of present value. The commonwealth would see total losses of $26.546 billion in GDP and $1.954 billion in state revenue.

The actual loss would likely be much more severe than this exercise suggests because some resident students would elect to attend school elsewhere outside the state. This exodus would result in the leakage of tuition dollars, student expenditures on goods and services, and federal/private support associated with student enrollments to other states. In addition, research indicates that college graduates who attended college outside the state from where they graduated from high school are less likely to return to their home states after graduation (Adelman 2004; Tornatzky et al. 2001). Therefore, the state would experience a loss of earnings over time and productivity as well.

Conclusion

This section provides a range of estimates of the economic influence of Virginia's public higher education sector. Using the broadest estimate based on an "economic footprint" analysis that considers the economic effects of all activities related to public higher education, one may conclude that the Virginia higher education system's presence is associated with over $52 billion in gross domestic product and approximately $3.9 billion in state revenue in terms of present value. In the most conservative scenario that counts only the expenditures of out-of-state students, $39.7 billion in GDP and $2.9 billion in state revenue can be attributed to Virginia public higher education. Regardless of the scenario selected, the economic impact of public higher education is substantial. These results demonstrate that the state's public colleges and universities are an economic asset that produces higher incomes, increased output, more jobs, and additional state tax revenues.

It is important to emphasize that the estimates provided here do not capture many other ways in which higher education affects economic activity. As previously discussed, the study makes only a limited a limited effort to capture spending connected with higher education foundations and college related visitations and tourism. It does not measure the economic impacts of publicly supported higher education entities such as the Eastern Virginia Medical School and operations of

[17] This percentage was computed using an estimated regression equation reported in Economic Modeling Specialists, International (EMSI) (2013) for the purpose of determining service area students who would have received higher education with the closure of public institutions and Virginia data.

the five state supported higher education centers. It also does not gauge the economic impact of closely related enterprises. Examples of such enterprises are firms for which universities have partial or full equity ownership such as ambulatory care and laboratory service businesses connected to the UVA and VCU Health Systems. The study also does not attempt to estimate the economic earnings and productivity gains for college non-completers, credit diploma and certificate programs recipients, or non-credit continuing education, contract training, and adult basic education participants. Although this study does measure the economic effects of university startups, it does not capture the effects of a much larger universe of university spinoff activity including student, faculty, and alumni businesses created without benefit of university-licensed technology. It also does not include the economic effects of university R&D and entrepreneurship resources on existing firm productivity and entrepreneurial abilities. Finally, the estimates do not capture other beneficial aspects of higher education such as increased state amenities, improved health, lower reliance on social services and welfare, and decreased likelihood of committing crimes and burdening the criminal justice system.

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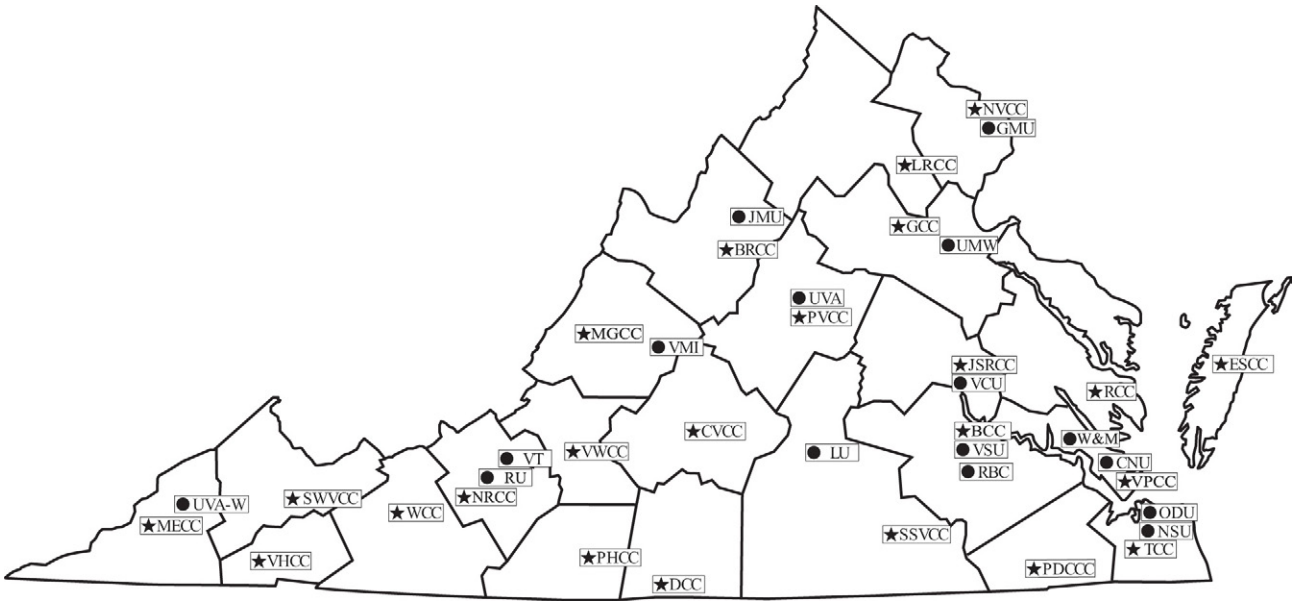
APPENDIX A.1: Map of Virginia Public Higher Education Institutions by Principal Location



KEY TO ABBREVIATIONS

Four-year Public Institutions

CNU	Christopher Newport University
GMU	George Mason University
JMU	James Madison University
LU	Longwood University
NSU	Norfolk State University
ODU	Old Dominion University
RU	Radford University
UMW	University of Mary Washington
UVA	University of Virginia
UVA-W	University of Virginia's College at Wise
VCU	Virginia Commonwealth University
VMI	Virginia Military Institute
VSU	Virginia State University
VT	Virginia Tech
W&M	William & Mary

Two-year Public Institutions

RBC	Richard Bland College

Virginia Community College System

BRCC	Blue Ridge Community College
BCC	Brightpoint Community College
CVCC	Central Virginia Community College
DCC	Danville Community College
ESCC	Eastern Shore Community College
GCC	Germanna Community College
JSRCC	J Sargeant Reynolds Community College
LRCC	Laurel Ridge Community College
MECC	Mountain Empire Community College
MGCC	Mountain Gateway Community College
NRCC	New River Community College
NVCC	Northern Virginia Community College
PHCC	Patrick & Henry Community College
PDCCC	Paul D Camp Community College
PVCC	Piedmont Virginia Community College
RCC	Rappahannock Community College
SSVCC	Southside Virginia Community College
SWVCC	Southwest Virginia Community College
TCC	Tidewater Community College
VHCC	Virginia Highlands Community College
VPCC	Virginia Peninsula Community College
VWCC	Virginia Western Community College
WCC	Wytheville Community College

Appendix A.2: Virginia Public Higher Education Institutions

Institution	Main Campus Location	Fall 2020 Headcount[a]	Carnegie Classification[b]
FOUR-YEAR PUBLIC INSTITUTIONS		**223,711**	
Christopher Newport University	Newport News	4,868	Master's Colleges & Universities: Small Programs
George Mason University	Fairfax County	39,032	Doctoral Universities: Very High Research Activity
James Madison University	Harrisonburg	21,593	Doctoral Universities: High Research Activity
Longwood University	Farmville	4,841	Master's Colleges & Universities: Medium Programs
Norfolk State University	Norfolk	5,457	Master's Colleges & Universities: Medium Programs
Old Dominion University	Norfolk	24,286	Doctoral Universities: Very High Research Activity
Radford University	Radford	10,695	Doctoral Universities: Doctoral/Professional Universities
University of Mary Washington	Fredericksburg	4,293	Baccalaureate Colleges: Arts & Sciences Focus
University of Virginia	Charlottesville	25,642	Doctoral Universities: Very High Research Activity
University of Virginia's College at Wise	Wise	1,906	Baccalaureate Colleges: Arts & Sciences Focus
Virginia Commonwealth University	Richmond City	29,417	Doctoral Universities: Very High Research Activity
Virginia Military Institute	Lexington	1,698	Baccalaureate Colleges--Arts & Sciences Focus
Virginia State University	Petersburg	4,020	Master's Colleges & Universities: Medium Programs
Virginia Tech	Blacksburg	37,024	Doctoral Universities: Very High Research Activity
William & Mary	Williamsburg	8,939	Doctoral Universities: High Research Activity

Institution	Main Campus Location	Fall 2020 Headcount	Carnegie Classification[b]
TWO-YEAR PUBLIC INSTITUTIONS		**153,075**	
Virginia Community College System		**150,761**	
Blue Ridge Community College	Weyers Cave	3,462	Associate's Colleges: High Transfer-Mixed Traditional/Nontraditional
Brightpoint Community College	Chester	9,440	Associate's Colleges: High Transfer-High Nontraditional
Central Virginia Community College	Lynchburg	3,370	Associate's Colleges: High Transfer-High Nontraditional
Danville Community College	Danville	2,411	Associate's Colleges: Mixed Transfer/Career & Technical-High Nontraditional
Eastern Shore Community College	Melfa	677	Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional
Germanna Community College	Locust Grove	7,680	Associate's Colleges: High Transfer-Mixed Traditional/Nontraditional
J. Sargeant Reynolds Community College	Richmond City	7,759	Associate's Colleges: High Career & Technical-High Nontraditional
Laurel Ridge Community College	Middletown	6,337	Associate's Colleges: High Career & Technical-High Nontraditional
Mountain Empire Community College	Big Stone Gap	2,253	Associate's Colleges: Mixed Transfer/Career & Technical-High Nontraditional
Mountain Gateway Community College	Clifton Forge	1,075	Associate's Colleges: High Transfer-High Nontraditional
New River Community College	Dublin	4,137	Associate's Colleges: Mixed Transfer/Career & Technical-High Nontraditional
Northern Virginia Community College	Annandale	52,869	Associate's Colleges: High Transfer-Mixed Traditional/Nontraditional

Institution	Main Campus Location	Fall 2020 Headcount	Carnegie Classification[b]
TWO-YEAR PUBLIC INSTITUTIONS		**153,075**	
Virginia Community College System		**150,761**	
Patrick & Henry Community College	Martinsville	2,050	Associate's Colleges: High Transfer-Mixed Traditional/Nontraditional
Paul D. Camp Community College	Franklin City	1,237	Associate's Colleges: High Transfer-High Nontraditional
Piedmont Virginia Community College	Charlottesville	4,864	Associate's Colleges: High Transfer-High Nontraditional
Rappahannock Community College	Glenns	2,629	Associate's Colleges: High Transfer-High Nontraditional
Southside Virginia Community College	Alberta	3,123	Associate's Colleges: High Transfer-High Nontraditional
Southwest Virginia Community College	Richlands	2,295	Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional
Tidewater Community College	Norfolk	16,769	Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional
Virginia Highlands Community College	Abingdon	2,086	Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional
Virginia Peninsula Community College	Hampton	6,256	Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional
Virginia Western Community College	Roanoke City	5,738	Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional
Wytheville Community College	Wytheville	2,244	Associate's Colleges: High Transfer-High Nontraditional

Institution	Main Campus Location	Fall 2020 Headcount	Carnegie Classification[b]
TWO-YEAR PUBLIC INSTITUTIONS		**153,075**	
Richard Bland College	**Petersburg**	**2,314**	**Special Focus Two-Year: Other Fields**

Source: State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/E2_Report.asp
Carnegie Foundation for the Advancement of Teaching. http://classifications.carnegiefoundation.org/resources/

a. Includes both undergraduate and graduate enrollment.

b. 2021 Carnegie Classification by the Carnegie Foundation.

APPENDIX A.3: Description of Data

Employment and Compensation

The data on employment is derived primarily from the IPEDS Employees by Assigned Position (EAP) Survey. This survey does not capture short-term temporary staff, staff whose services are contracted, or undergraduate students who are employed. It also does not report employment in university component units such as the UVA Physicians Group and VCU Health System. Therefore, supplemental employment information on university hospital employment was obtained from the UVA Institutional Assessment and Studies Department and the VCU Office of Institutional Research and Decision Support. College and university employment was assigned to the educational services industry employment (exogenous production) policy variable in REMI PI+ while the UVA and VCU Health System employment was assigned to the hospitals employment policy variable.

Employee compensation data (salaries and wages plus fringe benefits) was obtained from the Expenses by Natural Classification table published in the Notes to Financial Statements for institutional Comprehensive Annual Financial Reports (CAFRs).[18] Supplemental information on medical school compensation was obtained from UVA Physicians Group and VCU Health System and other unpublished institutional; tables were obtained from the financial reporting staff at Christopher Newport University, William & Mary, and the University of Virginia. Salaries and wages and employee fringe benefits assigned to auxiliary services were not included to avoid a double counting of expenditures. Expenditures on auxiliary services (e.g., bookstore, dining services) will already be largely reflected in student and visitor expenditures and in the multiplier effect of faculty and staff wages and salaries (since faculty and staff often spend their earnings at university dining and other auxiliary service facilities). Since the employee compensation for higher education activities (educational services and hospitals) was above the state industry averages, the REMI PI+ policy variable compensation variable was adjusted (compensation with exogenous employment) to increase the compensation for the economic impact simulation. College and university compensation increment over the expected value based on the educational services industry average was assigned to the REMI PI+ compensation policy variable. The same adjustment was done for UVA and VCU Health System compensation for the hospitals' compensation policy variable.

[18] This information was previously available from the Part C ("Expenses and Other Deductions") of the IPEDS Finance survey. However, since the last study, the format of the data submission changed and faculty and staff benefits were no longer disaggregated by function, meaning that hospital and auxiliary services benefits could not be separated from other functional classifications for use in this study to segregate these activities for the purpose of economic impact analyses.

Capital Expenditures

Capital expenditure data was obtained from tables describing changes in various capital asset categories derived from institutional CAFRs. Most of these were obtained from the Virginia Auditor of Public Accounts website. Supplemental information on component units' capital expenditures was obtained from the UVA Physicians Group and VCU Health System and from the Finance Departments of the University of Virginia (to disaggregate UVA—Main Campus and UVA-Wise capital expenditures) and William & Mary (to disaggregate William & Mary and Richard Bland College capital expenditures). Construction expenditure from these sources was counted as additions to infrastructure and buildings. Additions to equipment, software, and books and art were also entered into the model. Construction expenditures were entered as "industry sales" in REMI for the construction sector. For the remaining capital categories, only wholesale margins were counted. That is to say, it was assumed that the equipment, software, books, and art were purchased through state-based wholesale vendors but that the actual capital items were manufactured and shipped from outside the state. These wholesale margins were estimated as 7.2 percent of the purchase price for books and art, 8.3 percent for equipment, and 18.2 percent for software. These wholesale margins were obtained from IMPLAN® input-output software for the "book publishers," "institutional furniture," and "software publishers" industries, which were assumed to be representative of these capital purchase categories. The computed wholesale margins were assigned as wholesale trade firm sales in REMI PI+.

Student Expenditures

Student expenditures input data are based on IPEDS Institutional Characteristics (IC) data and student expenditure data from a University of Virginia economic impact study (Knapp and Shobe 2007). The raw UVA student survey data was re-tabulated to make it appropriate for use in this study. Student expenditures were adjusted for regional cost of living differences using total student expense for freshman students obtained from Part D ("Student Charges-Price of Attendance") of the IPEDS Institutional Characteristics Survey. These expenses included "room and board," "books and supplies," and "other expenses." For institutions not reporting on-campus charges, off-campus (not with family) charges were used. These totals were multiplied by the consumer expenditure pattern from the UVA survey for undergraduates to obtain undergraduate student spending by category. Student expenditure totals for undergraduates were multiplied by a factor of 1.3 (representing the factor by which UVA graduate student spending exceeds undergraduate spending on average) and multiplied by the consumer expenditure category pattern for UVA graduate students.

In order to obtain total student expenditures, institutional enrollment counts by residency for undergraduate and graduate/professional categories were obtained from the State Council for Higher Education in Virginia. The undergraduate headcounts, excluding in-state two-year college students and all part-time students at public higher education institutions, were

multiplied by the per student consumer expenditure by consumption category estimates. In-state two-year college students and part-time students were excluded from the calculation because these students are more likely to be permanent local residents or residents who have full-time or part-time jobs. Education for many of these students is likely to be a secondary rather than primary activity. Removing part-time students will also reduce problems associated with the growing number of out-of-state resident distance teaching students who do not actually reside in Virginia.

In order to avoid double counting of university payroll expenditure effects, graduate students employed by universities as graduate assistants were excluded from the student expenditure calculations. Information on graduate assistant employment by institution was obtained from the IPEDS Employees by Assigned Position (EAP) Survey. The total student expenditures were entered into the model as consumer spending by the 75 REMI consumer expenditure categories.

Visitor Expenditures

Visitor expenditures are estimated using University of Virginia student survey data and data on traveler expenditures from Virginia Tourism Corporation's FY 2021 Profile of Travel in Virginia. The student survey provided estimates of the number and length of stay of student visitors from the UVA student survey. This information was found to be comparable to the results of a student survey reported in other recent economic impact studies conducted by Longwood University, George Mason University, and Virginia Commonwealth University. The UVA survey estimated 9.2 visits per student and an average length of stay of 2.4 days, which computes to 22 visitor days. These UVA visitor estimates are multiplied by the number of out-of-state students and an average visitor expenditure of $106.09 from the Virginia Tourism Corporation to obtain total visitor expenditures. The total expenditure was entered as a REMI PI+ tourism spending policy variable for non-residents.

Graduate Earnings and Productivity

In order to estimate the contribution of human capital additions to the Virginia economy, two REMI PI+ policy variables were adjusted: compensation by industry attributable to the greater earnings of graduates who enter the Virginia workforce and labor productivity entered into the model as an exogenous increase in production without employment, investment, and compensation policy variable.

In order to approximate the number of graduates likely to enter and be retained in the Virginia workforce, a number of assumptions were made. First, it was assumed that all out-of-state resident graduates (approximately 19 percent of the total) leave Virginia. Only in-state graduates are assumed to enter the Virginia workforce. Next, this stock of graduates by degree level is reduced each year by an outmigration rate for Virginia residents based on age and degree-

level.[19][20] These outmigration rates from Virginia were computed using 2017-2021 U.S. Bureau of the Census American Community Survey Public Use Microdata. Graduates are assumed to graduate at age 30. Outmigration rates for 30 year olds are applied to the first post-graduation year, 31 year olds for the second post-graduation year, etc. Graduates are assumed to retire at age 65, meaning an average work life of 30 years. This number is generally smaller than recent estimates of work life expectancies for college-educated individuals and will impart a conservative bias to the results (Skoog, Ciecka, and Krueger 2019). The increased earnings and productivity due to these graduates to the Virginia economy begin in 2022. Therefore, aggregate estimates of earnings and productivity added to the Virginia economy decrease each year in real dollars and cease in the year 2052. All estimates of earnings and productivity are reduced by 10 percent to reflect the influence of "ability bias" on the earnings and productivity differences between degree earning and non-degree residents.

Graduate earnings gains were assigned to industries used in the REMI PI+ model in a series of steps. First, the graduates by degree type according to the Classification of Instructional Program (CIP) were tied to Standard Occupational Categories (SOC) using a degree-occupational crosswalk (2018 Standard Occupational Classification Crosswalk to 2020 Classification of Instructional Programs) obtained from the National Center for Education Statistics (2023). Second, the degrees were assigned to particular occupations based on degree weights from Bureau of Labor Statistics Employment Projections, Educational attainment for workers 25 years and older by detailed occupation (2018-19) published as part of the 2021 National Employment Matrix (Bureau of Labor Statistics 2022a). Third, the graduates by 3-digit SOC Code occupational groups and degree level were multiplied by the corresponding mean earnings differentials[21] observed between baseline high school graduate earnings (for associate's and bachelor's graduates) and Bachelor's graduate earnings (for Master's and Doctoral degrees) and average earnings for the assigned 3-digit SOC Code occupational grouping, degree level and age to approximate the annual earnings increments that would occur as a result of obtaining the degree over the graduate's work life. For example, the

[19] The age and degree specific outmigration rates were used for this study because they capture the large variation in migration rates that occurs based on life cycle stage (with high young adult migration rates and lower middle-aged adult migration rates) and educational attainment (with graduate degree earners being more mobile than undergraduate degree recipients). An inverse relationship between age and migration is observed because younger cohorts have a longer period to receive the economic benefits of moving, and older cohorts experience higher "psychic" costs of relocating because of a greater accumulation of place-specific social capital (Ehrenberg and Smith 2006). A direct relationship between degree and migration rate is seen because higher educational attainment is associated with occupations that draw from a national market. Moreover, higher degree earners may be more skillful spatial job searchers.

[20] No allowance is made for return migration. Some research suggests that higher levels of educational attainment are associated with much lower risk of return migration because more educated migrants are less likely to make migration "errors" (DaVanzo 1983).

[21] Mean earnings were computed for individuals with and without earnings. Therefore, mean earnings differentials will capture both differences in earnings and differences in employment rates.

additional annual earnings for a nursing bachelor's degree would be the difference between a Virginia high school graduate average earnings and the average earnings for a Virginia resident with a Bachelor's degree employed in an occupation with three-digit SOC code of 291 (a subset of the 2-digit SOC code occupational category "healthcare practitioners and technical occupations"). This initial differential would widen over the graduate's work life based on the bow-shaped age-earnings profile of the respective degrees in a manner similar to Figure 2.1 reported in Section 2. This widening gap occurs because of the interaction between education and work experience, a subject first explored in depth by Mincer (1974) and represented by Mincer equations. Average earnings by degree-level and 3-digit SOC code were computed using 2017-2021 U.S. Bureau of the Census American Community Survey Public Use Microdata for Virginia. These earnings were multiplied by an inflation/deflation factor based on the age-earnings profile for the corresponding degree level to obtain earnings estimates for each year corresponding to a 30-year work span.[22] Fourth, occupational employment totals were assigned to NAICS (North American Industrial Classification System) industries using occupational-industry employment weights from Bureau of Labor Statistics Occupational Employment Statistics data (Bureau of Labor Statistics 2022b). The earnings totals were then assigned to the 70 REMI industry categories for each year (2022-2051) using the REMI compensation policy variable.

In order to generate input data for the productivity simulation, data for earnings and value-added by industry were obtained from the Virginia REMI PI+ model. Ratios of value-added per earnings were formed for each REMI industry. These ratios were then multiplied by the previously estimated graduate earnings by REMI industry to generate estimates of graduate output. The results by year were assigned to the REMI policy variable "Industry Sales/Exogenous Production without Employment, Investment, and Compensation" by REMI industry. This method is similar to that used in REMI Inc. (2008) in a study of Oklahoma Higher Education and the same as previous Virginia public higher education studies.

University Startups

Information on university business startups was provided by technology transfer offices at four universities that had active in-state startups (i.e., George Mason University, the University of Virginia, Virginia Commonwealth University, and Virginia Tech). The list of university startups created included firms that were started with university licensed technology as well as a few firms that were created with licenses that had expired and had been reissued to university faculty members in forming new business enterprises. The list was matched with enterprise records from Virginia Employment Commission Quarterly Census of Employment and Wages (QCEW) for the 2nd quarter of 2021. The enterprise employment size and reported North

[22] Another adjustment sometimes made in converting cross-sectional earnings profile to lifecycle earnings is to assume real earnings growth over time (Bartik, Hershbein and Lachowska 2016). This would increase the educational achievement absolute earnings gap. Such an adjustment is not made in this study and may impart a further conservative bias in the results.

American Industrial Classification System (NAICS) industry code were identified. Employment totals by NAICS code were then aggregated into the 13 REMI industry categories represented (i.e., support activities for mining; computer and electronic product manufacturing; electrical equipment and appliance manufacturing; chemical manufacturing; wholesale trade; retail trade; publishing industries except internet; insurance carriers and related; professional, scientific and technical services; administrative and support services; management of companies and enterprises; educational services; ambulatory health care services; and religious, grantmaking, civic, professional and similar organizations). The employment totals by REMI industry were assigned to the REMI policy variable "Industry Employment (Exogenous Production)."

State Revenues

Beginning in 2013, REMI, Inc. discontinued providing fiscal estimates as part of its PI+ software. The company developed a new, more versatile software package called REMI Tax-PI that incorporates a customizable fiscal model to estimate state revenues and expenditures and allows users to incorporate dynamic economic-fiscal feedbacks. Documentation of the methodology used in the previous version of REMI PI+ is provided in Regional Economic Models, Inc. (2011). State revenue calculations are based on U.S. Census Bureau State Government Finances data for 12 revenue categories and REMI PI+ data. Intergovernmental revenue, taxes, miscellaneous revenue, liquor store revenue and insurance trust revenue are counted as state revenues. State average revenue rates for census revenue categories were calculated using state economic base data such as state personal income (for most of the revenue categories), state population, and state demand for selected industries. Rates were calculated using FY 2021 revenue data (U.S. Census Bureau 2016) and REMI base fiscal year data estimated using an average of 2020 and 2021 calendar year data to estimate the fiscal year total. For this study, total revenue calculations excluded intergovernmental revenue. State revenue was calculated using a base of state personal income for all categories.

COVID-19 and Economic Impacts

The FY 2021 data period was partially influenced by the COVID-19 pandemic. The pandemic began to affect the U.S. in March 2020 and Virginia shortly thereafter. Federal and state shutdown orders were instituted in March 2020 and public higher education institutions limited operations, sent students home, moved coursework online, and took other safety precautions. During the 2020-21 academic year, many students returned to campus, but institutions established some safety restrictions, including enforcing social distancing regulations (e.g., limitations on the sizes of group gatherings), offering substantially more online and blended instructional opportunities, engaging in regular COVID-19 antigen testing, and later mandating student and faculty/staff COVID-19 vaccinations when they became available in the winter/spring of 2021.

The effect of COVID-19 is reflected in economic impact results reported here in some ways but not others. The COVID-19 pandemic may have had a negative effect on public higher education enrollment, particularly that of community college students and institutional spending. These effects are reflected in economic impact estimates since actual student enrollment and institutional expenditures are used. COVID-19 impacts were partly mitigated by federal government assistance programs. For example, the Coronavirus Aid, Relief, and Economic Security Act (CARES Act), passed by Congress on March 27, 2020, created a Higher Education Emergency Relief Fund (HEERF) that provided $14 billion to higher education institutions to support their operations during the pandemic. A second tranche of $21.2 billion of funds through HEERF was approved by in December 2020. These funds were allocated to public and nonprofit institutions, student grants, student loans, work-study programs, and other uses.[23]

COVID-19 likely had some effect on student and visitor spending, but this issue has not been studied in depth to date. Three separate types of data are suggestive of the effect of COVID-19 on the student experience. Two of the data elements are available from IPEDS Postsecondary (Finance and Fall enrollment reports). First, auxiliary services revenues can be consulted to ascertain the effect of campus sales of food service, lodging, books, and supplies. Revenues for these services fell by 22 percent from FY 2019 to FY 2021. Secondly, the number of students that institutions reported taking coursework exclusively online increased to 41 percent in Fall 2020 from 8 percent the year before. Some institutions also collect data on enrollment of students by place of residence (on campus or campus), which is suggestive of dips on the order of 10-20 percent in reported "on campus" enrollment (which may be measured differently by institutions). A cursory examination of institutional level data suggests varying institutional effects, possibly because of differences in institutional policies, mitigation strategies, and student composition (e.g., graduate and upper level undergraduate STEM student needs for clinical and lab based experiences).

In addition, COVID-19 had a profound effect on consumer spending and travel, particularly in the early months of the pandemic. When COVID-19 first emerged, many service businesses were closed and consumer sentiment plummeted. When conditions began to ease and social distancing regulations were relaxed in May 2020, consumer spending on retail goods and services began to recover, but spending had shifted from services in favor of goods purchases and many goods purchases were made online rather than in local stores. In addition, federal government stimulus payments helped to rev up consumer spending in the years after the first wave of the pandemic.

[23] According to data from the Pandemic Response Accountability Committee (PRAC) website at *https://www.pandemicoversight.gov/*, Virginia public higher education institutions received approximately $1.3 billion in funds from the federal government as part of all federal pandemic programs. Only a portion of this amount would be reflected in FY21 federal government funding for Virginia public higher education.

No change in the methodology for estimating student and visitor spending or economic impacts from previous studies were made for this study for three reasons. First, it is difficult to devise a methodology for adjusting the Virginia public higher education system (and individual institutions) spending inputs without more concrete information of the effect of the pandemic on student residency, student spending patterns, and visitor numbers. Second, the decision to treat student and visitor spending the same as previous studies is consistent with the methodologies of other higher education impact studies conducted for this period. These studies aim to provide an economic impact estimate that is representative of normal college operations. A review of several other studies conducted for public higher education institutions and systems for FY 2020 and FY 2021 found that they made no special allowances for the effect of COVID-19 on student expenditures and only a few instances where allowance was made to partly account for its impact on visitor expenditures, mainly by accurately tabulating falling event attendance (though some studies substituted earlier pre-pandemic attendance figures to illustrate a more representative activity level).[24] The final reason for not downwardly revising student and visitor expenditures is that the estimates already very conservatively estimate (or rather underestimate) these expenditures. Student expenditures rely on institutional spending estimates provided for financial aid purposes for fall/spring semester attendance and do not account for special session or summer attendance sessions. It is estimated that not accounting for special session/summer attendance underestimates student spending by 1-2 percent. Also, financial aid spending estimates likely understate actual student spending. For example, figures drawn from Knapp and Shobe (2007) estimates of University of Virginia undergraduate local spending in 2005 was $9,502 compared to financial aid total spending (local and nonlocal) estimates of $8,989 for the same year (i.e., financial aid figures represent just 94.6 percent of actual estimated spending). Lastly, visitor estimates rely on Virginia Tourism Corporation estimates that provide more conservative estimates of visitor expenditures, and also and also do not fully account for attendance for all university events (such as football games). For example, a recent William & Mary study (Lightcast 2023) estimated COVID-19 impacted FY 2020 visitor expenditures based on event data at $25 million compared to just $8 million estimated for William & Mary in FY21 for this study.

[24] They include three studies by Tripp Umbach (University of Pittsburgh, University of Nebraska System, and University of Missouri System), two studies by Lightcast (William & Mary and University of Illinois System) and studies conducted by higher education institutions for the University System of Georgia, the North Dakota University System, and the University of Colorado. The Tripp Umbach studies substituted FY 2019 event visitation figures for Covid-affected attendance fiscal years because they were more typical of normal conditions.