Study of the Growing Economic Impact of Virginia Public Higher Education

FOR THE VIRGINIA BUSINESS HIGHER EDUCATION COUNCIL

Terance J. Rephann, Ph.D.

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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 2015 is $36.122 billion in Virginia gross domestic product expressed in terms of 2015 dollars and 167,277 jobs. State public higher education each year accounts for $3.257 billion in long-term state revenue.

- Every dollar spent on public higher education by the state is associated with an additional $1.92 in state revenue and an increment of $21.32 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 36,752 jobs, $2.911 billion in GDP, and $265 million in state revenues.

- Research expenditures by higher education are responsible for nearly 10,165 jobs, $557 million in GDP, and $57 million in state revenues.

- An estimated 59 percent of higher education research funds are derived from out-of-state sources, primarily the federal government.

- University startups directly employed 750 workers at the end of FY 2015. The total economic impact of these firms was 1,584 full- and part-time jobs and $177 million in GDP. These enterprises generate an estimated $11 million in state revenues during the year.

- An estimated 30.5 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 $2.165 billion and 38,186 Virginia jobs for 2015. The state revenue effect is $203 million.

EXECUTIVE SUMMARY

This study, which is the third since 2009, analyzes the impact of public higher education on Virginia's economy using Fiscal Year (FY) 2015 data, the latest available. The previous two economic impact studies were conducted in 2009 and 2013, and examined FY 2007 and FY 2011 data, respectively.

Virginia's public higher education system plays a key role in providing educational access to citizens across the commonwealth. Thirty-nine public 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, 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 and university spending on employee payroll, supplies and services, and capital projects inject billions of dollars annually into the economy. Student and visitor spending on goods and services also generates significant economic activity. Most importantly, these institutions play a vital role in preparing the commonwealth's workforce and developing future community and business leaders. Of all degrees issued by higher education institutions in the state, Virginia's public colleges and universities award 73 percent of all associate's degrees, 65 percent of bachelor's degrees, 48 percent of master's degrees, and 63 percent of doctor's degrees. College graduates earn significantly more than high school graduates, and they improve the productivity of Virginia businesses. Also, 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, Regional Economic Models, Inc. Policy Insight Plus (REMI PI+), 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 this study of the economic impact of Virginia's public system of higher education for FY 2015 are:

- The total economic footprint attributable to Virginia public higher education operations in FY 2015 is $36.122 billion in Virginia gross domestic product, expressed in terms of 2015 dollars, and 167,277 jobs. State public higher

education each year accounts for $3.257 billion in long-term state revenue.

- The economic footprint of Virginia's public higher education system is larger than reported in the two previous studies - in both absolute and relative terms. The increase can be attributed to growth in the number of graduates, higher education and related services spending due to larger college and university budgets, and sizeable increases in hospital revenues and expenditures. A smaller portion of the increase is due to the inclusion of university startups, not accounted for in the two previous studies, as part of the public higher education economic footprint. This absolute and relative increase in economic footprint underscores the growing importance of public higher education to the Virginia economy.

- Every dollar spent on public higher education by the state is associated with an additional $1.92 in state revenue and an increment of $21.32 to Virginia gross domestic product. These figures experienced significant increases compared to the previous two studies. For 2011, the comparable figures were $1.29 in state revenue and $17.40 in GDP. In 2007, every dollar was associated with $1.34 in state revenues and $13.31 in GDP.

- The medical centers at Virginia Commonwealth University and the University of Virginia make significant contributions to the state economy. Together, they account for 36,752 jobs, $2.911 billion in GDP, and $265 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 10,165 jobs, $557 million in GDP, and $57 million in state revenues. An estimated 59 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 750 workers at the end of FY 2015. The total economic impact of these firms was 1,584 full- and part-time jobs and $177 million in GDP. These enterprises generate an estimated $11 million in state revenues during the year.

- An estimated 30.5 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 $2.165 billion and 38,186 Virginia jobs for 2015. The state revenue effect is $203 million. The expenditures associated with out-of-state students alone (i.e., tuition payments, student spending on goods and services, and visitor expenditures) generated 16,344 jobs $968 million in GDP, and $80 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. The study updates a study conducted four years ago (Rephann 2013), which was itself based on a prior comprehensive study (Rephann, Knapp, and Shobe 2009). The current study is based on new information made available since the last study and largely replicates the methodology used in the 2013 study. 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 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 the 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 close attention to the changes that have occurred since the last study. 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.

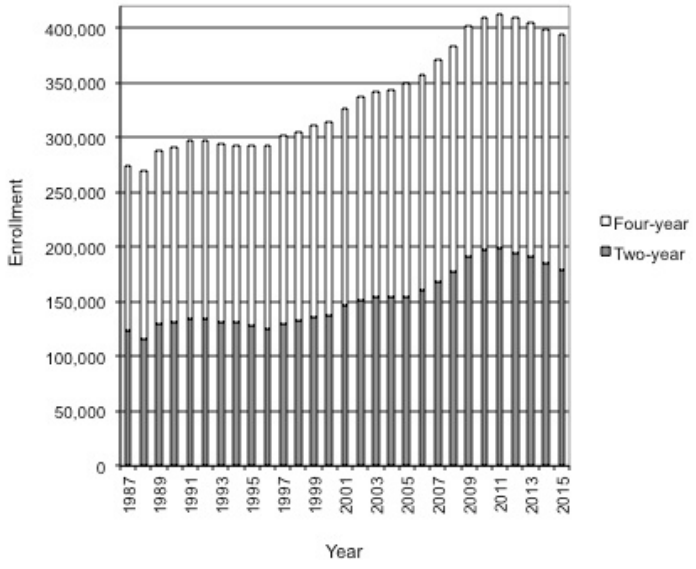
SECTION 1
VIRGINIA'S PUBLIC HIGHER EDUCATION SECTOR

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, and many offer coursework at one of the five state supported higher education centers found around the commonwealth (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). 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 has declined in recent years as the national economic recovery has taken hold and the size of high school graduate cohorts has plateaued. Enrollment shrank 4.7 percent from fall 2011 to fall 2015 compared to growth of 11.4 percent from fall 2007 to fall 2011. Two-year college enrollment decreased 9.9 percent compared to 0.1 percent growth at four-year colleges (see **Figure 1.1**). Community college enrollment typically follows a countercyclical pattern. As the economy improves, many potential students enter the job market due to the improved job opportunities (Betts and McFarland 1995). Whereas the national and Virginia unemployment rates were 8.9 percent and 6.6 percent respectively in 2011, they had declined to 5.3 percent and 4.4 percent by 2015, converging on levels associated with full employment. Moreover, the size of Virginia graduating high school cohorts (the principal source of new students) ceased to grow beginning in 2010-11. Declining fertility rates and slower net in-migration in many areas of the commonwealth have begun to shrink school enrollments. Thus, the number of graduating seniors has begun to decrease. Countering this trend to a small degree are higher high school graduation rates and a greater propensity for graduating high

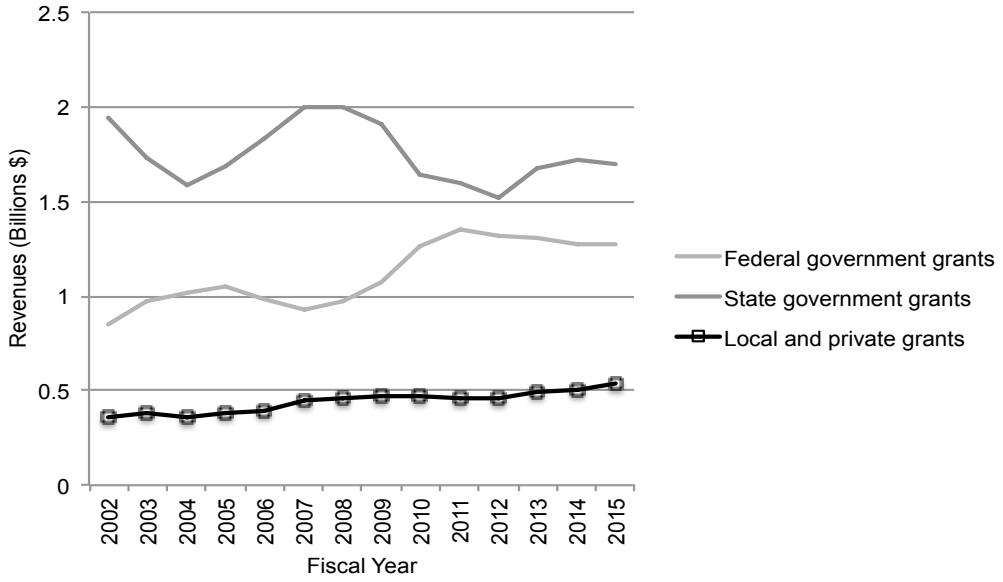
1 Virginia's public colleges and universities also operate numerous other off-campus clinical locations and agricultural or environmental research stations that conduct research, provide patient care, and offer educational experiences.

Figure 1.1 Virginia Public Higher Education Fall Enrollment, 1987-2015



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

Figure 1.2 Virginia Public Higher Education Operating and Non-operating Grant Revenues (Billions of 2015 Dollars) by Source, FY 2002-FY 2015



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

school seniors to enter college.[2] National and state studies continue to show that college education provides a superior rate of return on investment. The national unemployment rate during 2015 for a worker with a bachelor's degree education or higher was just 2.9 percent compared to 6.8 percent for a high school graduate.[3] Moreover, as will be shown in the next section, lifetime earnings for college-educated residents are much higher than high school graduates. Shifts towards a more service-based economy, technological changes including increased automation and globalization have also increased the importance of skills obtained from college education (Carnevale and Rose 2015). One study suggests that 74 percent of all jobs in Virginia will call for some level of postsecondary education by 2020 (American Institutes for Research 2016a).

State appropriations and grants in Virginia began to decline with the onset of the recent recession, but improved for the first time in FY 2013 and have stabilized since that time (see **Figure 1.2**).[4] On an FTE basis, real state appropriations and grants rebounded in FY 2013 as a result of increased appropriations and declining enrollment. They increased 8.5 percent from FY 2011 to FY 2015, but at $5,351 per FTE, were still significantly lower than FY 2007 level of $7,272. This experience mirrors that of most other states; state appropriations per

2 From 2009-10 to 2013-14, Virginia public school enrollments for 12th grade increased slightly from 87,657 to 88,544, while the number of high school graduates and completers decreased from 89,149 to 88,131. Over the same time period the on-time high school graduation rate increased from 86 percent to 90 percent and the college attendance rate increased from 70.8 percent to 71.9 percent. This information is based on Virginia Department of Education fall membership data, high school graduation and completion data, four-year on-time gradation rate data, and the postsecondary enrollment report (State Fiscal Stabilization Fund Indicator (C) (11)).

3 U.S. Census Bureau. 2016. Educational attainment by employment status (Table B23006). American Community Survey One-Year Estimates. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_15_1YR_B23006&prodType=table (Accessed January 24, 2017).

4 More recent data for FY 2016 from the Illinois State University's Center for the Study of Education Policy's Grapevine survey and information from the FY 2016-FY 2018 biennial state budget show continued growth in state support for public higher education.

Table 1.1 Virginia Public Higher Education Operating and Non-operating Revenues ($) by Source, FY 2015

Revenue Source	Four-year	Two-year	Total
Tuition and fees	2,252,392,646	359,245,533	2,611,638,179
Federal government grants, contracts and appropriations	968,686,694	305,943,069	1,274,629,763
State government grants, contracts and appropriations	1,303,409,902	390,864,820	1,694,274,722
Local and private grants, contracts, appropriations and gifts	512,675,070	25,831,841	538,506,911
Auxiliary enterprises sales and services	1,299,366,828	32,130,860	1,331,497,688
Other sources	2,138,801,985	25,419,279	2,164,221,264
Total revenue	8,029,139,088	1,138,502,720	9,167,641,808
Estimated out-of-state revenue			
Amount	2,453,312,671	343,811,963	2,797,124,634
Percent of total revenue	30.6%	30.2%	30.5%

Source: U.S. Department of Education, Integrated Post Secondary Data System, Finance Survey, 2015

FTE have risen but continue to lag behind highs realized in the previous decade (SHEEO 2016; American Institutes of Research 2016b). In contrast, federal government grants, which grew in the immediate aftermath of the recession, have receded since funding programs connected to the American Recovery and Reinvestment Act of 2009 (ARRA or "fiscal stimulus" program) expired in FY 2011. As a result, student tuition and fees, gifts/endowments, and auxiliary enterprise income have taken on added importance. About 43 percent of operating and non-operating revenues were derived from tuition and fees and 28 percent from state government appropriations and grants in FY 2015 (see **Table 1.1**). This funding situation is basically the inverse of the funding pattern in FY 2002 when 46 percent of revenues were derived from the state and 26 percent from tuition and fees. In addition, sales/services of hospitals was one of the fastest growing revenue categories, expanding at a rate of 30 percent in real terms from FY 2011 to FY 2015.

State public higher education has a broad mission to educate students, conduct research and development, and provide public service. Virginia's public colleges and universities spend about 26 percent on instruction, 17 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 10 percent on research (see **Table 1.2**). Institutions spend 12 percent on auxiliary services—activities such as residence halls, meal plans, and bookstores that are funded by student fees. Sixteen percent of four-year expenses are incurred for hospital services (reflecting UVA and VCU medical center activities) and also rely on patient fees. Like public institutions elsewhere in the nation, spending for Virginia institutions has recovered in recent years (American Institutes for Research 2016b). Most expense categories increased from FY 2011 to FY 2015.[5] Expenses for "hospital and other" grew the fastest.

Virginia public higher education degree production continues to increase, albeit at a slower pace than the previous decade. Virginia public higher education degree production grew by 5,867 degrees or 9.2 percent from 2010-2011 to 2014-2015 compared to 9,378 degrees or 17.3 percent from 2006-2007 to 2010-2011. Degree production lags enrollment by several years, and it does not yet fully reflect the

5 These expenditures were calculated by removing depreciation, operation and maintenance of plant, and interest expenses (a non-operating expense) from the IPEDS Finance Survey expenses and deductions total amount by area.

Table 1.2 Virginia Public Higher Education Expenses ($) by Type, FY 2015

Type of Expense	Four-year	Two-year	Total
Instruction	1,969,220,718	461,667,954	2,430,888,672
Research	896,309,862	0	896,309,862
Public service	205,850,459	9,095,903	214,946,362
Academic support	557,767,701	100,918,970	658,686,671
Student services	193,095,999	100,887,508	293,983,507
Institutional support	462,384,190	165,703,861	628,088,051
Operation and maintenance of plant	449,992,837	118,384,354	568,377,191
Depreciation	599,503,877	57,963,745	657,467,622
Interest	156,095,110	4,770,175	160,865,285
Scholarships and fellowships	214,013,272	129,643,996	343,657,268
Auxiliary services	1,092,802,899	20,328,153	1,113,131,052
Hospital services	1,286,839,996	0	1,286,839,996
Independent operations	1,047,690	0	1,047,690
Other expenses	49,439,624	5,429,689	54,869,313
Total	8,134,364,234	1,174,794,308	9,309,158,542

Source: U.S. Department of Education, Integrated Post Secondary Data System, Finance, 2015

downturn in enrollment experienced in recent years. Also, cohort graduation rates have been trending higher, helping to offset the effect of enrollment decline to some extent.[6] Public institutions have also seen a slight attrition in state market share in areas of degree production. This loss is largely due to the explosive growth of Liberty University, including its online programs.[7] Of all degrees issued by higher education institutions in the state, public institutions awarded 63 percent in 2014-15, down slightly from 65 percent in 2010-11. Virginia's public colleges and universities award 73 percent of all state associate's degrees, 65 percent of bachelor's degrees, 48 percent of master's degrees, and 63 percent of doctor's degrees. Virginia public higher education institutions confer a majority of degrees in all programmatic areas except for human services and public administration.[8] They awarded 95 percent of architecture and construction program degrees. They are responsible for 83 percent of engineering and technologies degrees and 83 percent of natural sciences and mathematics degrees, a pool of talent that helps to maintain state scientific competitiveness.

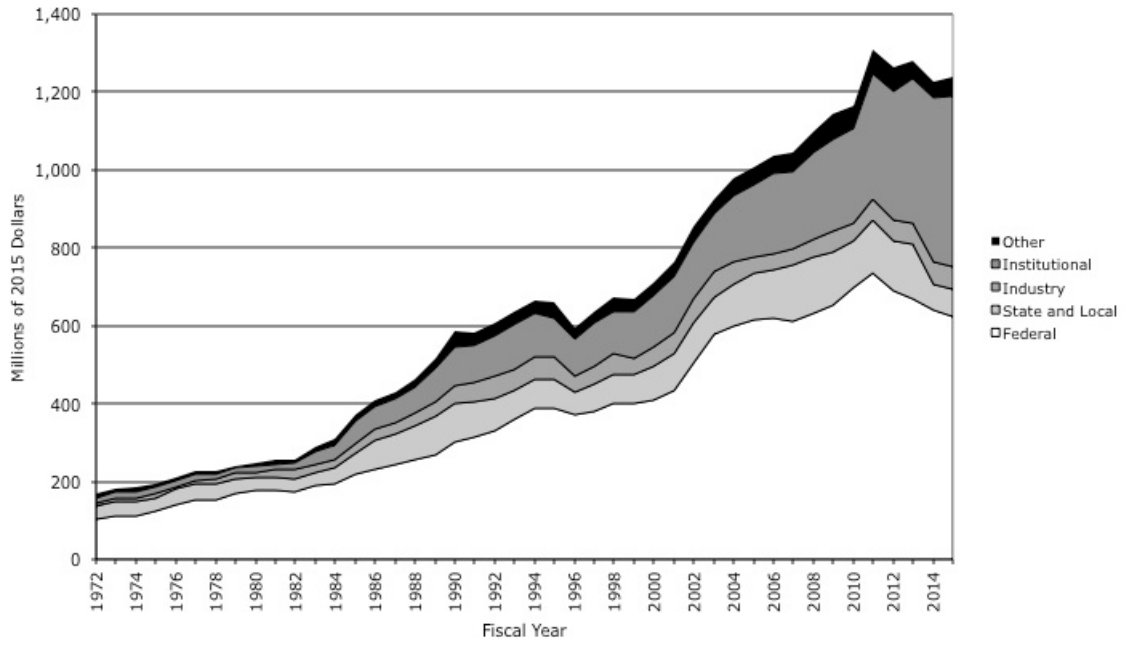
Demand for skilled workers in the commonwealth outpaces supply in many industries and regions. This gap is expected to increase as baby-boomers reach retirement age and labor markets tighten further in response to the continued business expansion. Virginia is projected to have 1.525 million job vacancies as a consequence of new job openings and retirements between 2010 and 2020 (Carnevale , Smith, and Strohl 2013). Two-thirds of these jobs (1,017,000) will either require or favor higher education experience. Virginia public higher

6 Six-year graduation rates for Virginia four-year public institutions rose from 68.7 for cohort year 2005 to 70.4 percent for cohort year 2008. Three-year graduation and transfer rates for two-year public institutions increased from 18.4 percent for cohort year 2008 to 21.8 percent for cohort year 2011. This information is based on U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Graduation Rates data.

7 The private higher education landscape has shrunken in other areas with the closure of nonprofit colleges such as St. Paul's College in Lawrenceville in 2013 and Virginia Intermont College in Bristol in 2014, and the near-death experience of Sweet Briar College in Amherst County. Private for-profit enrollments have also decreased with a federal government crackdown on certain for-profit career college practices.

8 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).

Figure 1.3 Virginia Public Higher Education Academic R&D Expenditures by Source of Funding, Millions of 2015 Dollars



Source: National Science Foundation Survey of Research and Development Expenditures at Colleges and Universities http://www.nsf.gov/statistics/srvyrdexpenditures/

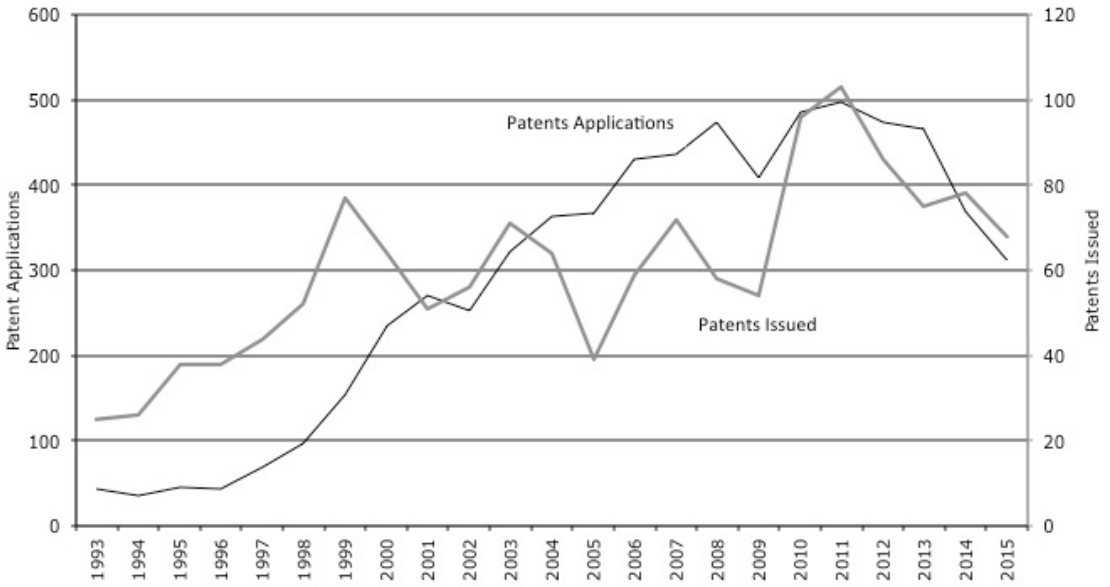
education will play a key role in educating this future workforce.

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, expenditures for science and engineering research expressed in terms of 2015 dollars increased by more than seven-fold from 1972 to 2011 (see **Figure 1.3**). Since that time, institutional expenditures from endowments and other institutional funds have only partly filled the void left by declining federal and state/local grants that commenced with the expiration of ARRA. Consequently, total university R&D expenditures declined 5.4 percent from FY 2011 to FY 2015. 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 generates commercialization activity such as university startups.

University research expenditures are tied closely to university innovation activities such as patent activity. **Figure 1.4** indicates that new patent applications and awards had been trending upwards through 2011, increasing 10-fold and three-fold respectively since 1993. Since that high-water mark year, patent applications and awards have fallen by over 33 percent. In contrast, patent applications and awards at universities nationwide increased 11 percent and 44 percent respectively over the same time period. It is unknown to what extent the decrease in Virginia patent activity is connected to declining research funding or greater difficulty in turning research expenditures into patented discoveries.

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 on a subset of such firms: firms that were established as a result of

Figure 1.4 Virginia Public University Patent Applications and Patents Issued, 1985-2015



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

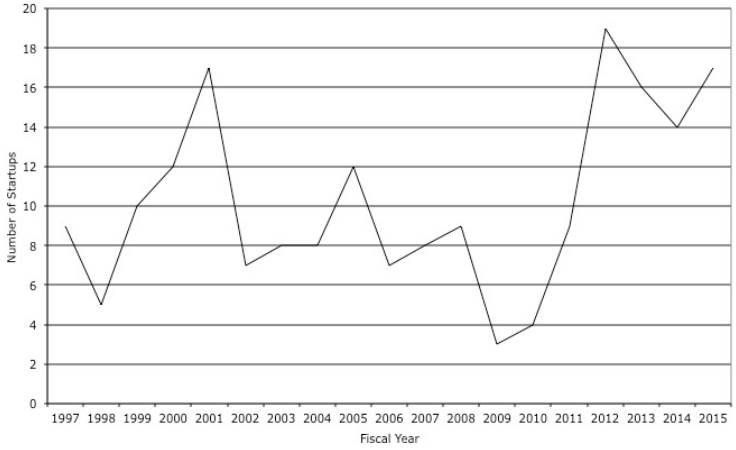
licensed university technologies, which are termed "university startups." This definition is used by the Association of University Technology Managers (AUTM) in soliciting information from university technology transfer offices about university-generated startups as part of the annual Licensing Activity Survey.[9]

AUTM data indicates that Virginia public higher education institutions generated 239 startups from 1997 to 2015. Over 80 percent of these startups were initially located in Virginia. **Figure 1.5** shows the number of Virginia-based university start-ups created each year during the period. An average of 10 firms were created each year for a total of 194 firms. Although not all of these 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 2015 indicate that about 31 percent of the 194 original firms reported payroll employment for the period. These 60 university startups had 750 employees. Seventy 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 which pays well above average wages. The remaining employment includes nine percent in educational services, nine percent in computer and electronic manufacturing, eight percent in publishing industries, two percent in chemical manufacturing, and two percent in other industries.

The AUTM survey does not capture university spin-off companies. By spin-off companies, we mean companies that were created as a result of faculty, student, and alumni Virginia public higher education experiences or exposure to entrepreneurial support services but not with university licensed technologies (EMSI 2015). 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 universities student generated 114 startups in FY 2015 (Center for Innovative Technology 2016); very few of these were connected to university-licensed technology.

9 This definition excludes licenses that were owned by other entities such as the Center for Innovative Technology and enterprises that were generated by other university startups.

Figure 1.5 Number of Virginia Public University Startups Located in Virginia by Year, 1997-2015



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

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). Virginia's college and university alumni are also a major source of entrepreneurial ventures. One recent 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).

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. Six institutions offer incubation or accelerator programs for startups, including George Mason University, James Madison University, Old Dominion University, the University of Virginia, Virginia Commonwealth University, and Virginia Tech (Center for Innovative Technology 2016). Institutional foundations have also become quite active in furnishing seed and/or proof-of-concept funds for new ventures. In FY 2015, three institutions (James Madison University, the University of Virginia, and Virginia Tech) offered $3,525,000 in such funding (Center for Innovative Technology 2016).

The extent to which pre-existing Virginia-based businesses expanded as a result of the expertise or licensed technologies they gained from Virginia public higher education institutions is also unknown. However, Virginia colleges and universities regularly collaborate with business and industry to foster innovation. For example, Virginia's public institutions forged sponsored research relationships with an estimated 1,039 companies in FY 2015 (Center for Innovative Technology 2016). Existing firms also benefit from the business development services offered by colleges and universities. For example, a recent George Mason University study reported that businesses receiving services from Mason Enterprise Center business incubators expanded their employment by 44 percent and revenue by 30 percent (Versel and Fuller 2013).

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.

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.

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 who enter the Virginia workforce and are retained within the state over time is calculated.

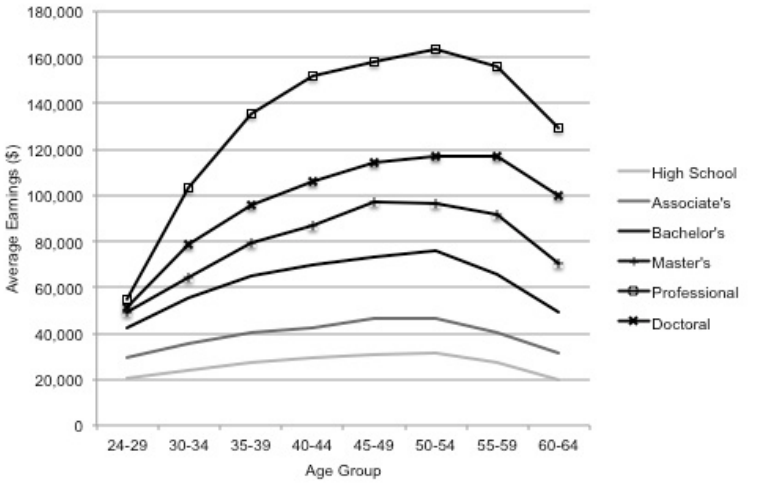
Table 2.1 Virginia Public Higher Education Employment and Expenditure, FY 2015

Item	Total
Employee compensation, including fringe benefits	$6,137,248,400
Outlays on goods and services[a]	$2,817,688,915
Capital expenditures	$1,095,427,296
Buildings and infrastructure	$679,027,526
Equipment	$360,862,184
Software	$26,369,729
Books and art	$29,167,857
Student expenditures	$2,539,452,187
Visitor expenditures	$117,136,203
Total institution related expenditures	$12,706,953,001
Employment	80,354

a This total excludes intra-university transactions between medical foundation components and universities such as management fees and facility rental payments.

Figure 2.1 shows average earnings by educational achievement level for different age groups computed from recent U.S. Census data for Virginia.[10] The cumulative differences between various 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, 2010-2014

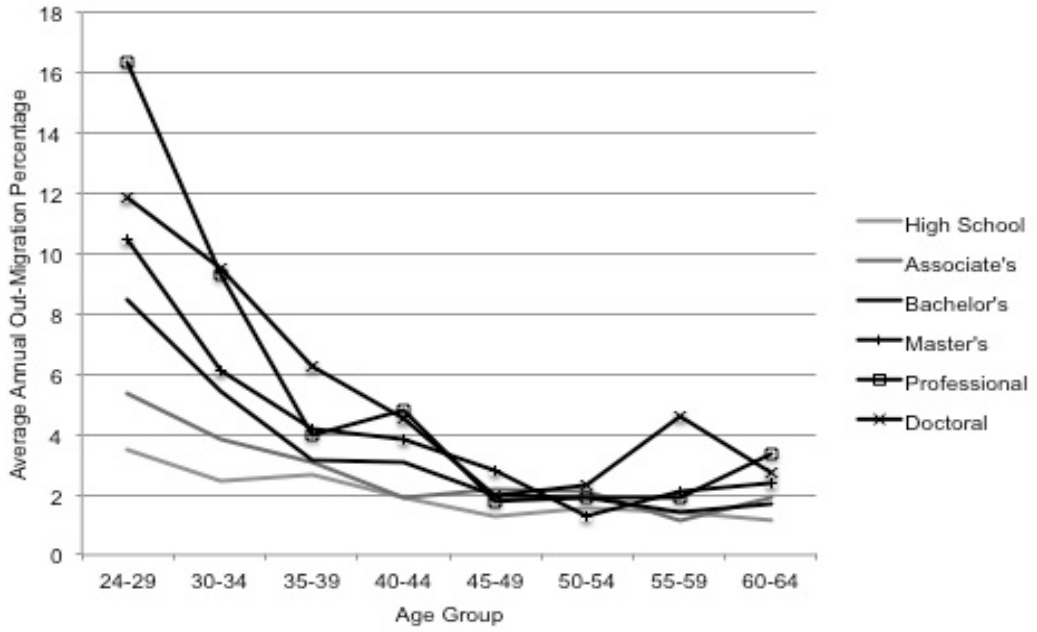


Source: American Community Survey Public Use Microdata Sample (PUMS), 2010-2014

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 2016a, 2016b; 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 (Kodrzycki 2001) and the propensity to migrate based on an individual's regional attachments. These regional attachments, represented by whether the graduate was born in the state, attended high school there, or resided there before matriculating, have been found to be statistically significant determinants of graduate retention (Gottlieb and Joseph 2006; Tornatzky et al. 2002; Kodrzycki 2001). **Figure 2.3** shows that the origin of Virginia public higher education graduates varies markedly by degree level. Over 98 percent of associate's degree graduates and 82 percent of bachelor's degree residents are state

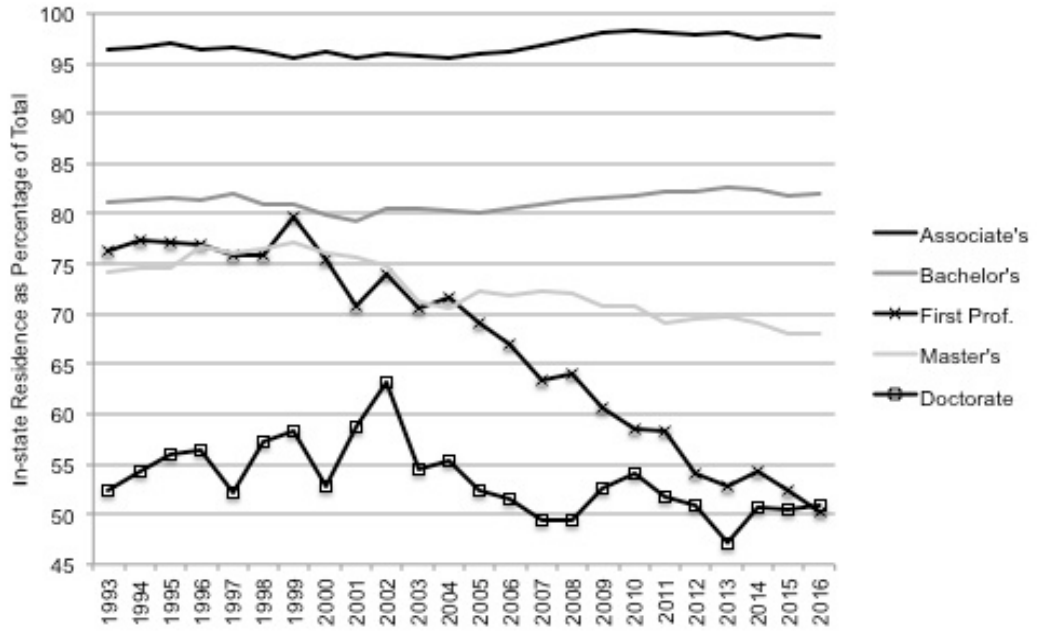
10 New research suggests that the premium earned by college graduates stayed relatively constant between 2010 and 2015, which spans the period between this study and the previous (Rephann 2013) public higher education study. However, the premium for graduate/professional education continued to increase over this period. Possible explanations for this recent phenomenon include "polarization" (a decrease in middle-skilled occupational demand due to technological change) and "skill downgrading" (a deceleration in business IT investments that has driven high skill workers into lower skill positions) (Valletta 2016).

Figure 2.2 Virginia Average Annual Out-Migration Percentage by Age Group and Educational Attainment, 2010-2014



Source: American Community Survey Public Use Microdata Sample (PUMS), 2010-2014

Figure 2.3 Percentage of Completions by Degree Level by In-state Residents, 1993-2015



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

residents, whereas only slightly over half 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.

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 10 Virginia-based university startups each year. In 2015, a total of 60 university startups reported 750 payroll employees.

REMI PI+ Model

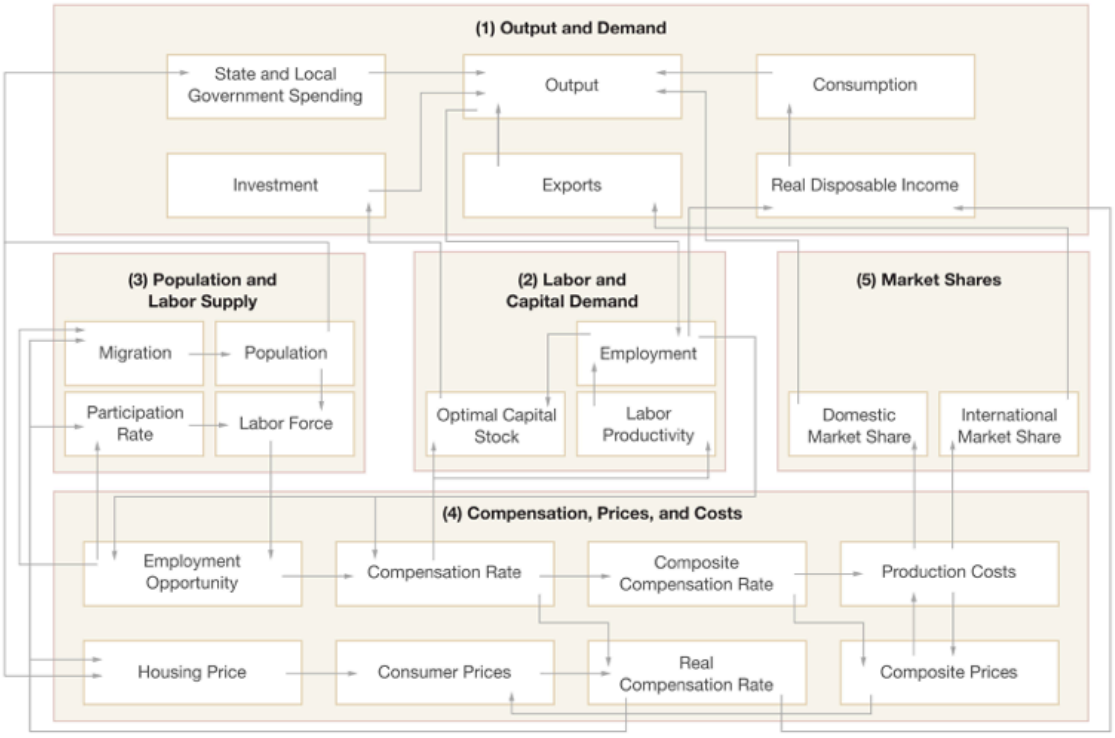
REMI PI+ (Policy Insight Plus) is a dynamic, multi-sector regional economic simulation model used for economic forecasting and measuring the impact of public policy changes on economic and population variables. REMI PI+ has been described as an eclectic economic model (Partridge and Rickman 2010). It utilizes different economic modeling methods such as input-output analysis, econometric forecasting, and computable general equilibrium in combination 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 several studies of state higher education sectors (Allgrunn 2010 for the South Dakota Public University System; REMI Inc. 2008 for the Oklahoma Higher Education System 2008; ICF Consulting 2003 for the University of California System; Lugar et al. 2001 for the University of North Carolina System).

The model offers several key advantages over static input-output models such as IMPLAN and RIMS II,[11] 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, demographic, and fiscal 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 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

11 IMPLAN, which stands for Impact Analysis for Planning, is maintained by the Minnesota IMPLAN Group, Inc. 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.

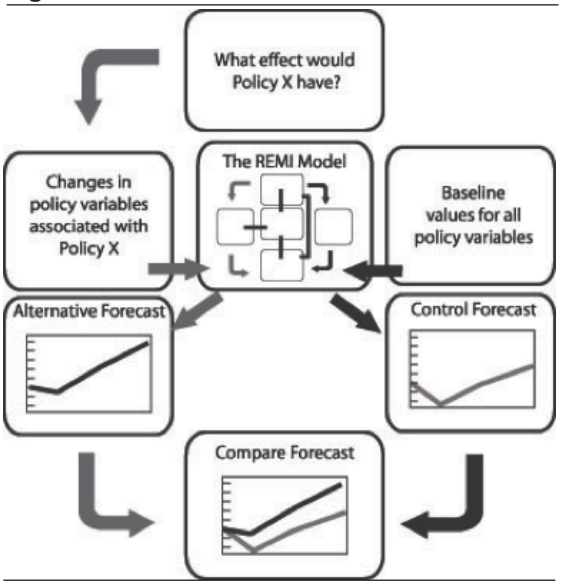
population changes is migration, which is influenced by relative wage levels as well as amenities. The Wage, Price, and Costs block is where the prices of factor and housing and product price levels are determined. The Market Shares block helps to measure exports to and imports to the region. Changes in market share are driven by production costs, demand characteristics, distance to markets, and output.

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 expenditure, 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.

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

Figure 2.5 REMI PI+ Model Simulation Flow



Source: Regional Economic Models, Inc.

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. 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 2014-15 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 (Schneider 2016). Once the earnings differentials are determined, the resident graduate workforce is reduced by an out-migration rate based on age and degree level to reflect attrition due to migration out of the state. Workforce attrition because of out-migration from the state is based on Virginia out-migration rates by age and educational attainment computed from the U.S. Census Bureau's American Community Survey PUMS data. Lastly, the average graduate is assumed to work for 30 years before retiring. In accordance with the previous study, 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 recent 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.

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. 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. In fact, the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS) Finance report no longer collects basic financial information on what were referred to as "component units" as it had previously. 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 Virginia Tech Carilion School of Medicine and Carilion Research Institute in Roanoke or the Edward Via College of Osteopathic Medicine in Blacksburg.[12]

Third, 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.

Fourth, 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. Recent 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 significantly better economic gains than high school graduates (Greenstone and Looney 2013). 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.

Fifth, 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 is 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

12 The Virginia Tech Carilion School of Medicine is scheduled to become part of Virginia Tech in 2018. Thus, in future years, expenditures connected to its operations and students (now 166 students) will be fully counted as part of Virginia's public higher education footprint.

expansions that can be attributed to higher education activities such as extension, business counseling, technology transfer, and collaborative research projects. The study also does not 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 information not available from IPEDS was obtained from the University of Virginia's Physician's Group and the Virginia Commonwealth University Medical Center for major foundation activities. In addition, information on capital expenditures was approximated by data tables from Comprehensive Audited Financial Reports (CAFR) for each institution. Detailed enrollment and degree level information by place of residence was obtained from the State Council of Higher Education for Virginia's 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 Corporation (2016). 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 the same data sources as the last Virginia public higher education study (Rephann 2013). It differs in primarily two ways. First, it relies on a new version of the REMI PI+ model that uses more recent economic data and introduces some

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	IPEDS finance; 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 UVA economic impact study (Knapp and Shobe 2007)
Visitor expenditures	Virginia Tourism Corporation (2016)
Graduate earnings	IPEDS completions; U.S. Census Bureau American Community Survey; National Crosswalk Service Center (CIP/SOC crosswalk, Occupational Projections and Training Data Files) and Bureau of Labor Statistics (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)

refined model equations. The REMI PI+ model discontinued the revenue generation response variable; thus calculations as explained in **Appendix A.3** are used to estimate state revenues in a way that is comparable to previous study estimates. Second, the study counts the economic impacts of university startups as part of the public higher education economic footprint for the first time.

Appendix A.3 describes in detail how each data element was assembled in order to use for input in the REMI PI+ model.

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 167,277 jobs, a total gross domestic product effect of $36.122 billion, and $3.257 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 $1.92 in state revenue and an increment of $21.32 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. 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

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 out-migration and retirement after 30 years	In-state with out-migration and retirement after 30 years	In-state with out-migration and retirement after 30 years
Productivity	In-state with out-migration and retirement after 30 years	In-state with out-migration and retirement after 30 years	In-state with out-migration and retirement after 30 years
University Startups	In-state	In-state	In-state

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?

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 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 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 is the same as used in previous Virginia public higher education studies (Rephann, Shobe, and Knapp 2009; Rephann 2013).[13]

13 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; OECD 2012; Trostel 2007; Bluestone 1993).

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 whose employment is tied to public higher education activities 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 2015 dollars. In addition, state revenues are estimated. 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 2014.

Economic Footprint and Impact Analysis

Results indicate that the economic footprint of Virginia public higher education activities are substantial. During the first year, 2015, when the expenditures are made, the economic effect is over $10.3 billion in GDP. This result is termed the expenditure-related effect. The effect of higher education operations from 2015 falls to $1.7 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 as a result of graduate out-migration from the state. The human capital-related effect becomes zero in year 2046 when all graduates from 2014-2015 are assumed to have retired from the workforce.

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

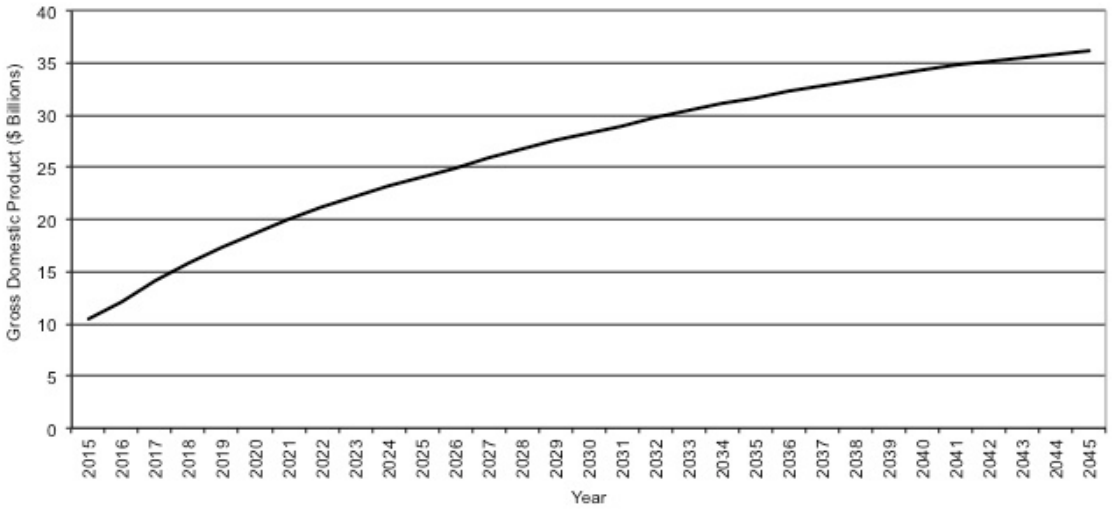


Figure 3.1 illustrates the cumulative present value GDP impact by year. It shows that when the discounted values are added up over a 31-year period, the total GDP effect is over $32 billion. **Table 3.2** divides the economic variables into expenditure-related and human capital-related components. The present value of the expenditure-related GDP effect is 10.277 billion, the human capital-related effect is $25.668 billion, and the university startup effect is $177 million. The total economic footprint attributable to Virginia public higher education for the period of analysis is $36.122 billion. Virginia's GDP in FY 2015 was $470.235 billion.[14] Therefore, the expenditure effect accounts for 2.19 percent of GDP. The human capital effect would represent 5.45 percent, and the university startup effect would constitute 0.04 percent of GDP. The total effect is 7.68 percent. The expenditure-related employment effect is 165,693, and the university startup employment effect is 1,584. This amounts to 3.30 percent and 0.03 percent respectively of estimated FY 2015 Virginia employment of 5,005,693, for a total effect equivalent to 3.33 percent (or roughly 1 in 30 Virginia jobs).[15,16] The present value of state revenues generated as a

14 Bureau of Economic Analysis. 2016. Quarterly Gross Domestic Product by State, 2016. http://www.bea.gov/regional/index.htm (Accessed December 8, 2016).

15 Bureau of Economic Analysis. 2016. State Annual Personal Income and Employment. http://www.bea.gov/regional/index.htm (Accessed December 28, 2016). FY 2015 employment is estimated as average of 2014 and 2015 calendar year employment figures.

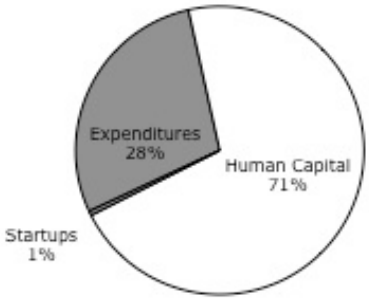
16 In FY 2011, the public higher education employment economic impact was 131,230 (Rephann 2013). For comparison purposes, this figure represented just 2.7 percent of an estimated 4,776,120 jobs statewide in FY 2011.

Table 3.2 Economic Footprint of Virginia Public Higher Education (Dollar Denominated Values Expressed in Present Value, Billions of 2015 Dollars)

Economic Variable	Expenditure-Related	Human Capital-Related	University Startup-Related	Total
GDP	10.277	25.668	0.177	36.122
Industrial output	17.985	42.673	0.273	60.931
Personal income	8.912	21.686	0.101	30.699
State revenues	0.945	2.301	0.011	3.257
Employment	165,693	N/A	1,584	167,277

N/A=not available

Figure 3.2 Source of Economic Footprint



result of public higher education activities during the FY 2015 year is $3.257 billion.

Slightly over 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**). Just 28 percent is accounted for by higher education expenditures. One percent depends on university startups.[17] 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**), well over half of the economic effect can be traced to higher education payroll and other outlays. Another 28 percent can be attributed to hospital activity at VCU and UVA. Fourteen percent is accounted for by student expenditures, and the remainder, three percent and one percent, respectively, to capital and visitor expenditures.

17 This result is consistent with recent research that indicates the economic impact of research commercialization and technology transfer is much smaller than that of improving student and graduate labor productivity and earnings (Motoyama and Mayer Forthcoming, Bartik and Erickcek 2008).

Figure 3.3 Source of Expenditure-related Economic Footprint

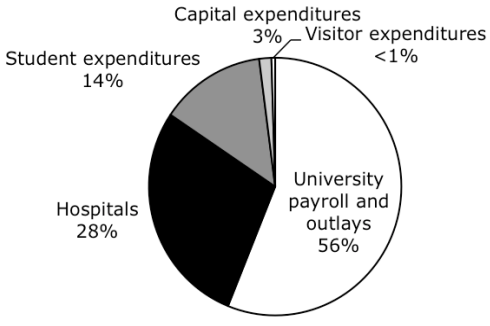


Table 3.3 provides another breakdown by expenditure function and funding source. It shows that the medical centers at Virginia Commonwealth University and the University of Virginia make a large contribution to Virginia's economy. Together they account for 36,752 jobs, $2.911 billion in GDP, and $265 million in state revenues. Higher education research activities are responsible for almost 10,165 jobs, $557 million in GDP, and $57 million in state revenues. An estimated 59 percent of these higher education research funds are derived from out-of-state sources, primarily the federal government.[18] 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 16,344 jobs, $968 million in GDP, and $80 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 $7.206 billion for GDP and

18 A breakdown of research funding by geographical origin was not available from the IPEDS Finance data. Therefore, data from the National Science Foundation (2016) was 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. No attempt was made to apportion these funds by geographical origin, and they are counted entirely as in-state contributions.

Table 3.3 Breakdown of Economic Footprint by Function and Source (Dollar Denominated Values Expressed in Present Value, Billions of 2015 Dollars)

	GDP	Industrial output	Personal income	State revenues	Employment
Human capital effect	25.668	42.673	21.686	2.301	N/A
University Startups	0.177	0.273	0.101	0.011	1,584
Total expenditures effect	10.277	17.985	8.912	0.945	165,693
Capital	0.160	0.275	0.105	0.011	2,048
Hospitals	2.911	5.174	2.501	0.265	36,752
Research	0.557	0.983	0.539	0.057	10,165
Portion attributable to out-of-state funds	0.334	0.590	0.324	0.034	6,103
Other institutional expenditures	5.209	9.192	5.049	0.536	95,078
Portion attributable to out-of-state student tuition	0.584	1.030	0.565	0.060	10,653
Portion attributable to other out-of-state funds	0.862	1.522	0.835	0.089	15,739
Student expenditures	1.392	2.276	0.689	0.073	20,809
Portion attributable to out-of-state students	0.335	0.546	0.163	0.017	4,850
Visitor expenditures	0.049	0.085	0.028	0.003	842
Total attributable to out-of-state revenues	2.165	3.773	1.916	0.203	38,186

126,983 for employment. The present value of the effect on GDP, including expenditure and human capital phases, is $32.874 billion. $25.668 billion of this effect, or 78 percent of the total, is human capital-related. In addition, these activities generate $2.969 billion in total state revenue.

According to IPEDS, state appropriations combined with state grants and contracts were $1.694 billion in FY 2015. The state general fund appropriation was $1.629 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 $65 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 $1.92 in state revenue and $21.32 of incremental gross domestic product.[19] If one focuses on just state appropriations for operating support, the leveraging figures per dollar of support are $2.00 in state revenue and $22.18 for GDP.

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 2015 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 9.3 percent. If one focuses on just state appropriations for operating support, the IRR increases to 10.4 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

19 Although there have been small changes in methodology from previous studies, the comparable figures for 2011 were $1.29 in state revenue and $17.40 in GDP. In 2007, every dollar was associated with $1.39 in state revenue and an increase of $13.31 in GDP.

Table 3.4 Economic Effects of Virginia Public Higher Education by Scenario (Dollar Denominated Values Expressed in Present Value, Billions of 2015 Dollars)

Economic Variable	Scenario I	Scenario II	Scenario III
Expenditure			
GDP	10.277	7.206	2.165
Industrial output	17.985	12.536	3.773
Personal income	8.912	6.306	1.916
State revenues	0.945	0.669	0.203
Employment	165,693	126,893	38,186
Human Capital			
GDP	25.668	25.668	25.668
Industrial output	42.673	42.673	42.673
Personal income	21.686	21.686	21.686
State revenues	2.301	2.301	2.301
Employment	N/A	N/A	N/A
University Startups			
GDP	0.177	0.177	0.177
Industrial output	0.273	0.273	0.273
Personal income	0.101	0.101	0.101
State revenues	0.011	0.011	0.011
Employment	1,584	1,584	1,584
Total			
GDP	36.122	32.874	28.010
Industrial output	60.931	55.209	46.719
Personal income	30.699	27.991	23.703
State revenues	3.257	2.969	2.515
Employment	167,277	128,478	39,770

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 $2.165 billion in GDP or 38,186 jobs. The state revenue effect is $203 million. The total economic effect resulting from human capital improvements is equivalent to $25.668 billion, resulting in a total economic effect of $28.010 billion for this scenario.

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 able 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.[20] Assuming that the non-attendees are representative of graduates, this percentage would translate into the loss of $16.530 billion in GDP and $1.482 in state revenue in terms of present value. The commonwealth would see total losses of $18.695 billion in GDP and $1.685 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

20 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.

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 and productivity over time 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 $36 billion in gross domestic product and approximately $3.3 billion in state revenue in terms of present value. $18.695 billion in GDP and $1.685 billion in state revenue would be lost if one were to use the most restrictive definition of economic influence that attempts to conservatively capture the economic loss that would result if the system did not exist. In reality, the true "economic impact" of Virginia higher education, based on the assumptions of this analysis, likely lies somewhere between this range of estimates. 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.

The economic footprint of Virginia public higher education is much larger than reported in a 2013 study entitled *Study of the Economic Impact of Virginia Public Education: 2013 Update*. Part of the increase can be attributed to the continued growth in the number of graduates in 2015 compared to the number from the 2011 graduate data used in the earlier study. Although student enrollment declined, expenditures per student FTE increased. Thus, overall higher education expenditures increased. Another major factor is a large increase in the sales and expenditures for university hospitals. This growth occurred over a period when the Affordable Care Act expanded coverage, and the university health systems aggressively expanded their affiliations with regional and community hospitals, introduced new outpatient sites and physician offices, and embarked on major building projects to accommodate more patients. Also, this study for the first time recognizes the role that university startups play in generating jobs and economic activity for the commonwealth. This increase in the public higher education economic footprint underscores the increasing importance of public higher education for the Virginia economy.

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 effort to capture spending connected with higher education foundations and college-related visitations and tourism. It also does not capture 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. Nor does it include the economic impact of independent institutions created as joint ventures such as the Virginia Tech Carilion School of Medicine and Carilion Research Institute in Roanoke. 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.

It should also be noted that the estimates provided here are not comparable to higher education impact studies conducted by other states or to Virginia impact studies conducted for other areas, such as say, tourism, port activity, or agriculture. State economic impact studies use a variety of modeling approaches and data sources. Moreover, the sectors themselves may be defined in different ways, sometimes very narrowly and sometimes much more broadly. Until such time as a set of uniform modeling tools, data, and standards are established for impact analysis, it would be problematic to compare the results of one study impact to another.

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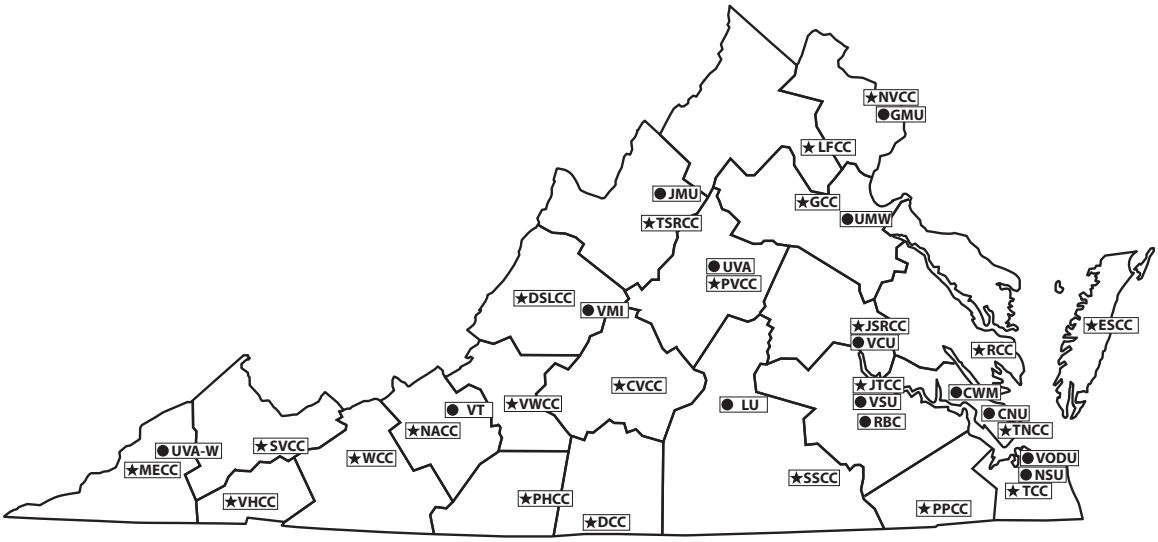
APPENDIX A.1

Map of Virginia Public Higher Education Institutions by Principal Location



Key to abbreviations:

● Four-year Public Institutions

CNU	Christopher Newport University
CWM	College of William and Mary
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

● Two-year Public Institutions

RBC	Richard Bland College

★ Virginia Community College System

BRCC	Blue Ridge Community College
CVCC	Central Virginia Community College
DSLCC	Dabney S. Lancaster Community College
DCC	Danville Community College
ESCC	Eastern Shore Community College
GCC	Germanna Community College
JSRCC	J Sargeant Reynolds Community College
JTCC	John Tyler Community College
LFCC	Lord Fairfax Community College
MECC	Mountain Empire 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
TNCC	Thomas Nelson Community College
TCC	Tidewater Community College
VHCC	Virginia Highlands Community College
VWCC	Virginia Western Community College
WCC	Wytheville Community College

Appendix A.2

Virginia Public Higher Education Institutions

Institution	Main Campus Location	Fall 2015 Headcount[a]	Carnegie Classification[b]
Four-year		214,480	
Christopher Newport University	Newport News	5,172	Master's Colleges and Universities (smaller programs)
College of William and Mary	Williamsburg	8,484	Research Universities (high research activity)
George Mason University	Fairfax County	34,112	Research Universities (high research activity)
James Madison University	Harrisonburg	21,227	Master's Colleges and Universities (larger programs)
Longwood University	Farmville	5,087	Master's Colleges and Universities (medium programs)
Norfolk State University	Norfolk	5,107	Master's Colleges and Universities (larger programs)
Old Dominion University	Norfolk	24,672	Research Universities (high research activity)
Radford University	Radford	9,743	Master's Colleges and Universities (larger programs)
University of Mary Washington	Fredericksburg	4,647	Master's Colleges and Universities (larger programs)
University of Virginia	Charlottesville	23,883	Research Universities (very high research activity)
University of Virginia's College at Wise	Wise	2,028	Baccalaureate Colleges--Arts & Sciences
Virginia Commonwealth University	Richmond City	31,242	Research Universities (very high research activity)
Virginia Military Institute	Lexington	1,717	Baccalaureate Colleges--Arts & Sciences
Virginia State University	Petersburg	4,696	Master's Colleges and Universities (smaller programs)
Virginia Tech	Blacksburg	32,663	Research Universities (very high research activity)
Total Public Two-Year Institutions		179,065	
Virginia Community College System		176,887	
Blue Ridge Community College	Weyers Cave	4,192	Associate's--Public Rural-serving Medium
Central Virginia Community College	Lynchburg	4,433	Associate's--Public Rural-serving Medium
Dabney S. Lancaster Community College	Clifton Forge	1,236	Associate's--Public Rural-serving Small
Danville Community College	Danville	3,561	Associate's--Public Rural-serving Medium
Eastern Shore Community College	Melfa	745	Associate's--Public Rural-serving Small
Germanna Community College	Locust Grove	6,993	Associate's--Public Rural-serving Medium
J. Sargeant Reynolds Community College	Richmond City	10,889	Associate's--Public Urban-serving Multicampus
John Tyler Community College	Chester	10,035	Associate's--Public Suburban-serving Multicampus
Lord Fairfax Community College	Middletown	7,002	Associate's--Public Rural-serving Large
Mountain Empire Community College	Big Stone Gap	2,718	Associate's--Public Rural-serving Medium
New River Community College	Dublin	4,477	Associate's--Public Rural-serving Medium
Northern Virginia Community College	Annandale	52,078	Associate's--Public Suburban-serving Multicampus
Patrick Henry Community College	Martinsville	2,594	Associate's--Public Rural-serving Medium

Virginia Public Higher Education Institutions (continued)

Institution	Main Campus Location	Fall 2015 Headcount[a]	Carnagie Classification[b]
Paul D. Camp Community College	Franklin City	1,473	Associate's--Public Rural-serving Small
Piedmont Virginia Community College	Charlottesville	5,438	Associate's--Public Rural-serving Medium
Rappahannock Community College	Glenns	3,566	Associate's--Public Suburban-serving Multi-campus
Southside Virginia Community College	Alberta	4,439	Associate's--Public Rural-serving Large
Southwest Virginia Community College	Richlands	2,563	Associate's--Public Rural-serving Medium
Thomas Nelson Community College	Hampton	9,316	Associate's--Public Suburban-serving Single Campus
Tidewater Community College	Norfolk	25,927	Associate's--Public Suburban-serving Single Campus
Virginia Highlands Community College	Abingdon	2,365	Associate's--Public Rural-serving Medium
Virginia Western Community College	Roanoke City	7,932	Associate's--Public Rural-serving Large
Wytheville Community College	Wytheville	2,915	Associate's--Public Rural-serving Medium
Richard Bland College	Petersburg	2,178	Associate's--Public 2-year colleges under 4-year universities

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 2010 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 Planning 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 was obtained from Part C ("Expenses and Other Deductions") of the IPEDS Finance survey. Supplemental information on medical school compensation was obtained from UVA Physicians Group and VCU Health System. 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. 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.

Capital Expenditures

Capital expenditure data was obtained from tables describing changes in various capital asset categories derived from Comprehensive Annual Financial Reports (CAFRs) posted on 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. 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 "firm 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 3.1 percent of the purchase price for books and art, 13.0 percent for equipment, and 2.5 percent for software. These wholesale margins were obtained from IMPLAN (an input-output software product produced by MIG, Inc.) 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 of Higher Education for 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 FY2015 Profile of Travel in Virginia (Virginia Tourism Corporation 2016). 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 $97.60 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. This policy variable allocates total spending to individual spending categories based on the BEA U.S. Travel and Tourism Satellite Accounts and uses retail and wholesale margins where appropriate.

Graduate Earnings and Productivity

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.

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 15 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 out-migration rate for Virginia residents based on age and degree-level.[21,22] These out-migration rates from Virginia were computed using 2010-2014 U.S. Bureau of the Census American Community Survey Public Use Microdata. Graduates are assumed to graduate at age 30. Out-migration 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 worklife of 30 years. This number is smaller than recent estimates of worklife expectancies for college-educated individuals and will impart a conservative bias to the results (Skoog, Ciecka, and Krueger 2011). The increased earnings and productivity due to these graduates to the Virginia economy begin in 2016. Therefore, aggregate estimates of earnings and productivity added to the Virginia economy decrease each year in real dollars and cease in the year 2046. 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 (2010 Standard Occupational Classification Crosswalk to 2010 Classification of Instructional Programs) obtained from the National Crosswalk Service Center (National Crosswalk Service Center 2012a). Some adjustments were made to the crosswalk in order to assign a handful of unassigned "orphan" degrees to occupational categories. Second, the degrees were assigned to particular occupations based on degree weights from National Crosswalk Service Center Occupational Projections and Training Data (National Crosswalk Service Center 2012b). Third, the graduates by 3-digit SOC code occupational groups and degree level were multiplied by the corresponding mean earnings differentials[23] 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 worklife.[24] For example, the 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 worklife based on the bow-shaped age-earnings

21 The age and degree-specific out-migration 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.

22 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).

23 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.

24 This step used American Community Survey (ACS) SOC codes in contrast to the last study in which ACS Census Occupation Codes were combined with a SOC code-Census Occupational Code crosswalk table. A handful of revisions to SOC codes were made in order to match a handful of orphan SOC codes from the National Crosswalk Center table to the ACS SOC codes.

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 2010-2014 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.[25] 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 2015). The earnings totals were then assigned to the 70 REMI industry categories for the each year (2016-2045) 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 the last Virginia public higher education study (Rephann 2013).

University Startups

Information on university business startups was provided by technology transfer offices at five universities that reported in-state startup activity in the FY 2015 Association of University Technology Managers (AUTM) Licensing Activity Survey (i.e., the College of William and Mary, 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 2015. The enterprise employment size and reported North American Industrial Classification System (NAICS) industry code were identified. Employment totals by NAICS code were then aggregated into the 10 REMI industry categories represented (i.e., support activities for mining; computer and electronic product manufacturing; electrical equipment and appliance manufacturing; chemical manufacturing; publishing industries except internet; professional, scientific and technical services; administrative and support services; educational services; ambulatory health care services; and nursing and residential care facilities). 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

25 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 to the results.

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 state 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 2014 revenue data (U.S. Census Bureau 2016) and REMI base fiscal year data estimated using an average of 2013 and 2014 calendar year data to estimate the fiscal year total. For this study, total revenue calculations excluded intergovernmental revenue. Revenue categories were calculated using a base of state personal income for all categories. This procedure produces slightly more conservative estimates of state revenue effect than the previous study. Moreover, it does not incorporate dynamic feedback effects that would further amplify the revenue impact.