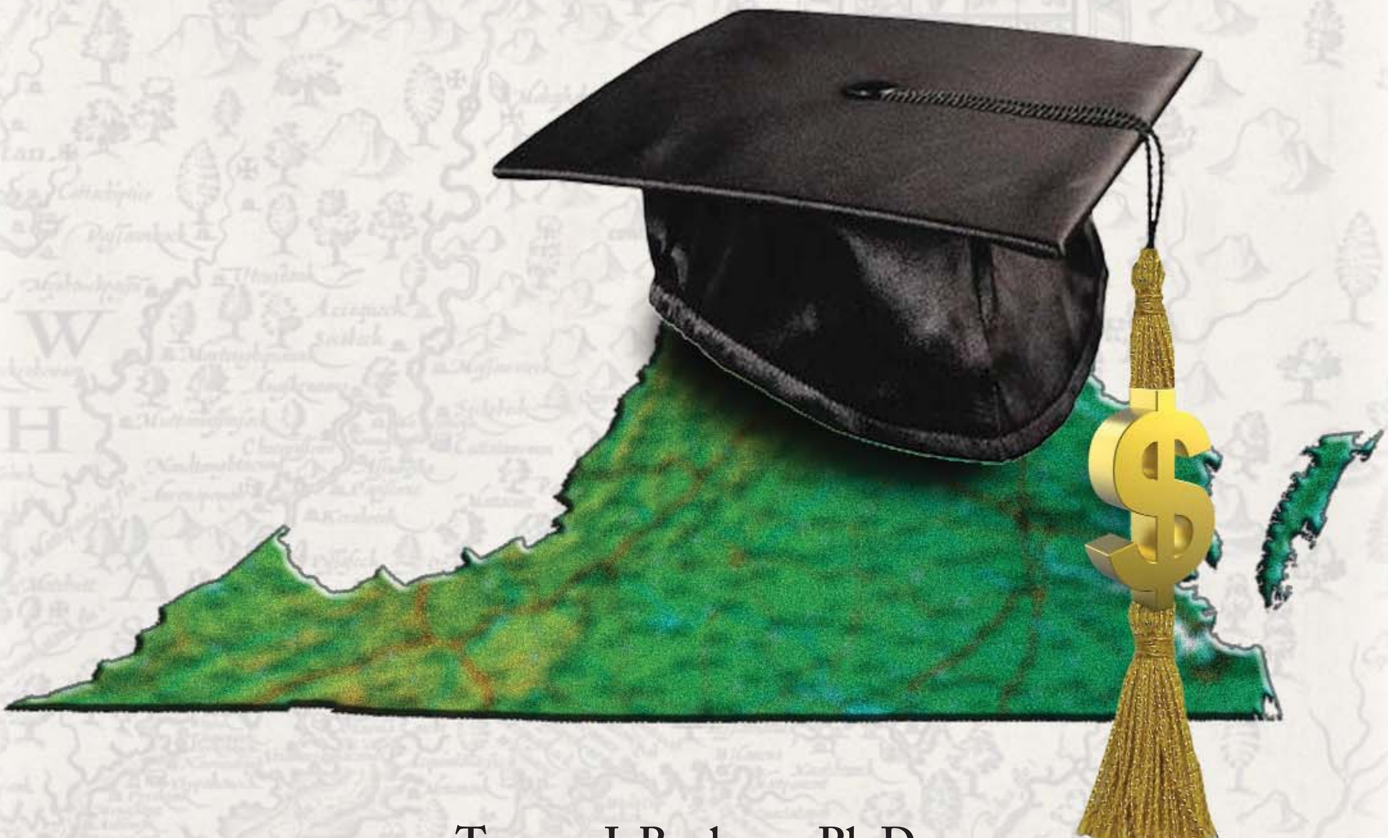
Study of the Economic Impact of Virginia Public Higher Education

FOR THE VIRGINIA BUSINESS HIGHER EDUCATION COUNCIL

FINAL REPORT



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October 2009

Weldon Cooper
Center for Public Service
University of Virginia

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October 9, 2009

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FOREWORD

This study examines the effect of the public higher education sector on Virginia's economy. The study consists of three distinct parts. The first part consists of a full accounting of the current flow of economic activity in Virginia that can be directly tied to the expenditures and activities of publicly supported institutions of higher education. The second part is a forecast of the additional economic impact of a policy initiative to increase the number of undergraduate and graduate degrees by Virginia public institutions by 70,000 over the period 2010 to 2020. The third part is an evaluation of a broader set of economic and social benefits generated by the public higher education sector, including enhancements to graduates' life circumstances such as improved health, community benefits such as reduced crime, and economic benefits that stem from industrial attraction, entrepreneurial activity, innovation, and workforce development.

The authors would like to thank various individuals for assistance in providing information that was useful in completing this study. VBHEC President Donald Finley helped to define the scope of the study. Chris Lloyd, Senior Vice President, McGuireWoods Consulting, LLC and VBHEC consultant, forwarded information that was pertinent to the study, helped to arrange input from stakeholders, offered helpful editing suggestions and coordinated the release of the study. The authors gained additional background from meetings with staff from the State Council of Higher Education for Virginia, including Deputy Director Thomas Daley, Policy Research and Data Warehousing Director Tod Massa, Academic Affairs and Planning Director Joseph Defilippo, Higher Education Restructuring Director James Alessio, Finance Policy Director Dan Hicks, and Communications and Government Relations Director Kirsten Nelson. Associate Vice Chancellor for Institutional Effectiveness for the Virginia Community College System, Susan Wood, also provided information on community colleges. Dawn Peebles, Financial Reporting Officer at Longwood University, and Randy Ellis and Laura Lingo of the Office of Financial Reporting and Analysis at the University of Virginia answered questions on the IPEDS financial reporting system. David Boling, Associate Comptroller for Financial Analysis at the University of Virginia provided valuable insights about how to measure capital outlays. Dominic Puleo, Chief Financial Officer for the Virginia Commonwealth University Health System, and Eric Stucko, Chief Financial Officer of the University of Virginia Health Services Foundation, provided financial data on the respective health systems that were not available from public sources. Mark Coburn, President of Virginia Tech Intellectual Properties, Inc., Mikael Herlevsen, Licensing Associate with the University of Virginia Patent Foundation, Zohir Handy, Manager of Technology Licensing at Old Dominion University, Jennifer Murphy, Director of Technology Transfer at George Mason University, and Ivelina Metocheva, Director of Technology Transfer at Virginia Commonwealth University, shared information about their institutions' business spinoffs. Student research assistants Jason Shapiro and Pei Du provided project assistance. Cooper Center staff members Steve Kulp and Dave Borszich assisted with document preparation. Any errors or omissions are the responsibility of the authors.

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October 2009

EXECUTIVE SUMMARY

From beginnings that can be traced to the College of William and Mary and the University of Virginia, the Virginia public higher education system has played a key role in preparing the Commonwealth's workforce and developing future leaders. Over the years, this role has expanded enormously. There are now a total of 39 public higher education institutions in the state, including 15 four-year institutions, one junior college, and 23 community colleges. They graduate 74 percent of all state degree recipients, including 74 percent of associate and bachelor's degree recipients and 77 percent of master's and doctorate degree earners, and slightly over half of first-professional degree awardees. In recent years, system enrollment has grown rapidly, adding 40 percent more students since 1987 and outpacing state population growth of 31 percent during the same period. Moreover, the sector has become more deeply enmeshed in knowledge, economy, and community building in many different dimensions, including research and development, stimulation of entrepreneurship, dissemination of new techniques and processes from extension and outreach programs, improvement to quality of life, and attraction of firms and tourists.

This study examines the effect of the public higher education sector on Virginia's economy. The study has several components. It provides a full accounting of the current flow of economic activity in Virginia that can be directly tied to the expenditures and educational activities of publicly supported institutions of higher education. It also presents a "what if" analysis of the additional economic impact that would result from an initiative to increase over the next decade the number of undergraduate and graduate degrees awarded by Virginia public institutions from current levels. The study examines the broader economic benefits that are reasonably attributable to activities of post-secondary institutions. These include not only the private pecuniary benefits that accrue to degree holders but numerous non-pecuniary, but nonetheless valuable enhancements to graduates' life circumstances such as access to jobs with better working conditions, better health, greater family stability, etc. It also includes community benefits such as reduced crime, increased volunteerism, and reduced dependence on social welfare programs. Lastly, the study catalogues economic gains that occur as a result of public higher education activities in the areas of industrial attraction, entrepreneurship, innovation, extension, workforce development, and neighborhood revitalization.

Economic effects for the first two components are measured using a regional economic impact model, Regional Economic Models, Inc. Policy Insight Plus (REMI PI+), that was calibrated for Virginia's economy. The model uses data from both public and private data sources, as well as information gathered from impact studies conducted by selected Virginia public higher education institutions. Outputs of the REMI PI+ model include calculation of the amount of Virginia gross domestic product, personal income, industrial output, employment, and state revenues 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. No attempt is made to separate out those activities that would not have occurred in the absence of 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 productivity and earnings potential that results from a student's acquisition of skills and knowledge.

The major findings of the study are as follows:

- Expenditures associated with Virginia public higher education are conservatively estimated to be $9.462 billion in FY2007. This total includes higher education institution and component foundation expenditures on payroll ($4.221 billion), goods and services ($1.835 billion), and capital ($1.146 billion). Expenditures of students made on Virginia goods and services are estimated at $2.198 billion. Visitor expenditures contribute an additional $62 million.

- The economic activity related to Virginia public higher education stems from the expenditures made by the institutions, foundations, students, and visitors as well as human capital improvements measured by increased productivity and earnings of graduates who enter and are retained in the state workforce. Measured in terms of net present value (NPV), which discounts future dollar streams, the total economic footprint attributable to one year of higher education operations is $23.976 billion in Virginia gross domestic product expressed in terms of 2007 dollars. Public higher education operations account for 144,550 total Virginia jobs.

- State public higher education operations each year generate $2.507 billion in long-term state revenue. Every dollar spent on public higher education by the state is associated with an additional $1.39 in state revenue and an increment of $13.31 to Virginia gross domestic product.

- Virginia GDP in 2007 was $384.132 billion. Therefore, the expenditure effect of $6.953 billion for Virginia's public higher education sector accounts for 1.8 percent of GDP. The expenditure-related employment effect is 144,550 or 2.9 percent of total Virginia employment in 2007 of 4,936,137. The total effect would be equivalent to 6.2 percent of Virginia GDP.

- The medical centers at Virginia Commonwealth University and the University of Virginia are significant state economic assets. Together they account for 27,311 jobs, $1.436 billion in GDP, and $190 million in state revenues.

- An estimated 24.6 percent of Virginia public higher education institutions' revenue is calculated to be 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 $1.575 billion and 34,833 Virginia jobs for 2007.

- Research expenditures by higher education are responsible for nearly 13,000 jobs, $588 million in GDP, and $72 million in state revenues. An estimated two-thirds of higher education research funds are derived from out-of-state sources, primarily the federal government, and correspondingly two-thirds of the economic footprint resulting from research expenditures can be traced to these sources.

- Out-of-state students stimulate the Virginia economy through the payment of tuition revenues, expenditures on state goods and services, and the tourism expenditures of visitors. This spending results in approximately 17,200 jobs, $776 million in GDP, and $139 million in state revenues.

- The economic footprint (which includes expenditure and human capital effects) can be broken down into regions. The Central Region, containing Richmond and Charlottesville, accounts for 33 percent of the total economic footprint. Hampton Roads and the West Central Region, containing Blacksburg, Dublin, Radford, Lynchburg, and Roanoke, account for 18 percent each. The Northern Region accounts for 16 percent. The Eastern Region, which encompasses the Eastern Shore, the Northern Neck and part of the Middle Peninsula, makes the smallest contribution as the result of having only two relatively small public higher education institutions, Eastern Shore Community College and Rappahannock Community College, within its boundaries. The employment effects of higher education related expenditures are estimated as follows: Central Region 67,425; Hampton Roads Region 22,241; West Central Region 21,074; Northern Region 17,462; Valley Region 10,221; Southside Region 3,285; Southwest Region 2,399; and Eastern Region 393.

- The incremental economic impact of increasing graduate production by 70,675 graduates over the baseline 2010 level of 57,600 over the next 10 years would result in a net present value gross domestic product impact of $18 billion. The effect on state revenues in net present value terms would be $1.9 billion in 2007 dollars.

- The social benefits of public higher education include improved community productivity, higher community educational attainment, better community health, lower crime, and greater social engagement.

Some social benefits that result in lower public assistance needs are realized in the form of government fiscal savings. An analysis of Virginia resident data from the U.S. Census indicates that total lifetime savings on public assistance, Medicaid, unemployment compensation, workers compensation, and corrections costs amount to $16,027 for an associate degree and $22,548 for a bachelor's degree in terms of present value.

- Approximately $350 million state and local government expenditures in terms of present value would be saved as a result of the additional education received by public higher education degree awardees in FY07 who continued to reside in Virginia throughout their lives. The degree initiative of producing approximately 70,000 more degrees between 2010 and 2020 would result in state and local government expenditure savings of $358 million.

- Fifty-six business startups created as a result of university-licensed technology over the period 1991-2008 have generated at least 626 Virginia jobs. The total economic impact of these fifty-six startups is 1,396 jobs, $124.2 million dollars in GDP and $9 million in state revenue.

- Virginia's public colleges and universities play important leadership roles in the state and their local communities by serving on planning committees, economic development task forces, and business contact groups. They have also assisted in recent state industrial recruitment activities and participated in incentive packages that attracted plants and facilities such as Rolls Royce in Prince George's County (500 jobs), SRI International in Rockingham County (100 jobs), and Northrop Grumman and CGI Group, Inc. in Russell County (700 jobs).

- Additionally, Virginia public higher education's support for technology transfer, business consulting and technical assistance, non-credit training and workforce development, the Virginia Cooperative Extension Program, and other activities are important for Virginia's economic competitiveness.

These results show that Virginia public higher education institutions make large contributions to Virginia's economy and government fiscal balances. They are also important assets in building the commonwealth's innovative, entrepreneurial, and workforce potential, and improving its quality of life. Moreover, significant additional economic impact could be realized by expanding public higher education capacity to produce more graduates.

INTRODUCTION

The purpose of the study is to evaluate the statewide economic impact of publicly supported higher education in Virginia. Although the value of public higher education cannot be reduced entirely to dollar figures, public institutions compete for funds that can be used in alternative ways. Therefore, demonstrating the economic contribution of public institutions and the return to investment of state funds provides a framework for economic accountability. The definition of public includes 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 described in Appendix A.1.[1] Although many in-state students at Virginia private colleges receive assistance through the Tuition Assistance Grant (TAG) program, the economic effects of these public contributions will not be considered for the purposes of this study. Furthermore, the impact of Virginia's private colleges are not measured; but their contributions to the state economy are substantial and could be estimated using the same methodology adopted in this study.

The study has three components. First, it provides a full accounting of the current flow of economic activity in Virginia that can be directly tied to the expenditures and activities of publicly supported institutions of higher education. Second, it presents a "what if" analysis of the additional economic impact that would result from an initiative to increase the number of undergraduate and graduate degrees awarded by Virginia public institutions. In undertaking this work, the study uses Regional Economic Models, Inc. Policy Insight Plus (REMI PI+) regional economic modeling software. Direct spending by the institutions, spending by students and visitors, and the flow of new degree recipients into the workforce are used to compute direct, indirect and induced contributions to economic activity. Outputs of the REMI model include calculation of the amount of Virginia gross domestic product, personal income, industrial output, employment and state tax revenues. Lastly, the study evaluates a broader set of economic and social benefits generated by the public higher education sector.

The study is divided into seven sections. The first section examines the history and important characteristics of Virginia's public higher education sector. These features include location, enrollment patterns, financial characteristics and differences between two-year and four-year institutions. The second section describes modeling and methodological issues related to estimating economic impacts of public higher education. The third section presents important features of the REMI PI+ regional economic impact model, describes model data assembly and introduces modeling scenarios used in estimating state economic footprint and impact. The fourth section presents the results of the economic footprint and impact analysis. The fifth section provides an analysis of the initiative to increase the number of degrees awarded by Virginia institutions by 70,000 in the next decade. The sixth section examines other private and public benefits associated with investment in college education, including enhancements to life circumstances such as access to better working conditions and better health and community benefits such as reduced dependence on social welfare programs. The seventh section catalogues other higher education economic development contributions in areas such as research and development, agricultural and industrial extension, small business training, work force development, leadership, and urban revitalization.

1. The study does not examine the economic effects of the Eastern Virginia Medical School (EVMS) located in the Hampton Roads region because the Governor did not appoint a majority of its board during the period of time that this study examines.

SECTION 1
VIRGINIA'S PUBLIC HIGHER EDUCATION SECTOR

American public higher education can trace its beginnings to the Commonwealth of Virginia. The College of William and Mary, founded in 1693 under Royal Charter, is the second oldest college in the nation. From the beginning, it depended on public funds raised through tobacco taxes and export duties (Brubacher and Rudy 1997).[1] College of William and Mary alumnus and Board of Visitor member Thomas Jefferson established the University of Virginia. Jefferson's goal was to establish a publicly supported secular "academical village." The University of Virginia was one of the nation's first state universities.[2] It introduced distinctive programs in the arts and sciences and was the first to offer graduate and professional education. Moreover, it was intended to be both publicly supported and secular.

From these roots many other green shoots grew. Old Dominion University, Christopher Newport University, and Virginia Commonwealth University have historical connections to the College of William and Mary. In 1960, the College of William and Mary established the two-year Richard Bland College. George Mason University, the University of Mary Washington, and Patrick Henry Community College once served as branch campuses of the University of Virginia. In 1954, the University of Virginia founded Clinch Valley College, renamed The University of Virginia's College at Wise in 1999.

Virginia's other public higher education institutions have other origins. The Virginia Military Institute is the nation's first state-supported military college. Virginia Polytechnic Institute and State University, popularly known as Virginia Tech, and Virginia State University are post-bellum land grant institutions that owe their existence to the federal Morrill Acts. James Madison University, Radford University, Longwood University and the University of Mary Washington began as state-funded teacher training schools called normal schools because their task was to establish teaching standards or *norms*. They became co-educational only in recent decades. A formal system of state-supported two-year community colleges was not established until 1966 in tandem with the national spurt of community college growth. However, two schools, Danville Community College and New River Community College, had already been created by their respective local communities and were integrated into the emerging system.

Today's public higher education sector has enormous geographical and even international reach.[3] There are a total of 39 public higher education institutions in the state, including 15 four-year institutions, one junior college (Richard Bland College), and 23 community colleges (see **Table 1.1** and **Figure 1.1**). Thus, most Virginia residents are within commuting distance of either a college/university main campus or one of approximately 50 branch campuses and centers (see **Table 1.2**). For instance, Virginia Tech operates five branch campuses that offer graduate and professional programs, in Falls Church (Northern Center), Roanoke (Roanoke Center), Abingdon (Southwest Center), Richmond (Richmond Center) and Virginia Beach (Hampton Roads Center). Undergraduate and graduate study opportunities are also available at other state-funded facilities. For instance, the New College Institute in Martinsville brings together several public higher education partners to make degree programs more accessible to residents of the Martinsville region. The Virginia Community College System's 23 service regions (see Figure 1.1) cover the state. The main campus hubs are supplemented by 40 branch campuses and centers. In addition, community colleges offer dual enrollment at local high schools that bring college coursework to high school juniors and seniors. Contract training offers education and training to individual workplaces around the state. Finally,

1. The College of William and Mary became a fully publicly supported institution in 1906 by act of the General Assembly [Virginia Historical Society, On This Day: Legislative Moments in Virginia History http://www.vahistorical.org/onthisday/3506.htm, Accessed August 3, 2009]
2. Brubacher and Rudy (1997) argue that it is "America's first real state university."
3. For example, Virginia Commonwealth University operates a branch campus in Qatar (VCUQatar) that offers programs in graphic, interior and fashion design.

Table 1.1. Virginia Public Higher Education Institutions

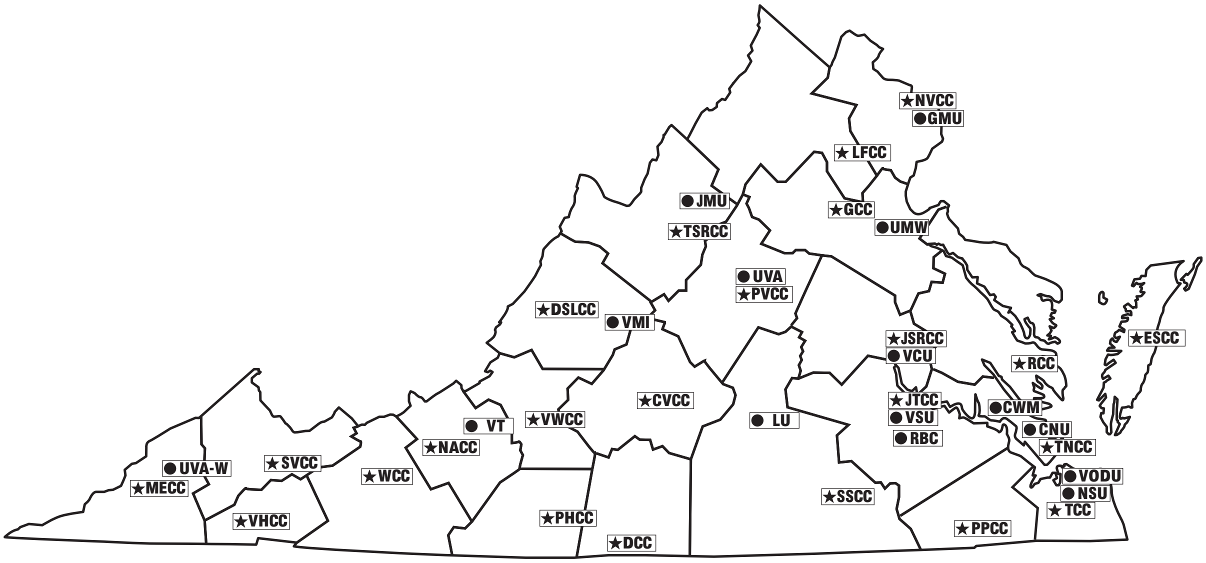
Institution	Main Campus Location	Fall 2008 Headcount[a]	Carnegie Classification[b]
Four-year			
Christopher Newport University	Newport News	4,763	Baccalaureate Colleges--Liberal Arts
College of William and Mary	Williamsburg	7,892	Doctoral/Research Universities--Intensive
George Mason University	Fairfax County	30,714	Doctoral/Research Universities--Intensive
James Madison University	Harrisonburg	18,454	Master's Colleges and Universities I
Longwood University	Farmville	4,727	Master's Colleges and Universities I
Norfolk State University	Norfolk	6,325	Master's Colleges and Universities I
Old Dominion University	Norfolk	23,086	Doctoral/Research Universities--Extensive
Radford University	Radford	9,157	Master's Colleges and Universities I
University of Virginia's College at Wise	Wise	1,964	Baccalaureate Colleges--Liberal Arts
University of Mary Washington	Fredericksburg	5,084	Master's Colleges and Universities II
University of Virginia	Charlottesville	24,541	Doctoral/Research Universities--Extensive
Virginia Commonwealth University	Richmond City	32,284	Doctoral/Research Universities--Extensive
Virginia Military Institute	Lexington	1,428	Baccalaureate Colleges--Liberal Arts
Virginia Polytechnic Institute and State University	Blacksburg	30,739	Doctoral/Research Universities--Extensive
Virginia State University	Petersburg	5,042	Master's Colleges and Universities I
Two-year			
Blue Ridge Community College	Weyers Cave	4,466	Associate's Colleges
Central Virginia Community College	Lynchburg	5,412	Associate's Colleges
Dabney S. Lancaster Community College	Clifton Forge	1,272	Associate's Colleges
Danville Community College	Danville	4,026	Associate's Colleges
Eastern Shore Community College	Melfa	939	Associate's Colleges
Germanna Community College	Locust Grove	6,515	Associate's Colleges
J. Sargeant Reynolds Community College	Richmond City	13,074	Associate's Colleges
John Tyler Community College	Chester	8,776	Associate's Colleges
Lord Fairfax Community College	Middletown	5,867	Associate's Colleges
Mountain Empire Community College	Big Stone Gap	3,075	Associate's Colleges
New River Community College	Dublin	4,889	Associate's Colleges
Northern Virginia Community College	Annandale	42,663	Associate's Colleges
Patrick Henry Community College	Martinsville	3,109	Associate's Colleges
Paul D. Camp Community College	Franklin City	1,628	Associate's Colleges
Piedmont Virginia Community College	Charlottesville	4,874	Associate's Colleges
Rappahannock Community College	Glenns	3,307	Associate's Colleges
Richard Bland College	Petersburg	1,634	Associate's Colleges
Southside Virginia Community College	Alberta	5,606	Associate's Colleges
Southwest Virginia Community College	Richlands	3,984	Associate's Colleges
Thomas Nelson Community College	Hampton	10,557	Associate's Colleges
Tidewater Community College	Norfolk	26,898	Associate's Colleges
Virginia Highlands Community College	Abingdon	2,650	Associate's Colleges
Virginia Western Community College	Roanoke City	8,532	Associate's Colleges
Wytheville Community College	Wytheville	3,363	Associate's Colleges

Source: U.S. Deptartment of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx and State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/e2-report.asp

a. Includes both undergraduate and graduate enrollment.

b. 2000 Carnegie Classification by the Carnegie Foundation based on institution's degree-granting activities. http://www.carnegiefoundation.org/classification/

Figure 1.1 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	The University of Virginia's College at Wise
VCU	Virginia Commonwealth University
VMI	Virginia Military Institute
VSU	Virginia State University
VT	Virginia Polytechnic Institute and State University

● 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

Virginia Community College System (continued)

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

Table 1.2. Virginia Public Higher Education Institution Branch Campuses and Centers

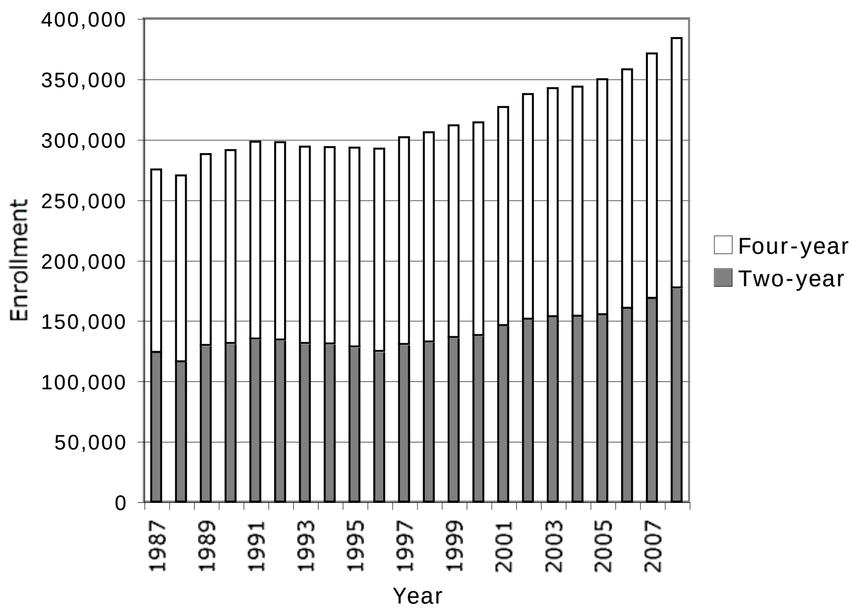
Institution	Branch Campus or Center	Location
Four-year		
George Mason University	Arlington Campus	Arlington
	Prince William Campus	Manassas
	Mason in Loudoun	Sterling
Norfolk State University	Virginia Beach Higher Education Center	Virginia Beach
University of Mary Washington	College of Graduate and Professional Studies	Stafford County
Virginia Tech	Hampton Roads Center	Virginia Beach
	Northern Virginia Center	Falls Church
	Richmond Center	Richmond City
	Roanoke Center	Roanoke City
	Southwest Virginia Center	Abingdon
Two-year		
Blue Ridge Community College	Augusta Center at Augusta Medical Center	Fishersville
	Harrisonburg Center	Harrisonburg
Central Virginia Community College	Altavista Center	Altavista
	Appomattox Center	Appomattox
	Bedford Center	Bedford
	Brookneal Center	Brookneal
Dabney S. Lancaster Community College	Greenfield Center	Daleville
	Rockbridge Regional Center	Buena Vista
Danville Community College	Regional Center for Advanced Technology and Training	Danville
Germanna Community College	Fredericksburg	Fredericksburg
	Daniel Technology Center	Culpeper
J. Sargeant Reynolds Community College	Parham Road Campus	Richmond City
	Western Campus	Richmond City
John Tyler Community College	Midlothian Campus	Midlothian
Lord Fairfax Community College	Fauquier Campus	Warrenton
	Luray-Page County Center	Luray
Northern Virginia Community College	Alexandria Campus	Alexandria
	Loudoun Campus	Sterling
	Manassas Campus	Manassas
	Medical Education Center	Springfield
	Woodbridge Campus	Woodbridge
	Arlington Center	Arlington
	Reston Center	Reston
	Extended Learning Institute	Springfield
Patrick Henry Community College	Main PHCC Campus	Martinsville
	Franklin County	Rocky Mount
	The PHCC Site at the Patrick County Community Bldg.	Stuart
Paul D. Camp Community College	Hobbs Suffolk Campus	Suffolk
	PDCCC at Smithfield	Smithfield
Rappahannock Community College	Warsaw Campus	Warsaw
Southside Virginia Community College	Blackstone	Blackstone
	Chase City	Chase City
	Cumberland	Cumberland
	Emporia	Emporia
	Keysville	Keysville
	South Boston	South Boston
	South Hill	South Hill
Thomas Nelson Community College	Historic Triangle	Williamsburg
Tidewater Community College	Chesapeake Campus	Chesapeake
	Portsmouth Campus	Portsmouth
	Virginia Beach Campus	Virginia Beach

distance learning programs bring learning to individual homes.

Public higher education's scope has also grown over time. While colonial era higher education was considered the preserve of a white, male elite, barriers to full participation have gradually dissolved. In addition, colleges and universities have diversified their curricula and missions to encompass education, research, public service, and economic development. Colonial era college curricula emphasized theology and classic subjects. But, following the Revolutionary War, enlightenment influences spurred a more secular and scientific orientation (Brubacher and Rudy 1997). The establishment of land grant institutions through the federal Morrill Land-grant Acts provided more impetus to the shift to vocational technological education and also introduced a public service element in the form of "extension services" in response to the need for dissemination of practical information about university innovations. During the late 1880s and early 20th century, higher education institutions transitioned from being primarily centers of learning to modern research universities (Goldin and Katz 1999). Following World War II, university research and development activities expanded through federal research patronage, as did public enrollments spurred by the G.I. Bill. With the passage of the Bayh-Dole Act (also known as the University and Small Business Patent Procedures Act) in the early 1980s, there has been a further bolstering of the role of colleges and universities in regional economic development through commercializing university research, encouraging business spinoffs and entrepreneurship, promoting partnerships with private industry and engaging local communities through economic leadership and planning (Drucker and Goldstein 2007; Goldstein and Renault 2004). Modern public colleges and universities simultaneously wear many hats, and their success is measured in different ways.

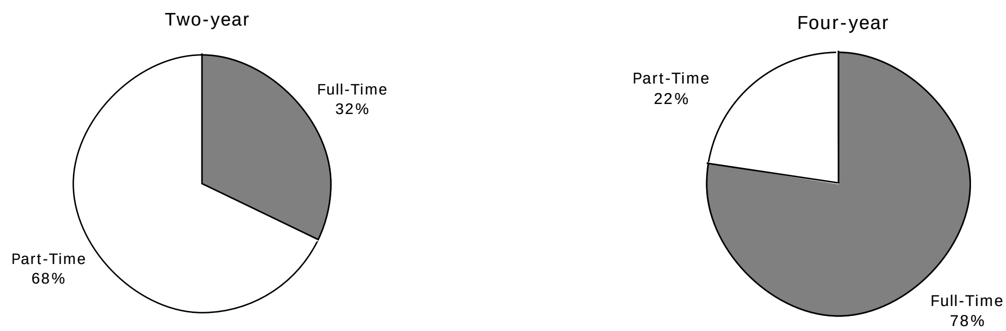
Virginia public higher education enrollment has grown in tandem with geographical expansion and addition of services. During the last twenty-two years, Virginia's public higher education institution enrollment has grown rapidly, adding 40 percent more students since 1987 (see **Figure 1.2**). This rate of growth exceeds state population growth of 31 percent during the same period as a greater share of the population enrolls in postsecondary education. The growth has been slightly faster at two-year colleges (43 percent) compared to four-year colleges (37 percent), but 74 percent of two-year college growth has occurred since 2000 whereas four-year growth has been more even over the period. In part, this growth pattern reflects greater community college enrollment responsiveness to business cycles, including the current economic recession as a consequence of their more affordable tuition and the greater demand for displaced workers to retool themselves. The faster growth also reflects community colleges' role as gateway institutions with open door admission

Figure 1.2 Virginia Public Higher Education Enrollment, 1987-2008



Source: State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/e2_report.asp

Figure 1.3 Enrollment by Credit Course Load, 2008

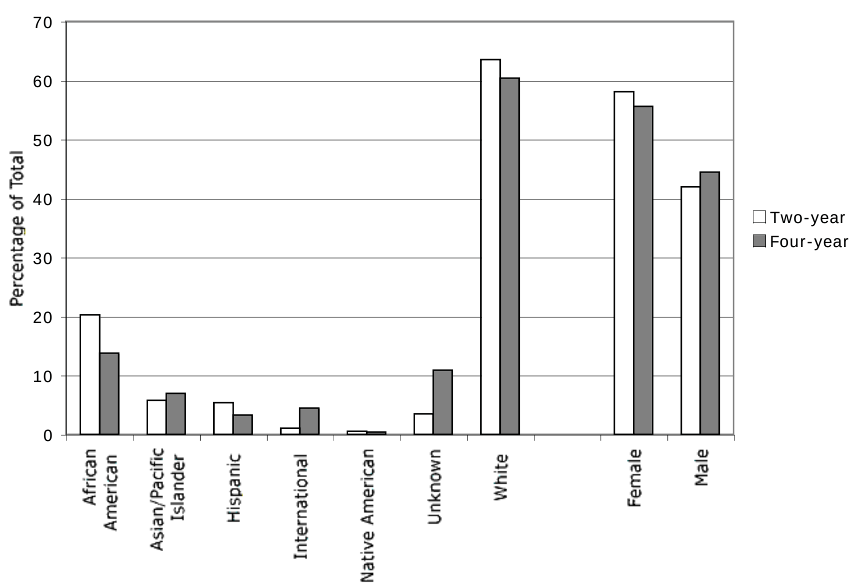


Source: State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/e2_report.asp

policies, more affordable tuition and geographically accessible locations, which are attractive to first-generation students, as well as non-traditional college students such as displaced workers, homemakers and working adults.

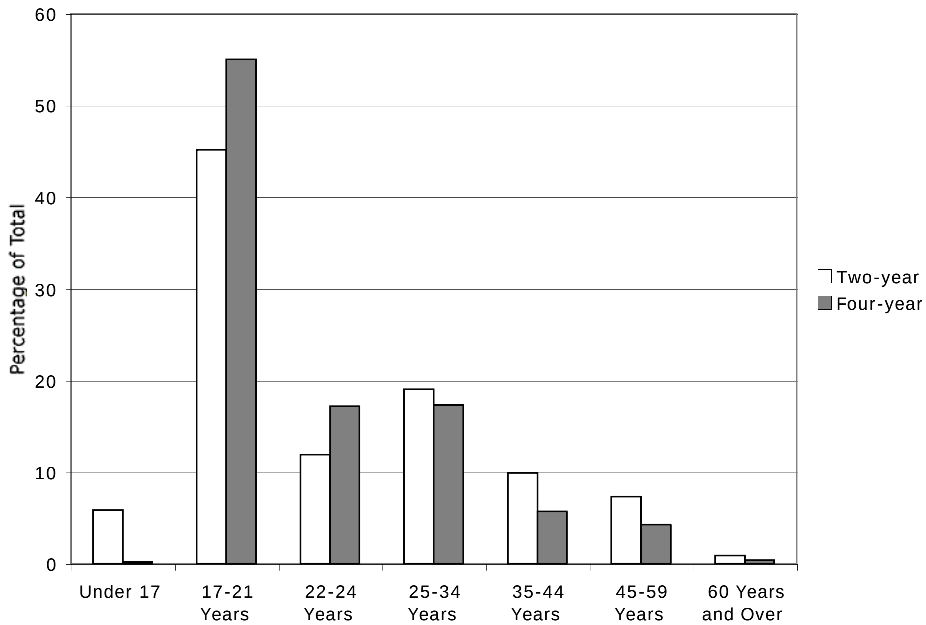
Two-year and four-year institutions differ in important respects, with two-year schools serving a much more diverse population of students. Two-year students are much more likely to be part-time (see **Figure 1.3**), minority, female (see **Figure 1.4**), and outside the traditional college age bracket (see **Figure 1.5**). Over two-thirds of two-year college students are part-time compared to less than a fourth for four-year students, with two-year students much more likely to balance school, workplace, and family demands. African American and Hispanic students make up nearly 26 percent of enrollment in two-year schools compared to 17 percent in four-year schools. Two-year colleges also serve a relatively large proportion of high school age students through the dual enrollment Early College Scholars program (6 percent of their total enrollment versus less than one percent for four-year institutions). Older adult students are also more highly represented in their ranks (37 percent of total enrollment is 25 years of age or older compared to 28 percent for four-year colleges).

Figure 1.4 Enrollment Distribution by Race and Gender, 2008



Source: State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/e2_report.asp

Figure 1.5 Enrollment Distribution by Age, 2008



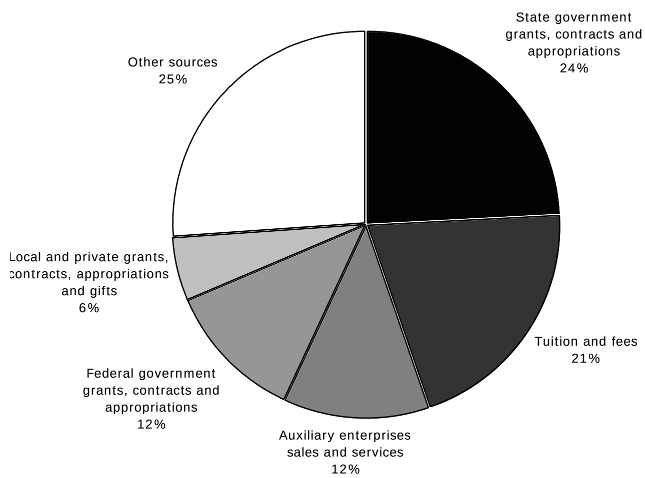
Source: State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/e2_report.asp

Public higher education derives about one fourth of its revenue from state government (see **Figure 1.6**). Overall, it spends about 29 percent on instruction, 12 percent on auxiliary services, and 11 percent on research (see **Figure 1.7**). Here too there are significant differences in the revenue and expenditure patterns of two-year and four-year colleges. Approximately half of community college revenues come from the state compared to less than one quarter for four-year institutions (see **Table 1.3**). Four-year colleges, on the other hand, depend proportionately more on out-of-state revenues. They serve a much higher proportion of non-resident students (see **Table 1.4**) and consequently draw a proportionately higher percentage of tuition revenues from out-of-state sources. Because four-year colleges have many students who reside on campus, the colleges earn more from auxiliary services such as student housing and cafeteria services.

The varied expense patterns reflect differences in educational missions and scale. Forty-six percent of two-year institution expenses are incurred for instruction compared to 27 percent at four-year institutions (see **Table 1.5**). In contrast, 15.1 percent of four-year expenses are incurred for hospital services (reflecting UVA and VCU medical center expenses) and 12.4 percent for research compared to zero on each category for two-year colleges. Also, four-year college spending is much higher on a student full-time-equivalent (FTE) basis because of the wider array of services offered, higher faculty and staff salaries, and the expenses of specialized programs that require costlier research labs, clinical spaces and equipment.

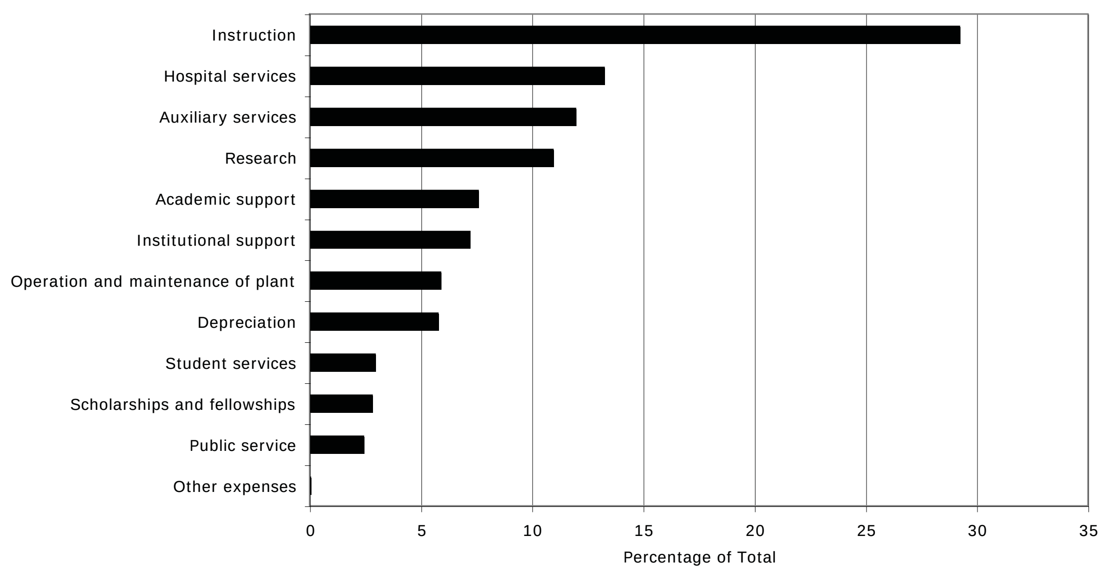
Today, both two-year and four-year schools in the Virginia public higher education system play a key role in educating the future workforce. Public institutions graduate 74 percent of all degree recipients (see **Figure 1.8**), including 74 percent of associate and bachelor's degree recipients, 77 percent of master's and doctorate degree earners, but only slightly over half of first-professional degree awardees. In addition, public institutions confer 96 percent of architecture and construction trades degree program awards (see **Figure 1.9**). They are also responsible for over 80 percent of degrees in engineering and technologies and in natural sciences and mathematics, a pool of talent that helps to maintain state scientific competitiveness.

Figure 1.6 Virginia Public Higher Education Revenue by Source, FY 2007



Source: U.S. Dept. of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx

Figure 1.7 Virginia Public Higher Education Expenses, FY 2007



Source: U.S. Dept. of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx

Table 1.3 Virginia Public Higher Education Operating and Non-operating Revenues ($) by Source, FY 2007

Revenue Source	Four-year	Two-year	Total
Tuition and fees (in-state and out-of-state students)	1,240,115,649	214,418,620	1,454,534,269
Federal government grants, contracts and appropriations	709,789,197	103,617,113	813,406,310
State government grants, contracts and appropriations	1,334,415,602[a]	369,711,381	1,704,126,983
Local and private grants, contracts, appropriations and gifts	376,344,714	13,352,691	389,697,405
Auxiliary enterprises sales and services	854,119,948	13,614,142	867,734,090
Other sources	1,808,806,864	28,268,645	1,837,075,509
Total revenue	6,323,591,974	742,982,592	7,066,574,566[b]
Estimated out-of-state revenue[c]			
Amount	1,599,022,514	136,307,668	1,735,330,182
Percent of total revenue	25.3%	18.4%	24.6%

Source: U.S. Dept. of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx

a George Mason University reported a $46.8 million capital appropriation as a state non-operating grant (correspondence with Robert Bussjaeger, Director of Financial Reporting and Tax Accounting, September 4, 2009). This amount was subtracted from the IPEDS total.

b Operating and non-operating revenues will not equal operating expenses described in Table 1.4 because some non-operating revenues are not used and cannot be used to fund current expenses. For instance, UVA's endowment appreciated by 25 percent in FY07 due to favorable market conditions that year resulting in over $700 million in investment income. These funds are dedicated to certain uses in perpetuity and cannot be assigned elsewhere.

c Revenue from out-of-state sources includes federal operating grants and contracts, federal appropriations, federal non-operating grants and the out-of-state derived portion of tuition and fees and other residual categories (e.g., private gifts and contracts, auxiliary enterprises) imputed on the basis of out-of-state enrollment.

Table 1.4 Student Residency by Institution Level and Degree Program, Percentage of Total, Fall 2008

Institution Level	In-state	Out-of-state
Two-year	94.5	5.5
Four-year		
Undergraduate	80.7	19.3
Graduate	71.9	28.1
Professional	59.7	40.3

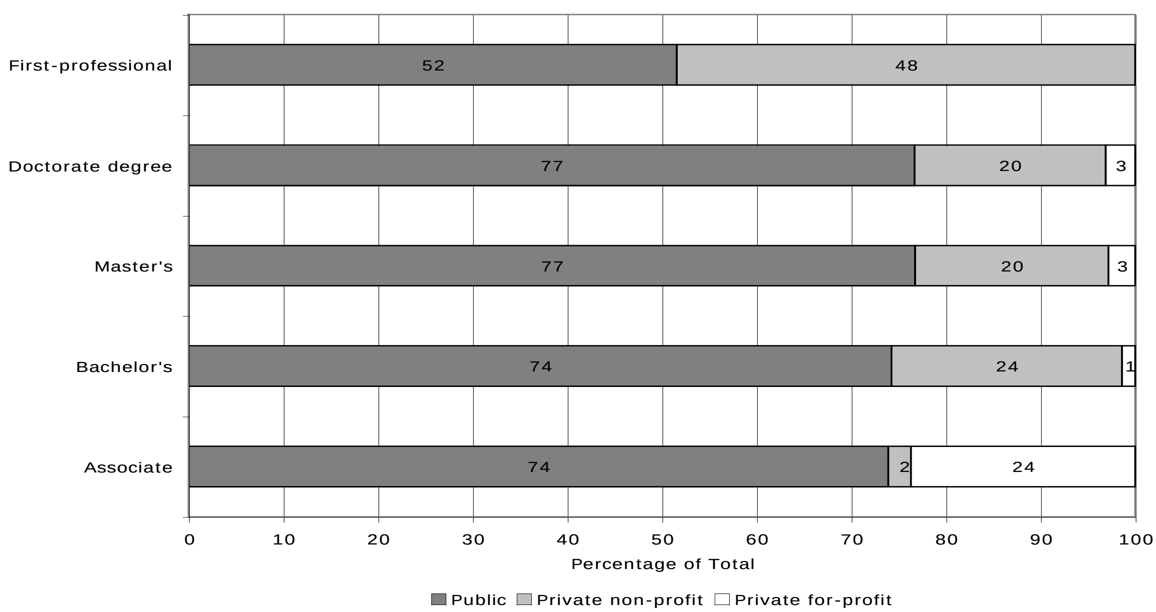
Source: State Council of Higher Education for Virginia, Basic enrollment report by institution, http://research.schev.edu/enrollment/e2_report.asp

Table 1.5 Virginia Public Higher Education Operating Expenses ($) by Type, FY 2007

Type of Expense	Four-year	Two-year	Total
Instruction	1,472,154,687	344,793,331	1,816,948,018
Research	679,753,819	0	679,753,819
Public service	145,852,440	4,659,871	150,512,311
Academic support	399,368,643	71,621,757	470,990,400
Student services	127,565,548	55,844,520	183,410,068
Institutional support	335,170,489	112,902,511	448,073,000
Operation and maintenance of plant	292,619,557	72,983,037	365,602,594
Depreciation	333,780,383	24,796,019	358,576,402
Scholarships and fellowships	121,163,411	53,793,522	174,956,933
Auxiliary services	732,206,760	11,319,761	743,526,521
Hospital services	823,179,025	0	823,179,025
Other expenses	1,385,708	261,503	1,647,211
Total	5,464,200,470	752,975,832	6,217,176,302

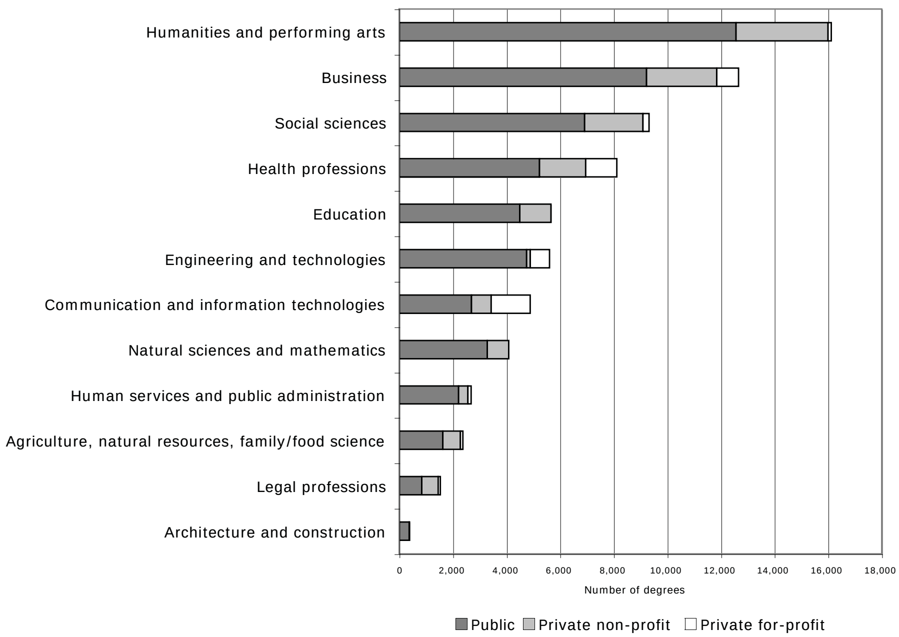
U.S. Dept. of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx

Figure 1.8 Virginia Degrees by Level and Institutional Control, 2006-2007



Source: U.S. Dept. of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx

Figure 1.9 Virginia Degrees by Field and Institutional Control, 2006-2007



Source: U.S. Dept. of Education, National Center for Education Statistics. Integrated Postsecondary Education Data System (IPEDS). http://nces.ed.gov/ipeds/datacenter/login.aspx

SECTION 2
REVIEW OF METHODOLOGICAL ISSUES

Higher education institutions can affect a state, regional, or local economy through a variety of different channels. Among these paths are the expenditures of the institutions and their students, improvements to human capital, knowledge creation through research, knowledge dissemination from extension and outreach, stimulation of entrepreneurship, influences on industry location decisions, improvements to quality of life, expenditures of visitors and tourists, and the provision of regional leadership on economic development matters (Bartik and Erickcek 2007; Goldstein and Renault 2004). However, traditional economic impact analysis has focused on only the most easily quantifiable features, such as expenditures on educational inputs (Felsenstein 1996).

Higher Education Expenditures

Although the expenditures associated with higher education are relatively straightforward to identify in theory (e.g., higher education employee payrolls, higher education outlays on goods and services and student expenditures), assigning these expenditures in a way that the net regional impacts of educational institutions can be gauged is complex. There are several reasons for this difficulty.

First, there are obvious differences in the degree to which models adequately represent the features of a regional economy. Giesecke and Madden (2006) identify several categories of economic impact methods with a continuum running from simplistic economic base analysis, to input-output techniques and to computer general equilibrium (CGE) models. These models differ in the degree to which they capture inter-industry relationships and the complex role of markets in regional economies. Economic base models relate export base expenditures to changes in overall economic activity due to a single multiplier effect. Input-output models trace expenditures backwards through the industrial supply chain to identify the additional business volume that results from aggregated industry "multiplier effects." CGE models attempt to capture the effects of expenditure changes by allowing product and factor (e.g., labor, capital) markets to adjust. For example, the injection of new expenditures not only increases area output, it raises wage levels and induces in-migration and in-commuting of workers, raises local housing prices, and increases demand for public services. These adjustments may have additional effects on local output, both positive and negative.

Second, in efforts to ensure that the flows from all higher education activities are captured, there is a considerable hazard of double counting (Siegfried et al. 2007). This problem arises because of the aggregate manner in which financial accounts are often presented, and the inability of the researcher to identify the exact geographical origin of expenditures. For instance, typically, impact models will account for the effects of university payrolls spent in the regional economy. However, if some of this spending occurs at higher education institutions themselves, the impact will already be accounted for in institutional expenditures to create the goods and services being sold. Employees may purchase higher education services and products ranging from auxiliary services such as cafeteria and bookstore items to tickets to university sporting events. Another example is the expenditures of students who work part-time in local eateries and other establishments. The expenditures of students are typically represented in higher education impact studies by independently surveying the students about their local purchases. However, if these expenditures are drawn from regional earnings, the earnings and induced spending may already be reflected in economic impact results.

Third, the funds used for expenditures on public higher education have alternative uses. If public higher education institutions ceased to exist, the funds would be used elsewhere in the economy, perhaps on other consumer goods, capital goods, government services, or private educational goods and services. The displacement that occurs as a result of the reallocation of funds from alternative uses must be measured if the net contribution (what is customarily referred to as "economic impact") of the educational institution to the regional economy is to be gauged.[1] Alternatively, if in-state private higher education options were not available, the funds spent on public higher education might be redirected to spending outside the state, including public or private higher education available in other states.

The existence of in-state public educational opportunities stems the leakage of this spending elsewhere. This "import substitution" function of higher education can be re-interpreted as a net gain to the regional economy in much the same way that expenditures originating from outside the state in the form of out-of-state student tuition and expenditures or federal grants and or "export expenditures" represent an injection of funds into the regional economy.

In economic impact analysis, accurate measurement boils down to isolating these three forces that shape "impact": displacement, import substitution, and export. Three approaches to dealing with this issue have been adopted. First, many studies adopt the conservative approach of estimating only the portion of expenditures that can be attributed to external (export or out-of-state) sources. The popularity of this method can be attributed to the endorsement of the American Council on Higher Education of a study done by Caffrey and Isaacs (1971) that laid out a template for assembling the primary and secondary data to estimate economic impacts (Blackwell et al. 2002). Second, many have utilized the non-committal approach of "economic footprint" measurement in which all higher education expenditures are captured regardless of source to show the effect of higher education without attributing causal impact. Third, some studies have attempted to estimate the magnitude of import substitution by asking students what they would do if higher education options no longer existed.[2] For instance, a system-wide survey of North Carolina public higher education students found that 33 percent of in-state students and 63 percent of out-of-state students would have gone outside of North Carolina if the University of North Carolina system were not available.[3]

While this approach might generate reasonable answers when the question concerns the options a student might consider if a single institution were closed, it would be hasty generalization to expect the same degree of accuracy for a question involving the closure of an entire public educational system. Students typically apply for admission to different colleges and might be aware of "second best" choices in the hypothetical situation that their first choice is denied, but it is not likely that they have seriously considered the ramifications that removing an entire system of state-supported higher education institutions would have on the availability and costs of education elsewhere. Furthermore, the capacity of private institutions in Virginia could not be immediately increased.[4] Bartik and Erickek (2007) cast considerable doubt over the possibility of performing these types of thought experiments or properly accommodating them in regional models designed for marginal analysis.

Clearly, the import substitution possibilities of higher education will differ based on student attributes, such as socioeconomic status, parental educational background, career and life goals, peers, and distance from alternative educational institutions (Chapman 1981). For instance, Kodrzycki (2001) finds that out-migrating students are much more likely to come from upper middle class families and families whose parents are college educated. Frenette (2008) shows that distance to educational institution is a significant deterrent to matriculation, particularly for members of household drawn from lower socioeconomic levels.

Likewise varied institutional missions, selectivity, and program mixes suggest that some institutions will be responsible for more import substitution than others.

1. These displacements may be positive or negative depending on the magnitude of leakages outside of the local economy associated with the alternative expenditure and disincentive effects of taxation.
2. The import substitution can also be based on conjecture or the results of previous studies. For example, Norfolk State University impact study (Brod 2004) assumes half of those from within the region would go elsewhere without the institution and three quarters of those from outside of the region would attend elsewhere. Bluestone (1993) uses survey data and guestimates to arrive at the conclusion that 57 percent of entering students would not attend college at all at the University of Massachusetts, Boston if a public higher education option did not exist in Massachusetts.

3 The study does not address what share of students would have opted to go to in-state community colleges and private colleges versus not going to college at all.
4. In the short run, private for-profit and non-profit colleges within the state could not cope with the influx. Non-profit colleges could accommodate with adjustments an estimated 11,000 students (State Council of Higher Education for Virginia 2005).

Large institutions and those with more highly specialized programs draw their students from a wider radius and closing them would induce substantial out-migration. On the other hand, community colleges primarily draw students from their service area that for reasons of financial and geographical access would likely not have gone to school without the existence of the college. Many residents are induced to attend community college because of its much lower costs, closer proximity, and greater ease in combining course work with employment and home obligations. In between the two are regional colleges and universities that draw relatively large proportions of students from their immediate regions.

Human Capital

Bluestone (1993) and Berger and Black (1993) marked a break from the conventional expenditure-only approach to recognize the role of higher education outputs, especially human capital. However, measuring the economic impacts of these outputs is fraught with even greater difficulties than higher education expenditures (Felsenstein 1996). While degrees granted is a useful broad measure of educational output these figures must be converted into economically meaningful numbers.

The first obstacle to making the conversion arises from determining the impact of human capital stocks on economic outcomes.[5] Earnings and productivity gains that accrue to individuals and firms from additional human capital investment are not readily observable. Fortunately, census data on earnings and educational achievement and productivity and workforce quality is available to make reasonable imputations. For example, earnings differentials by educational achievement level based on national averages provide one gauge of the value-added of a degree. 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 assign that portion of the earnings differential to ability rather than education. Some researchers argue that this 'ability bias' is important with recent estimates from twin studies suggesting that the bias ranges from 6-12 percent of the earnings differential, while others argue that there are equal and offsetting errors and biases such as measurement error that render national averages usable (McMahon 2009).

The second obstacle stems from assigning human capital stocks to regions. This problem results from the fact that human capital is mobile. Graduates migrate and individuals with higher levels of education are even more prone to migrate because their more specialized skills command a larger geographical market. Therefore, states do not necessarily reap the full rewards in terms of resident educational attainment by increasing the production of college graduates.[6] The ability of states to retain graduates depends on two factors. First, the propensity to migrate is influenced in part by an individual's regional attachments or alternatively stated, the psychic costs of moving. These regional attachments, represented by whether the graduate was born in the region, 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). Strong regional labor markets are also important in retaining graduates (Kodrzycki 2001).

The economics literature provides disparate estimates of the net effects of increased college graduation flows on state stocks of human capital. At one end of the divide, Bound et al. (2004) found that the effect of a state producing a flow of 1,000 new college graduates would increase the net number of state residents with college education by only 300 after 15 years. The net stock addition is lower than the flow of graduates because of the attrition of resident graduates who seek employment elsewhere and discouragement of would-be in-migrants which results from the drop in relative wages induced by the initial increases in graduate occupational supply. At the other end, Trostel (2007a) estimates that there is a nearly one-to-one relationship

5. There are also problems with using years of education as a human capital measure. First, there is tremendous heterogeneity in the value-added by years of education, academic discipline and quality of degrees from different institutions. Second, human capital, like physical capital, depreciates over time if not accompanied by lifelong learning.

6. Brown and Heaney (1997) argue that because completing a degree increases the probability of migration, the loss of earnings and productivity of migrants who would have remained had they not received an education should be deducted from any human capital impact analysis.

between graduate flows and long-term human capital stock additions because a more educated labor force attracts employers.

Retention rates computed from college/university tracer studies and longitudinal survey data provide a basis for comparison, but they merely track specific graduating cohorts over time and do not attempt to capture the equilibrium effects of increased supplies of educated labor on regional stocks of human capital. A survey of state higher education conducted by the National Association of State Universities and Land Grant Colleges (NASULGC 2001) indicates that the average responding institution reported that 67 percent of graduates reside in the state for "a significant period of time" after graduation. Unfortunately, individual institutions define the time-period differently. Kodrzycki (2001), using National Longitudinal Survey of Youth (NLSY) data finds that migration of college graduates is most pronounced within the first five years of graduation. Approximately 15 percent of college graduates move to a different state a year after graduating; this increases to 30 percent by the fifth year and levels off at 39 percent in the tenth year.[7] Perry (2001) computes that 81 percent of resident graduates still lived in-state four years later versus 17 percent of non-resident graduates using data from the Baccalaureate and Beyond Longitudinal Study (B&BLS). Statistics from Adelman (2004) using the National Education Longitudinal Study (NELS: 88/2000) show that 61.9 percent of both resident and non-resident graduates were living in the same state in which they obtained the bachelor's degree on average 3.5 years later.

A third obstacle to converting increases in human capital stock into an economic impact measure is the existence of economic spillover effects. For instance, increases in regional workforce higher education attainment have been found to be associated with productivity increases that raise the wages of high-school dropouts and high school graduates (Moretti 2004a, 2004b).

Not all of the economic effects of human capital investment can be expressed in terms of increased graduate earnings and productivity. For example, higher education has been found to be associated with a greater likelihood of starting a small business, a higher rate of business survival, and greater small business success (Dobbs and Hamilton 2007; Storey 1994; Bates 1990). Some studies of higher education have attempted to capture the effects of the increased economic activity and employment due to alumni entrepreneurship through graduate surveys. For example, a study of the Penn State University system (Tripp Umbach 2004) found that more than 15,000 alumni-owned businesses employed more than 425,000 residents, although it was not clear from the report how many of the firms or jobs were created after and as a result of the graduate's education. College education attainment is also associated with lower public expenditures on certain public services such as subsidized medical care, the criminal justice system, and welfare (McMahon 2009; Trostel 2007b). These expenditures have obvious fiscal and economic consequences.

Research and Development

Research is another key part of the higher education mission that received much more attention in the economic development literature in recent years because of success stories surrounding the Massachusetts Institute of Technology (MIT) nurturing of technology startups in the Route 128 region and Stanford University's role in the rise of Silicon Valley. *New Growth Theory* (Romer 1990), which assigns great importance to research and development in economic growth, has provided the theoretical underpinnings. However, some scholars question the empirical evidence supporting the role of R&D as a major driver of regional growth, especially when compared to higher education expenditures and human capital. Bartik and Erickek (2007) note that studies of university research and development economic effects are not easily generalized because results are extremely sensitive to the innovation measure, time period and regions used by the study. Lester (2005) points out that university research and development activities account for only a small share of U.S. R&D output activity. Private corporations are overwhelmingly the most active patenters, but just 2 percent of patents are issued to universities. Moreover,

7. Bartik (2009) estimates that the percentage of college graduates that live in the state of their birth during their working ages is 49 to 59 percent using U.S. Census 2000 Public Use Microdata Sample (PUMS) data. Moreover, he corroborates that the propensity to stay stabilizes around the age of 30 for college graduates.

only about 2-3 percent of startups are located near universities. Finally, university technology licensure revenue, although growing, is relatively small and equates to just 4 percent of university research and development expenditures.

Typical direct outputs of higher education research and development activities include research papers, patents, revenues from licensed technologies, number and type of industry-university cooperative research centers and business startups resulting from university research. But, there is some disagreement over the economic value derived from each of the various types of research outputs. For instance, an output like a refereed journal in the sciences confers legitimacy on the author but does not necessarily translate into an immediate commercial benefit to the author, sponsoring higher education institution, or readers. Patents may provide a better proxy for innovation value but they too may have pitfalls. Not all innovations will be patented. Furthermore, quantity does not translate into quality; the mere issuance of a patent does not mean that the patent is innovative or economically useful. For that reason, many researchers have turned to patent citations as a measure of innovation value (Trajtenberg 1990). When patents are cited, the patent applicant and/or examiner provides independent corroboration of the innovation contribution of the patent. Patents cited with greater frequency therefore generally have more inovation value.

Licensure revenues from patented higher education technologies provide one readily available measure of economic value. These revenues, in turn, are re-spent on university technology patenting and licensure services, royalties to faculty inventors and payments to the colleges and universities to support research activities and facilities. These payments then generate multiplier effects like other university related expenditures. But, this measure generates only a small part of the regional economic impact that can be attributed to such activities (Pressman et al. 1995). To the extent that licensure activity results in local startups or generates additional employment in resident firms, these additions should be counted as university related impacts.

For the nation, startups based on university-licensed technology generate a significant amount of economic activity. The Association of University Technology Managers (AUTM) estimated that nationwide such spinoffs were responsible for $42 billion in economic activity and 367,407 jobs in FY 2002 (Lynch and Aydin 2004). Yet a relatively small number of universities such as the Massachusetts Institute of Technology (MIT) and Stanford account for the most successful startups. Still, the results of other state university studies suggest modest impacts that cannot be ignored. For instance, the University of Florida generated 61 companies that created 921 direct jobs with a total impact (including indirect effects) of 1,925 in employment (Harrington 2006).

These figures underestimate the job creation attributable to university innovation. First, not all jobs created with licensed technologies are used by new startups. Pre-existing companies form the bulk of the client base. However, most of the documented jobs appear to be associated with such startups. For example, Pressman et al. (1995) find that 70 percent of the jobs created by MIT licensed technologies were in start-up companies, but these startups accounted for only 35 percent of the total number of licenses. Second, many faculty businesses may rely on unlicensed technologies or sell consultancy expertise. MIT faculty and graduates are said to have created approximately 4,000 firms by 1997 since the school was established, but only 200 of these were startups (Lester 2005). An economic impact study for George Mason University suggests that the income accruing to such outside activities may be significant for universities. For that school, full-time faculty earned supplemental income amounting to 24 percent of their university income (Fowler and Fuller 2005). However, it is unclear how much of the income can be attributed to business and consulting activity connected to university research.

The clustering of research and development activities found at large research universities may help to create a "regional innovative milieu" that catalyzes innovation spillovers and influences firm location decisions. Two factors appear to be important in influencing firm location behavior: the potential for sharing in "tacit" or unpublished knowledge generated by university researchers (Audretsch and Stephan 1996) and the availability of a pool of graduate students that can be trained and recruited for temporary or permanent employment. Some of these relationships may be formalized in Industry-University Cooperative Research Centers (IUCRCs) where faculty expertise, graduate students, and facilities are shared with firms. IUCRCs, including ones funded by the National Science Foundation and the U.S. Department of Commerce, have been found to result in some benefits to participating firms such as additional patenting activity, lower likelihood of company failure, and improved products or processes (Campbell et al. 2009; Feller et al. 2002; Adams et al. 2001).

Firm Growth

Higher education institutions may affect regional firm growth both directly and indirectly. Institutions interact directly with firms and entrepreneurs by providing specific business planning, technical and real estate services. For example, colleges sponsor entrepreneurial development services by partnering with Small Business Development Centers. Services provided by the centers have been shown to increase firm capacity in many instances (Chrisman 1985).

In addition, institutions support industrial extension and technical assistance centers such as Virginia's Philpott Manufacuring Extension Partnership, which provides business process and industrial engineering services to small and medium sized firms. Such programs can lead firms to adopt specific technologies and industrial processes earlier than they would have otherwise and to be more receptive to new technology investment (Shapira and Rephann 1996).

Finally, colleges and universities sometimes lease land and provide business support services in the form of university research parks (also called science and technology parks) and business incubators in an effort to cluster firms to promote synergistic growth. Luger and Goldstein (1991) indicate that university research parks have had mixed success in generating business tenants and that some of the parks that survive are converted to more general business parks that accept all kinds of tenants, many of which would likely have located in the region anyway. However, the type of institution that sponsors the park and its relationship with the park are predictive of success. Link and Link (2003) reinforces the importance of these connections, suggesting that restrictive tenant criteria limiting occupants to technology firms or firms that collaborate with faculty and graduate students grow at a faster pace in terms of the number of firms and employment.

Higher education institutions also affect firm growth indirectly by increasing the regional supply of skilled labor. The importance of an educated workforce in attracting and retaining businesses is well established (Blair and Premus 1987). Among high tech firms it is generally listed as the most important factor, with other attributes associated with higher education such as quality of life and technology infrastructure also ranking high (Varga 1998; Haug and Ness 1993).

University R&D activities can also attract firms. However, evidence suggests that the attractive force varies significantly by industry sector, geographic location, and entrepreneurial dynamics of the region. Varga argues that industrial activities involving significant research and development, prototype manufacturing, and customized production are best poised to take advantage of university proximity while batch production using established technology will find low-cost production locations elsewhere. This hypothesis is consistent with some major research findings, including Jaffe's (1989) research relating university R&D to innovation in the pharmaceuticals, medical technology, electronics optics and nuclear technology sectors, and Bania, Eberts and Fogarty's (1993) finding that university research stimulates firm startups in electrical and electronic equipment. Varga's work suggests that city size or agglomeration economies play an important role in the ability of a region to capitalize on university research. The same university research expenditures have much greater impact on innovation output in metropolitan areas with at least one million residents than elsewhere. There are other "X factors" that determine a region's technological "absorptive capacity," according to Feldman (1994) and Mayer (2007). They point to cases where top-tier research universities in large cities, such as Johns Hopkins University in Baltimore, have failed to stimulate regional technology employment. They argue that a region must also host an "innovative milieu" or an "innovation infrastructure." Alternatively stated, they emphasize the need for an entrepreneurial culture that is able to digest research and development outputs. Smilor et al. (2007) suggest that university and regional leadership can be an important mechanism for fostering such an environment.

Tourism and Amenities

Regional economies can benefit both directly and indirectly from the presence of higher education institutions through tourism and amenity creation. Universities attract visitors because of students and faculty, conference activities, student recruitment activities, alumni events, special events arranged around sports, cultural and entertainment programs, and the availability of medical services. The array of university sponsored activities provided, the more diverse private goods and services available because of the existence of a large transient population that is more attuned to certain amenities, and creativity spurred by a more experimental culture may all help foster an ambience or regional milieu that attracts additional visitors and population in-migration.

Amenities are known to be important determinants of regional migration flows. Amenities such as climate and natural landscape (e.g., lakes, mountains) are usually counted (Graves 1980; McGranahan 1999). But more recent speculation surrounds aspects of the built environment such as historical buildings, bike paths, and parks and cultural and entertainment opportunities like restaurants, bookstores, art galleries and museums for highly educated migrants. Florida (2002) assigns special significance to colleges and universities in creating the kinds of amenities that attract members of the so-called creative class, workers in knowledge and design industries that in turn act as a magnet for dynamic high technology firms. Wojan et al. (2007) provide empirical evidence that larger college enrollments are associated with greater concentrations of "bohemians," artists and designers that form the core of the creative class. They also find that a higher proportion of these creative workers, in turn, is associated with greater regional employment growth. Shapiro (2006) finds that, while 60 percent of the effect of higher rates of educational attainment is explained by improved productivity, the residual 40 percent is caused by improvement in the quality of life, which he attributes to the greater availability of consumer services such as restaurants and bars.

SECTION 3
METHODOLOGY AND DATA

REMI PI+ Model

The Regional Economic Models, Inc. Policy Insight Plus (REMI PI+) model is a dynamic, multi-sector regional economic simulation model that can be used to forecast economic activity and measure the impact of public policy changes on economic activity, population characteristics, and government fiscal variables. The model, which is categorized as an integrated regional econometric input-output model, offers advantages over conventional stand-alone econometric or input-output models (Rey 2000). Regional economic forecasts and simulations are generated by regional equations that are calibrated for the specific region. The national macroeconomic forecast built into the model can be altered by the user. The model used in this analysis includes 70 industry sectors and was customized for the state of Virginia.

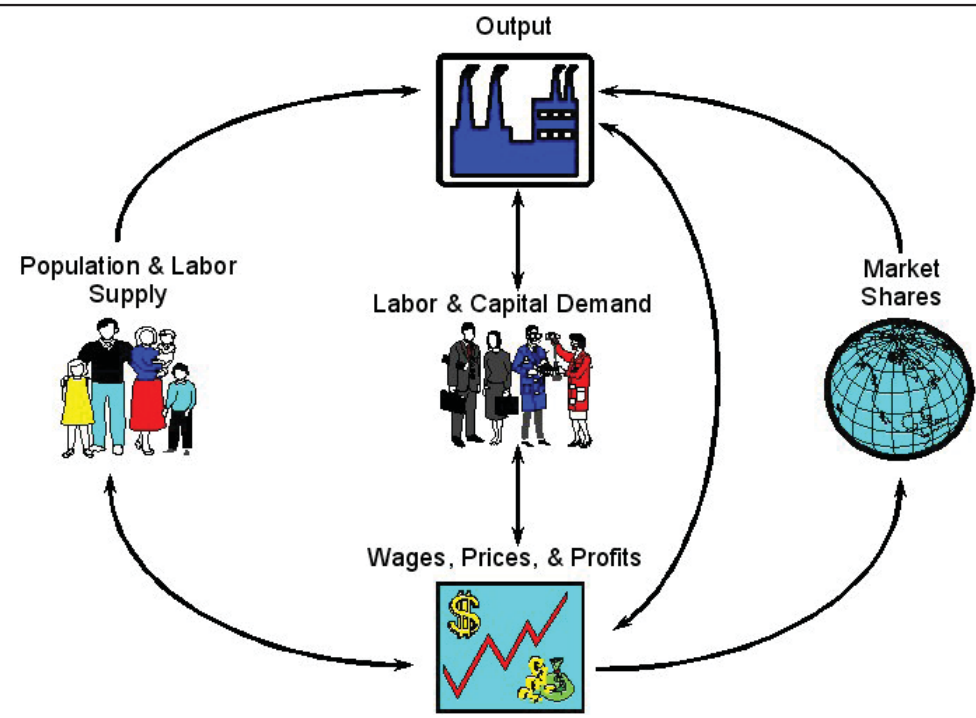
Professor George Treyz of the University of Massachusetts at Amherst developed the REMI model in the late 1970s and early 1980s. The model was distributed as a software product in the early 1980s and has been continuously enhanced with new model features reflecting theoretical developments in economics, new data sources, and new software interfaces based on changes in computer software standards. REMI PI+ and earlier versions of the software have been used in thousands of national and regional economic studies, including several studies of the higher education sector (Felsenstein 1996 for Northwestern University; Lugar et al. 2001 for the University of North Carolina System; ICF Consulting 2003 for the University of California System; Harrington et al. 2003 for public postsecondary centers and institutes in Florida; Washington Research Council 2004 for a hypothetical expansion in public higher education in the state of Washington; McMillen 2005 for the University of Connecticut; Bartik and Erickcek 2007 for a hypothetical expansion in public higher education in the Grand Rapids and Kalamazoo metro areas).

The model offers several key advantages over static input-output models such as IMPLAN and RIMS II,[1] 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 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 wide cross-section of economic, demographic and fiscal variables. The newest version of REMI policy insight used here also incorporates features of Nobel Prize-winning economist Paul Krugman's *New Economic Geography*, which recognizes the effects of concentrated product and labor availability on regional productivity.

The model contains five major modules or blocks (see **Figure 3.1**), which interact simultaneously. *The Output Block* determines expenditures for final demand, including consumption, investment, government and imports as well as demand for intermediate inputs. Final demand responds to changes in other model blocks. This module contains a key engine in the model, an input-output model based on the Bureau of Economic Analysis (BEA) benchmark transactions table that shows flows of goods and services among industries. *The Labor and Capital Demand Block* determines employment, capital and fuel demand as well as labor productivity. *The Population and Labor Force Block* determines the population characteristics of the region, including age, race and sex composition. Labor force participation adjusts in response to changes in wages and employment opportunities. A key driver of 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 from and imports to the region. Changes in market share are driven by production costs, demand characteristics, distance to markets and output.

1. 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 3.1. Simplified Economic Structure of the Key Interactions in Regional Economies Based on the REMI PI+ Model



Source: Regional Economic Models, Inc.

Input Data

The part of the study described in this section corresponds to REMI results reported in section 4 ("Economic Footprint Analysis") and section 5 ("Degree Initiative Analysis). It uses an expenditure approach to allocate input data for determining economic impact. Public higher education expenditures are divided into several different categories, including payroll, outlays on goods and services, capital expenditures, student expenditures and visitor expenditures. In addition, the effects of human capital development are represented by additions to the earnings and productivity of graduates. The method for calculating the human capital additions to the Virginia workforce makes use of data from the U.S. Census Bureau on gaps in average earnings by educational attainment. Workforce attrition due to out-migration from the state is captured. In accordance with the general recomendations of McMahon (2009), no adjustments are made for ability bias. Moreover, 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.

An effort was made to capture the most pertinent features of public higher education and for which data could readily be constructed.[2] 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. **Figure 3.2** shows the various facets of higher education impact through inputs and outputs. **Table 3.1** indicates the degree to which these features are captured in the analysis. A few caveats are in order.

First, this part of the study includes information on the operational and capital expenditures of higher education institutions from the U.S. Department of Education. However, detailed information on the expenses of university-related foundations were not

2. The impact of expenditures associated with higher education administration by the State Council on Higher Education (SCHEV) and the Virginia Community College System (VCCS) and the Tuition Assistance Grant (TAG) program for students studying at in-state non-profit institutions was not measured because it was considered peripheral to the study.

Figure 3.2 Virginia Public Higher Education Inputs and Outputs

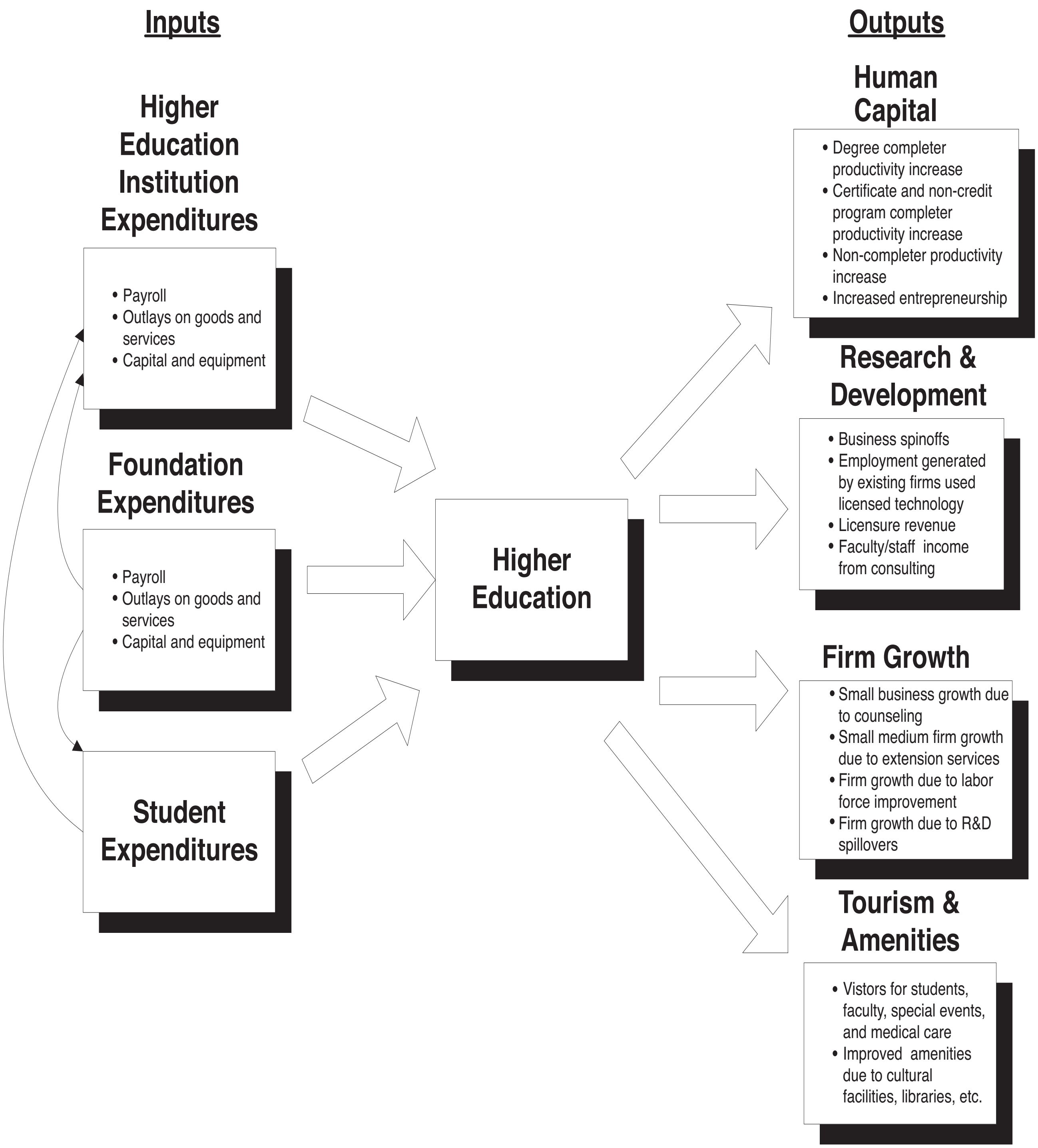


Table 3.1 Degree to Which Features of Economic Impact are Captured in REMI Analyses

Category	Inclusion
Inputs	
Institution payroll	Yes
Institution outlay on goods and services	Yes
Medical system payroll	Yes
Medical system outlay for goods and services	Yes
Institution foundation operational expenditures[a]	Partly
Capital spending[b]	Mostly
Student expenditures	Partly
Outputs	
Productivity enhancement from degree completion	Yes
Productivity enhancement from credit program certificate completers and non-completers	No
Productivity enhancement from non-credit coursework, contract training and adult basic education	No
Productivity enhancement from hospital patients' improved health	No
Productivity enhancement from institution R&D	No
Productivity enhancement from extension/technology transfer	No
Institution business spin-offs	No
Economic activity associated with other licensure activity	No
Expenditures from patent licensure income[a]	Partly
Faculty earnings from consulting and other non-institutional employment	No
Employment and earnings from alumni created businesses	No
Business start-ups, relocations, and expansions due to educated workforce or proximity of R&D activity	No
Effects of amenities on population in-migration	No
Visitor spending connected to student visits	Yes
Visitor spending connected to faculty visits, special events and medical care	No

a. Partly captured as pass through to university or student expenditures (e.g., scholarships)

b. The capital expenditures of foundations other than the UVA Health Services Foundation and the Medical College of Virginia were not captured.

available from this source. Such foundations are often classified as component units because of their close connection with the host institution. 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 several reasons that some foundation spending is not incorporated in this part of the 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, the data were not readily available from public sources in a standardized, consistent format for use in the model. According to FY 2007 data from the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS), Virginia public higher education foundations generated slightly over 2 billion dollars in expenses. Two foundations, the University of Virginia Health Services Foundation and the Medical College of Virginia Foundation, accounted for two-thirds of state higher education foundation spending. Therefore, their expenses were obtained from their respective financial offices.

Second, 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.

Third, the full human capital effects of higher education are not captured in this part of the study. 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. In addition, the earnings and productivity effects from college and university non-credit training continuing education, contract training and adult basic education are excluded. Finally, businesses started by college and university alumni are not estimated.

Fourth, the full effects of some university research and development and economic development activities are not captured. Economic activity generated by university business spin-offs and start-ups relying on university intellectual property licenses are not included. Nor is income resulting from faculty consulting and other employment. This part of the study does not attempt to estimate economic activity related to business start-ups, relocations, and expansions that can be attributed to higher education activities such as extension, business counseling, technology transfer and collaborative research projects. Nor does it attempt to capture business start-ups, relocations and expansions due to the availability of more skilled workers and research and development activities.

Lastly, this part of the study does not attempt to estimate the economic effects resulting from additional regional amenities. These amenities would include many of the "creative class" lifestyle amenities that may be an important factor in attracting and retaining a skilled workforce as well as some retirees. These amenities include aspects of the built environment, university services such as visual and performing arts and the presence of a more open, tolerant, diverse and experimental culture.

Table 3.2 REMI PI+ Model Input Data Sources

Category	Data Sources
Employment	IPEDS employees by assigned position; institutional data
Employee compensation	IPEDS finance; University of Virginia Health Services Foundation; VCU Medical Center
Outlays on goods and services	IPEDS finance; University of Virginia Health Services Foundation; VCU Medical Center; data used in Virginia Tech impact study by Beddow et al. (2000)
Capital expenditures	IPEDS finance; Virginia Health Services Foundation; VCU Medical Center
Student expenditures	IPEDS institutional characteristics; IPEDS employees by assigned position; data used in Knapp and Shobe UVA impact study (2007); Visitor expenditures Virginia Tourism Council
Visitor expenditures	Knapp and Shobe UVA impact study (2007); Virginia Tourism Corporation (2008)
Student enrollment	State Council of Higher Education for Virginia
Graduate earnings	IPEDS completions; U.S. Census Bureau; National Crosswalk Service Center; (CIP/SOC crosswalk and National Industry-Occupation Employment Matrix)
Productivity	U.S. Census Bureau; National Crosswalk Service Center; (CIP/SOC crosswalk and National Industry- Occupation Employment Matrix); Black and Lynch (1996)

Table 3.2 shows the specific sources used to compute input data. The main source of data used in this study is the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS) database, which contains data on higher education institutions that receive federal student financial aid. 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 solicited from the University of Virginia Health Services Foundation and the Virginia Commonwealth University Medical Center. In addition, detailed enrollment information by place of residence and degree level 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 recent 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 (2008).

Table 3.3 shows the values of the gross expenditure input data. The specific manner of constructing these data for the simulations described later is detailed in Appendices A.3 and A.4.

Table 3.3 Virginia Public Higher Education Employment and Expenditures, FY 2007

Item	Total
Employee compensation, including fringe benefits	$4,221,460,977
Outlays on goods and services	$1,835,373,192
Capital expenditures	
Buildings and infrastructure	$857,764,951
Equipment	$255,734,521
Books and art	$32,604,600
Student expenditures	$2,197,665,478
Visitor expenditures	$61,577,604
Total institution related expenditures	$9,462,181,323
Employment	62,693

SECTION 4
ECONOMIC FOOTPRINT ANALYSIS

This section describes the results of several analyses of Virginia public higher education using the REMI PI+ model. The results show that, regardless of how you measure public higher education activities, there are substantial positive short-term and long-term economic effects at regional and statewide levels. A full accounting of public higher education related expenditures and graduate workforce entry results in an estimated 144,550 jobs due to expenditures, a total gross domestic product effect of $24.0 billion, and $2.507 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 $1.39 in state revenue and an increment of $13.31 of Virginia gross domestic product.

Following the terminology used by other economic impact studies, the term "economic footprint" is used to denote the economic consequences of all activities related to public higher education. No attempt is made to separate out those activities that would not have occurred in the absence of public higher education. 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 conservative estimate of the expenditure "economic impact" of public higher education.

Economic effects are divided into two distinct phases. The *expenditure phase* refers to the period during which expenditures related to higher education operations occur. For example, the institutions spend money on payroll and goods and services, and students spend on local goods and services. The *human capital phase* is the period during which graduates enter and participate in the state workforce. It is assumed that only graduates who are Virginia residents enter the Virginia workforce. In addition, this graduate workforce is reduced by 3 percent each year to reflect attrition due to migration out of the state. Lastly, the average graduate is assumed to work for 30 years before retiring. The data supporting these assumptions are described more fully in Appendix A.3.

This section consists of four parts. In the first part, the assumptions behind each analysis (or "scenario") are discussed. In the next three parts, the results of each scenario are presented. 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 explored (see **Table 4.1**) in order to examine different facets of public higher education's mark on the state economy. The analyses attempt to answer several questions. First, what overall effect do all activities associated with public higher education have on Virginia's economy? Second, what is the economic effect of current publicly funded higher education operations? Third, what is the net value added by 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 and to the productivity of graduates who remain in the state workforce?

The first, a so-called economic footprint analysis, examines the economic effect of higher education related inputs, regardless of source of funding, including health service foundations and capital expenditures. The second scenario is the same as the first except that it focuses on operational expenditures to support education and research activities of higher education. Capital expenditures and health service foundation expenditures are removed. The institutional expenditure data are derived entirely from U.S. Department of Education IPEDS operating expenses information, which also identifies funding sources and amounts. Using IPEDS operating data permits economic and fiscal results to be compared to state contributions. The third scenario examines the net value-added of public higher education. Since expenditures derived from in-state sources

Table 4.1 Assumptions Behind Scenario Model Runs

Item	Scenario I, Economic Footprint: All Operations	Scenario II, Economic Footprint: Current Higher Education Operations	Scenario III, Export and Human Capital
Institution spending	All	All	Out-of-state
Medical foundation spending	All	None	None
Student spending	All	All	Out-of-state
Visitor spending	Out-of-state	Out-of-state	Out-of-state
Capital spending	All	None	None
Population increase due to student enrollment	Out-of-state	Out-of-state	Out-of-state
Productivity	In-state	In-state	In-state
Graduate earnings	In-state	In-state	In-state

(including Virginia state government, in-state students, and resident donors) could have been spent elsewhere in the state economy, they are not represented as an expenditure injection. This scenario includes only the portion of higher education 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 is captured.

In order to succinctly represent and compare the results of these alternative scenarios, the economic effects over time are converted to present values and summed. Net present value indicates the value now of dollars that accrue in the future.[1] 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 3 percent. This real discount rate is consistent with other educational impact studies that use net present values (Trostel 2007b; Bluestone 1993).

Economic activity is represented by several variables including: (1) employment, (2) value added, (3) industrial output, (4) personal income, and (5) state revenues. Employment includes full-time and part-time workers and the self-employed and is measured by place-of-work rather than place-of-residence. Industrial output reflects the total value of industry production during a period, including the value of intermediate input purchases. Value-added reflects only the value of production for final demand and is measured by gross domestic product (GDP). All values are expressed in terms of 2007 dollars. State revenues are calculated at state average rates using REMI PI+ and include revenue sources such as sales taxes, license taxes, individual and corporate income taxes, liquor store revenue and intergovernmental revenue.

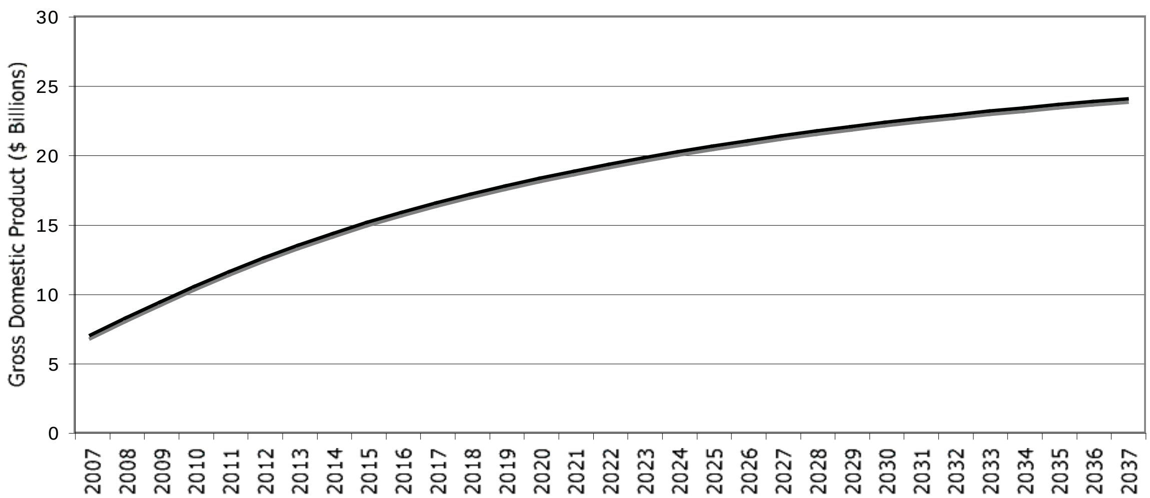
Scenario 1: Economic Footprint Analysis

The economic footprint of Virginia public higher education activities on Virginia GDP is substantial. During the first year, 2007, when the expenditures are made, the economic effect is nearly $7.0 billion. This effect of the 2007 expenditure falls to $1.2 billion the following year when the expenditures are discontinued under the simulation and in-state graduates are added to the Virginia workforce. The residual economic activity decreases each year after the initial entry of graduates because of a steady attrition in the number of graduates who remain in the Virginia workforce and becomes zero in year 2038 when all graduates are assumed to have retired from the workforce.

Figure 4.1 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 nearly $24.0 billion. **Table 4.2** divides the economic variables into expenditure-related and human capital-related components. The net present value (NPV) of expenditure-related GDP

1 The Net Present Value (NPV) formula is: $NPV = \sum_{n=1}^{N} \frac{Y_n}{(1+r)^n}$ where r is the discount rate and Y_n is the value of the economic variable at time period n. r is set at 3.0 percent and the time horizon (n) is 30 years.

Figure 4.1 Cumulative Present Value of Economic Footprint on Virginia GDP, By Year



effect is $6.953 billion and human-capital related effect is $17.023 billion. The total economic footprint attributable to Virginia public higher education for the period of analysis is $23.976 billion. Virginia's GDP in 2007 was $384.132 billion.[2] Therefore, the expenditure effect accounts for 1.8 percent of GDP. The human capital effect would represent 4.4 percent and the total effect 6.2 percent. The expenditure related employment effect is 144,550. This amounts to 2.9 percent of 2007 Virginia employment of 4,936,137.[3] The NPV of state revenues generated as a result of public higher education activities during the FY07 year is $2.507 billion.

2 Bureau of Economic Analysis. 2009. Gross Domestic Product by State, 1963-2008. http://www.bea.gov/regional/gsp/ (Accessed July 27, 2009).

3 Bureau of Economic Analysis. 2009. Annual Personal Income and Employment, 1929-2008. http://www.bea.gov/regional/spi/ (Accessed July 27, 2009).

Seventy-one percent of Virginia's public higher education economic footprint can be attributed to human capital improvements (see **Figure 4.2**). This result suggests that focusing on higher education expenditures, as most studies do, severely underestimates the economic influence of higher education. When the expenditure impact is disaggregated (see **Figure 4.3**), over 60 percent of the economic effect can be traced to higher education payroll and other outlays. Another 21 percent can be attributed to student expenditures. Fifteen percent is accounted for by health service foundation payments and the remainder, 3 percent and 1 percent respectively, to capital and visitor expenditures.

Table 4.3 provides another breakdown by expenditure function and funding source. It shows that the medical centers at Virginia Commonwealth University and

Table 4.2 Economic Footprint of Virginia Public Higher Education (Dollar Denominated Values Expressed in Net Present Value, Billions of 2007 Dollars)

Economic Variable	Expenditure Related	Human Capital Related	Total
Virginia GDP	6.953	17.023	23.976
Industrial output	10.528	25.627	36.155
Personal income	6.207	14.730	20.937
State revenues	0.830	1.677	2.507
Employment	144,550	N/A	N/A

N/A = not available

Table 4.3 Breakdown of Economic Footprint by Function and Source (Dollar Denominated Values Expressed in Net Present Value, Billions of 2007 Dollars)

	GDP	Industrial Output	Personal Income	State Revenue	Employment
Human capital effect	17.023	25.627	14.730	1.677	N/A
Total expenditures effect	6.953	10.528	6.207	0.830	144,550
Capital	0.219	0.353	0.139	0.027	3,596
Medical Centers	1.436	2.135	1.582	0.190	27,311
Research	0.588	0.883	0.589	0.072	12,927
Portion attributable to out-of-state funds	0.394	0.593	0.395	0.048	8,677
Other institutional expenditures	3.321	5.004	3.040	0.376	75,491
Portion attributable to out of state student tuition	0.525	0.789	0.526	0.065	11,547
Portion attributable to other out of state funds	0.405	0.609	0.404	0.049	8,940
Student expenditures[a]	1.361	2.109	0.843	0.161	24,631
Portion attributable to out of state students	0.224	0.387	0.379	0.071	5,075
Visitor expenditures	0.027	0.043	0.014	0.003	594
Total Attributable to out of state revenues	1.575	2.421	1.719	0.237	34.833

a Also includes effect of population in-migration. See Appendix A.3.

Figure 4.2 Source of GDP Economic Footprint

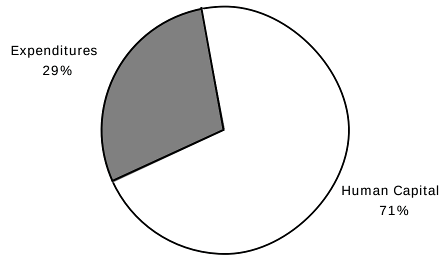
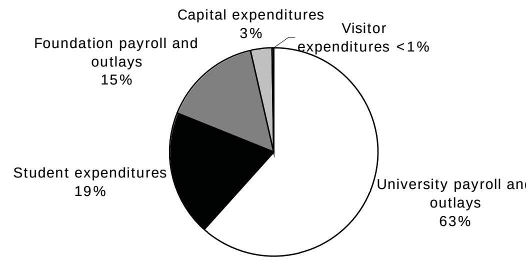


Figure 4.3 Source of Expenditure-related GDP Economic Footprint



University of Virginia are significant state economic assets. Together they account for 27,311 jobs, $1.436 billion in GDP, and $190 million in state revenues. Higher education research activities are responsible for nearly 13,000 jobs, $588 million in GDP, and $72 million in state revenues. An estimated two-thirds of higher education research funds are derived from out-of-state sources, primarily the federal government, and correspondingly two-thirds of the economic footprint can be traced to these sources.[4] State government is estimated to provide $94.8 million in research support. Out-of-state students are also a source of substantial economic stimulus. Economic activity that can be traced to out-of-state students through the effect of tuition revenues, student expenditures on state goods and services and student visitor expenditures totals approximately 17,200 jobs, $776 million in GDP, and $139 million in state revenues.

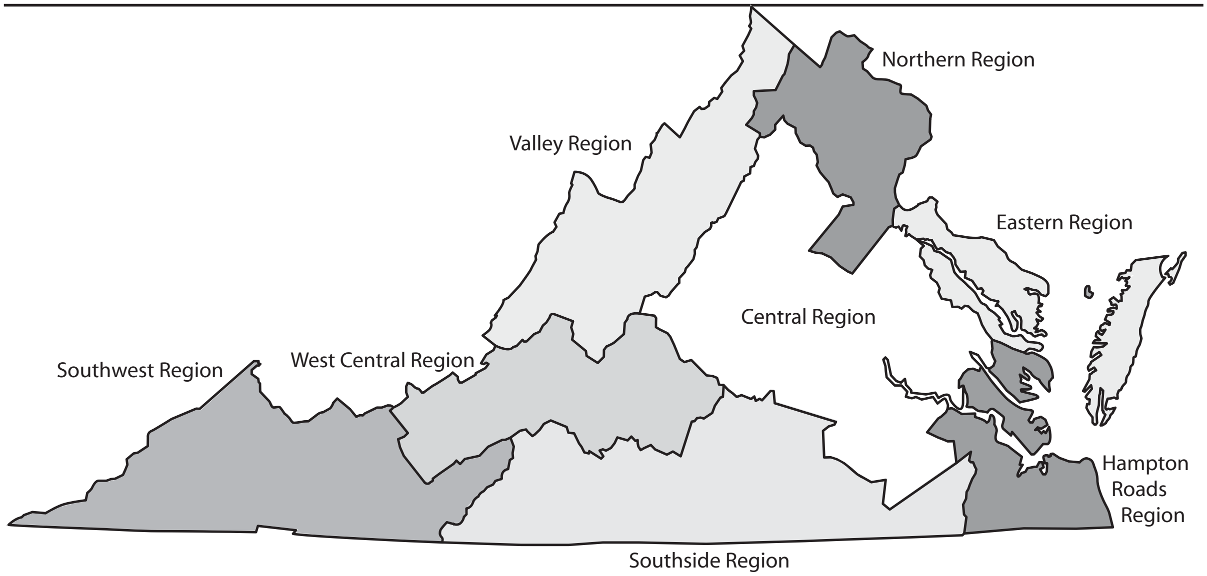
In order to examine the contribution of public higher education institutions located in Virginia's regions to the state economic footprint, a regional classification adopted by the Council on Virginia's Future (CoVF) was used (see **Figure 4.4**). It is important to note that many institutions have multiple branches and distance learning activities that complicate adopting any regional classification scheme. For instance, Virginia Tech has branch centers in Arlington, Roanoke, Abingdon, Richmond and Hampton Roads. Moreover, the 23 community college service regions do not always fit neatly into the boundaries of the eight CoVF regions. Lastly, some institutions such as Old Dominion University have large online enrollment numbers that may be drawn from throughout Virginia, the U.S. and the world. However, the assumption is made that all of the expenditures and graduates associated with a particular institution are credited to the region where the main campus is located. For instance, in the case of Virginia Tech, for sake of the model, all institutional expenditures occur in Blacksburg in the West Central region.

Eight models were created using institutional expenditure, student and visitor expenditure, and degree information aggregated up to the regional level. **Table 4.4** provides a regional breakdown of the GDP impacts. Using information from the table, it can be shown that nearly half (46 percent) of expenditure effects originate from the Central Region. This result can be explained by the presence of two of Virginia's largest universities (Virginia Commonwealth University and the University of Virginia) and two major university medical centers (University of Virginia Health System and the Medical College of Virginia). The employment effects of higher education related expenditures are as follows: Central Region: 67,425; Hampton Roads Region: 22,291; West Central Region: 21,074; Northern Region: 17,462; Valley Region: 10,221; Southside Region: 3,285; Southwest Region: 2,399; and Eastern Region: 393.

Figure 4.5 shows the net present value of all GDP effects. Once again, the presence of major universities shapes the results. The dominance of these institutions occurs because of much higher expenditures during the expenditure phase, but more importantly

4 A breakdown of research funding by geographical origin was not available from the IPEDS Finance data. Therefore, data from the National Science Foundation (2008) were used to estimate the portion of expenditure derived from out of state. Funds from the federal government, industry, and nonprofit foundations are counted as out-of-state.

Figure 4.4 Council on Virginia's Future Regions



because of the larger earnings and productivity gains that result from completing bachelor's, graduate and professional studies. The Central Region accounts for 33 percent of the total economic activity. The Hampton Roads Region, which includes Old Dominion University, and the West Central Region, which includes Virginia Tech, account for 18 percent each. The Northern Region, which includes George Mason University, accounts for 16 percent. The Eastern Region (which encompasses the Eastern Shore, the Northern Neck, and a portion of the Middle Peninsula) shows the smallest result because of having only two relatively small public higher education institutions, Eastern Shore Community College and Rappahannock Community College.

Comparison of Scenarios 1, 2, and 3

Table 4.5 shows the results of all three economic impact scenarios. The second scenario, which removes health sciences foundation and capital expenditures, shows an expenditure effect of $5.661 billion for GDP and

Table 4.4 Virgina Public Higher Education GDP Economic Effect by Region, Net Present Value, Billons of 2007 Dollars

Region	Expenditure Related	Human Capital Related	Total
Central	3.388	4.550	7.938
Eastern	0.017	0.046	0.063
Northern	0.830	3.081	3.911
Southside	0.147	0.453	0.600
Southwest	0.104	0.307	0.411
Hampton Roads	1.025	3.373	4.398
Valley	0.458	1.833	2.291
West Central	0.983	3.380	4.364
Total	6.953	17.023	23.976

Figure 4.5 Regional Source of Economic Footprint of Virginia Public Institutions of Higher Education, GDP

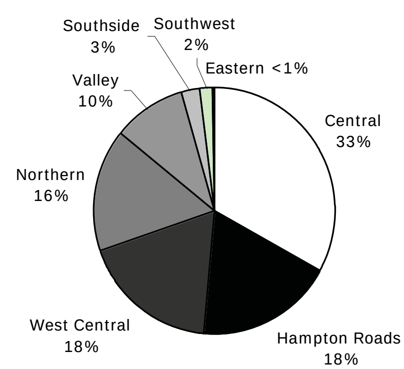


Table 4.5 Economic Effects of Virginia Public Higher Education by Scenario (Dollar Denominated Values Expressed in Net Present Value, Billions of 2007 Dollars)

Expenditure	Scenario I	Scenario II	Scenario III
Economic Variable			
Virginia GDP	6.953	5.661	1.575
Industrial output	10.528	8.570	2.421
Personal income	6.207	5.132	1.719
State revenues	0.83	0.689	0.237
Employment	144,550	118,881	34,833
Human Capital			
Virginia GDP	17.023	17.023	17.023
Industrial output	25.627	25.627	25.627
Personal income	14.73	14.73	14.73
State revenues	1.677	1.677	1.677
Employment	N/A	N/A	N/A
Total			
Virginia GDP	23.976	22.684	18.599
Industrial output	36.155	34.197	28.049
Personal income	20.937	19.863	14.73
State revenues	2.507	2.365	1.678
Employment	N/A	N/A	N/A

118,881 jobs. The NPV of the effect on GDP, including expenditure and human capital phases, is $22.684 billion. $17.023 billion of this effect or 75 percent of the total is human capital related. In addition, $2.365 billion in total state revenue is generated.

According to IPEDS, state appropriations combined with state grants and contracts amounted to $1.704 billion in FY 2007. The state general fund appropriation was $1.618 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 $86 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 $1.39 in state revenue and $13.31 of incremental gross domestic product. If one focused on just state appropriations for operating support, these leveraging figures would obviously be much larger.

The third scenario provides a conservative estimate of the economic enhancement that is the result of 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 spending, spending by students who reside outside the state, and visitors. The funds are "new" to the state. In effect, the state public higher education sector exports these services. Table 4.5 indicates that the expenditures of these funds result in an economic impact approximately equal to $1.575 billion in GDP, 34,833 jobs, and $237 million in state revenue. The total economic effect resulting from human capital improvements is equivalent to $17.023 billion, resulting in a total economic effect of $18.599 billion for this scenario.

One might ask how much of the human capital economic effect is an "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 simply disappeared. Using institutional survey data and certain assumptions, Bluestone (1993) surmised that approximately 57 percent of University of Massachusetts–Boston students would not attend college if public higher education did not exist in the state. A survey of students attending the University of West Florida's Emerald Coast branch campuses and centers shows that 23 percent of students would not have attended college if the locations were not available (University of West Florida 2009). A conservative approach to estimate Virginia's college-going rate would be to select something closer to the lower of the two estimates. If one assumed that 25 percent of resident graduates would not have attended college without the availability of Virginia public higher education, this would translate into the loss of $4.256 billion in GDP and $419 million in state revenue in terms of present value. The Commonwealth would see total losses of $5.831 billion in GDP and $656 million in state revenue.

The actual loss would likely be much more severe than this thought experiment suggests, not only because the college going estimate without Virginia public higher education is understated, but because some resident students would elect to attend school elsewhere outside the state. This would result in the leakage of tuition dollars, student expenditures on goods and services and federal/private support associated with student enrollments to other states. In addition, research indicates that college graduates who attended college outside the state from where they graduated from high school are less likely to return to their home states after graduation (Adelman 2004; Tornatzky et al. 2001). Therefore, the state would experience a leakage of earnings and productivity as well.

Conclusion

This section provides a range of estimates of the economic influence of Virginia's public higher education sector. Using the most expansive 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 nearly $24 billion in gross domestic product and over $2.5 billion in state revenue in terms of net present value. $5.831 billion in GDP and $656 million 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 engine that produces higher incomes, state tax revenues, increased output, and more jobs.

It is important to emphasize that the estimates provided here do not capture many other ways in which higher education affects economic activity. For example, public higher education institutions create new technological innovations and business spinoffs, improve the entrepreneurial abilities and productivity of existing firms by changing business planning and industrial processes, and increase the state's amenity resources. In addition, the estimates do not capture other beneficial aspects of higher education such as improved health, lower reliance on social services and welfare, and decreased likelihood of committing crimes and burdening the criminal justice system. These issues will be taken up in later sections.

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. Such 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.

SECTION 5
DEGREE INITIATIVE ANALYSIS

This section provides a "what if " analysis using the REMI PI+ model. It examines the effect on economic activity of a hypothetical policy initiative that increases Virginia degree production. Many economic and public policy researchers have commented on the need for the United States to produce more college graduates in order to raise workforce educational achievement levels to remain economically competitive in the global marketplace (Ruppert 2003; Douglass 2006). This analysis provides estimates of the effects on employment, output, income, and tax revenue of adopting such a policy.

The simulation considers the effect of increasing degree production by 1,285 degrees each year from a baseline level of 57,600 degrees projected by SCHEV in 2010 to a level of 70,450 degrees in 2020 (see **Table 5.1**). This results in a total of 70,675 more degrees awarded than would occur under baseline conditions.

The goal of the analysis is to measure the additional value created by the degree initiative and not to measure its "economic footprint," which would be much larger. Thus, the assumptions underlying this degree initiative simulation are similar to the third scenario described in the previous section. Only spending that is derived from out-of-state sources is counted for the purposes of determining the expenditure impacts. These expenditures include the portion of institutional spending funded by out-of-state student tuition and out-of-state gifts, grants and contracts. They also include out-of-state expenditures on local goods and services, and visitor expenditures. Capital expenditures are not counted. Expenditures derived from in-state sources such as in-state student expenditures on goods and services and institutional expenditures funded by in-state student tuition revenues and state government appropriations are not included. The human capital impacts are determined in the same manner as the previous section. The added earnings and productivity of in-state graduates who join and are retained in the Virginia workforce are included. Additional details on the method for generating the computed data are provided in Appendix A.4.

The change in state expenditures and revenues needed to accomplish the goal of increasing the number of graduates was not estimated and used for two reasons.

Table 5.1 Degree Initiative Degree and Enrollment Assumptions

Year	Enrollment	Associate/ Bachelors	Graduate/ Professional	Total
2007	370,749	41,210	13,050	54,260
2008	384,189	42,485	13,742	56,227
2009	388,883	42,843	14,071	56,914
2010	393,571	43,200	14,400	57,600
2011	402,351	44,205	14,680	58,885
2012	411,131	45,210	14,960	60,170
2013	419,911	46,215	15,240	61,455
2014	428,691	47,220	15,520	62,740
2015	437,472	48,225	15,800	64,025
2016	446,252	49,230	16,080	65,310
2017	455,032	50,235	16,360	66,595
2018	463,812	51,240	16,640	67,880
2019	472,592	52,245	16,920	69,165
2020	481,372	53,250	17,200	70,450

First, it assumed that the new state expenditures would have a near neutral impact on overall economic activity because they would be redirected from other state spending. Second, evidence suggests that higher education institutions can achieve at least some improvement in college retention and graduation rates by reallocating resources rather than increasing overall spending (Webber and Ehrenberg 2009).

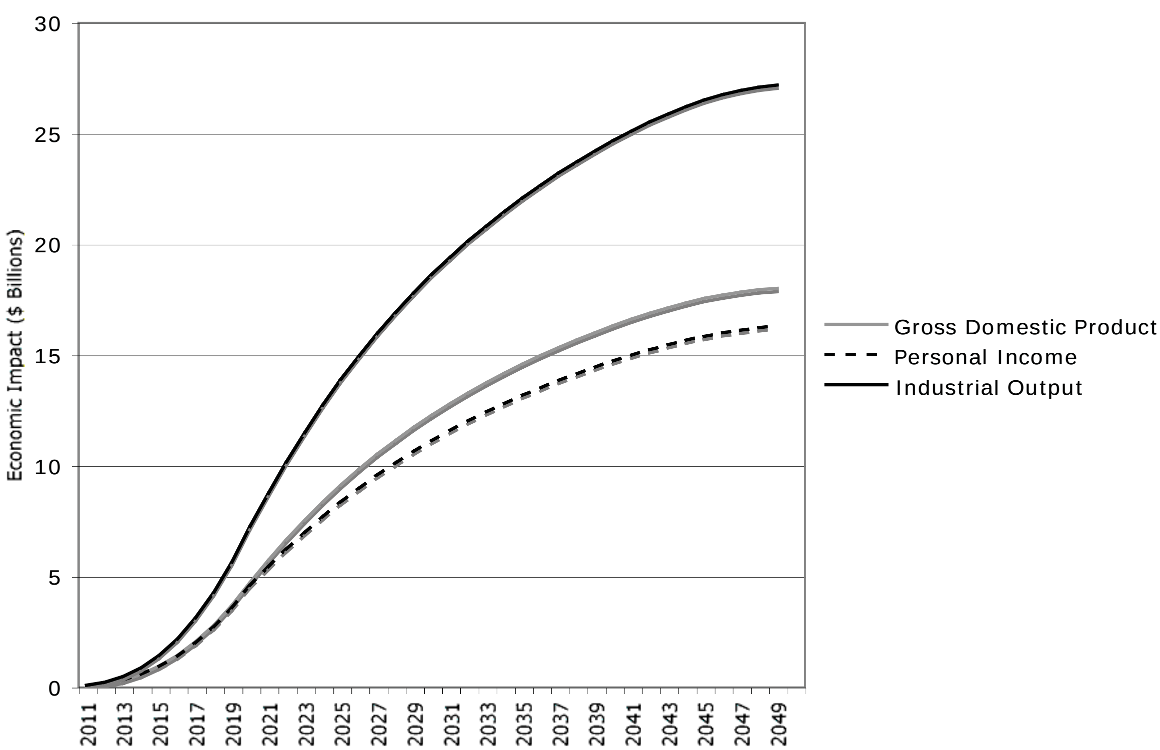
Figure 5.1 shows the present value of the economic impact of the degree initiative as it builds over time for gross domestic product, personal income and industry output. The impact ascends during the period 2011-2020 because of the joint effects of ratcheted up expenditures from out-of-state sources attributable to growing enrollments and the increasing stream of resident graduates entering the workforce. The simulation assumes that expenditures are curtailed to baseline levels in 2021 in order to trace the economic effects of graduates throughout their work lives during the subsequent period (2021-2050). During the period 2021-2050, only the human capital effects are present and they gradually erode over time because of labor force attrition due to migration and retirement. By the year 2050 all of the cohorts have retired from the Virginia workforce.

Table 5.2 Economic Impact of Degree Initiative, Net Present Value, Billions of 2007 Dollars

Economic Variable	Amount
Virginia GDP	17.964
Industrial output	27.149
Personal income	16.261
State revenues	1.862

Table 5.2 converts the stream of dollar denominated economic impacts of the degree to present value terms using 2007 dollars. The result of the initiative is a gross domestic product impact in present value terms of nearly $18 billion dollars and state revenues of $1.862 billion. These results suggest that the degree initiative would have significant economic and fiscal effects.

Figure 5.1 Cumulative Present Value of Degree Initiative Economic Impact By Year, Gross Domestic Product, Personal Income, and Output



SECTION 6
PRIVATE AND SOCIAL BENEFITS OF HIGHER EDUCATION

The clearest demonstration of the value of college education is the increased income realized by the degree recipients. College graduates command higher wages and salaries upon entry into the labor market, and, after taxes, have additional disposable income for spending or saving. These private earnings increases formed the basis for a large part of the economic contribution of public higher education reported in the previous sections. This private monetary gain, however, forms only part of the picture, because some of the benefits obtained are not readily apparent in financial terms. For example, improved health outcomes that result in better quality of life, better workplace conditions, and the satisfaction that comes from learning and exposure to new ideas are not expressed in dollar denominated terms. Moreover, the individual graduate does not capture all of the benefits of a college education. For instance, other members of the household, the immediate neighborhood or region, or society at large may benefit from the "externalities" that arise as a result of an individual's educational attainment. These benefits likely arise because the graduate has a positive influence on others or affects the availability of regional resources. The presence of these other benefits is one of the principal rationales for public support for higher education.[1]

In this section, we will outline several different concepts to distinguish between these different types of benefits[2] created by public higher education. The term ***private pecuniary benefit*** refers to a financial benefit that accrues to an individual receiving the college education or accruing to his/her household. This benefit will be measured as increments to earnings, fringe benefits and investment income that occur as a result of increased educational attainment. ***Private non-pecuniary benefit*** is used to describe a non-monetary benefit that accrues to the household such as improved health as a result of the educational attainment. A ***social pecuniary benefit*** is a benefit realized by society measured in terms of dollars. These benefits include positive government fiscal impacts that occur as a result of reduced need for public assistance and law enforcement expenditures as well as increased tax revenues. They also include improvements in the earnings of other community members. Lastly, ***social non-pecuniary benefit*** refers to a social benefit that is not easily converted to a dollar value such as improvements in community health or better public decision-making because of the existence of college graduates in the community.

While there has been significant economic research documenting positive private pecuniary benefits, many researchers have found that private non-pecuniary and social benefits are also substantial.[3] For instance, Blomquist et al. (2009) find that the social value of expanding the community college educational system in Kentucky exceeds the private value by about 50 percent. Cutler and Lleras-Muney (2006) suggest that the non-pecuniary health benefits alone represent about half of the private monetary benefit. Other studies estimate the social or non-pecuniary benefits equal or exceed the value of private pecuniary benefits (McMahon 2009; Oreopoulous and Salvanes 2009; Wolfe and Haveman 2003). These studies argue in favor of a more complete accounting of educational benefits.[4]

The first part of our analysis, summarized in **Table 6.1,** reviews existing literature on the private and

1. The other rationales are (a) that individuals don't understand the full private benefits of higher education and therefore under-invest in education and (b) that private credit markets do not provide adequate levels of credit and charge high interest rates for higher education loans because human capital cannot be offered as a collateral and returns on investments for individual loans are difficult to estimate and highly uncertain.
2. This section focuses on the pecuniary and non-pecuniary private and public benefits from investment in human capital resulting in new college graduates. Social benefits have also been identified for research and development activities (Salter and Martin 2001). However, this literature is smaller and will not be covered here.
3. Some economic researchers dissent from the widely held view that social and private non-pecuniary benefits are substantial. For example, Lange and Topel (2006) have questioned the existence of social benefits.
4. Public higher education obviously has social costs as well, such as state budget appropriations for educational operations and financial assistance. In addition, college operations and the concentration of students may impose some external costs on communities such as traffic congestion and nuisance type crime.

social pecuniary and non-pecuniary benefits of public higher education. This review does not yield Virginia-specific results, but it points to some likely benefits, as documented in these other studies, that result from spending on public higher education. With that background, we then estimate a portion of the social pecuniary benefits that Virginia receives as a result of public higher education spending in the form of positive fiscal impacts based upon recent data from the U.S. Census's *Current Population Survey*.

Private Pecuniary Benefits

Numerous studies document the sizeable earnings advantages from investment in additional years of postsecondary education (Card 1999). Data from the U.S. Census Bureau indicate that 30-34 year olds

Table 6.1. Private and Social, Pecuniary and Non-pecuniary Benefits Summary

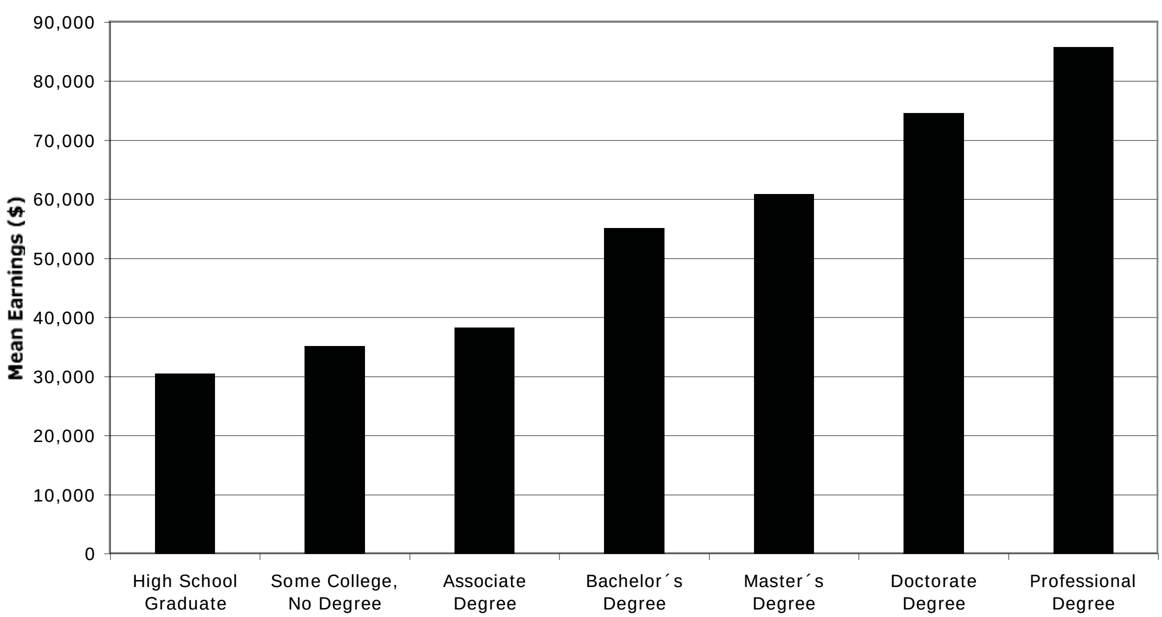
Private Pecuniary	Private Non-Pecuniary	Social Pecuniary	Social Non-Pecuniary
Labor market			
Increased own earnings (Card 2009)	Better workplace conditions, more job satisfaction (Oreopoulous and Salvanes 2009; Duncan 1976)	Increased metro area resident earnings (Moretti 2004b)	
Higher spouse earnings (Wong 1986)	Lower job search costs (Royalty 2000)	Increased tax revenue (Trostel 2007b)	
Better financial fringe benefits (Duncan 1976)		Lower public assistance costs (Trostel 2007b; Grogger 2004; Jayakody et al. 2000; An, Haveman, and Wolfe 1993)	
Household management			
Improved investment and consumption decisions (McMahon 2009; Benham and Benham 1975; Solomon 1975)			
Health			
	Better own health and longevity (Grossman 2006; Cutler and Lleras-Muney 2006)	Lower public health spending (Trostel 2007b)	Better community health (Wheeler 2008)
	Better child and spouse health (Grossman 2006; Currie and Moretti 2003)		
Education			
	Improved child educational achievement (Angrist and Lavy 1996)		Improved community education achievement (Do 2004; Rephann 2000)
Crime			
		Lower law enforcement costs (Trostel 2007b)	
Civic			
			Increased voting and volunteering. More social capital (Oreopoulous and Salvanes 2009; Helliwell and Putnum 2007; Dee 2004; Freeman 1996)
Environment			
			More recycling (Jakus, Tiller, and Park 1997)

with associate degrees earn 25 percent more than high school graduates, bachelor's degree recipients realize 80 percent more, master's degree graduates earn 99 percent more, doctorate degree awardees achieve 144 percent more and professional degree recipients yield 181 percent more (see **Figure 6.1**). The earnings gaps only increase over time with greater work experience (Card 1999). Moreover, certificate and degree program completers are rewarded with even larger wage and salary premiums (the so-called "sheepskin effect") over those who attended college without completing (Card 1999). That is to say, a bachelor's degree recipient receives more than quadruple the premium of a college attendee who finishes only one year of a bachelor's degree program without completing degree requirements. Although it has been argued that some portion of these earnings differentials can be attributed to unobservable factors such as latent prior ability, drive, and family background, equally plausible arguments have been made that countervailing factors, such as measurement error, neutralize the effect of those biases (McMahon 2009).

Education is also associated with pecuniary private benefits from improved labor market opportunities and greater consumer savings and financial returns that result from smarter household buying and investing decisions. Current U.S. Census Bureau data indicate that coverage by employer-based health coverage increases with educational attainment from 53 percent for high school graduates to 77.3 percent for bachelor's degree graduates (See **Figure 6.2**). Duncan (1976) shows that the total value fringe benefits such as medical insurance benefits, pension plans, paid vacations and sick leave, stock options, and free/subsidized meals and products increase with years of education. Individuals with higher educational achievement levels also save money on consumer good purchases such as food, eyeglasses and automobiles (McMahon 2009; Benham and Benham 1975) and achieve higher yields on their savings because they are generally more savvy investors (Solomon 1975).

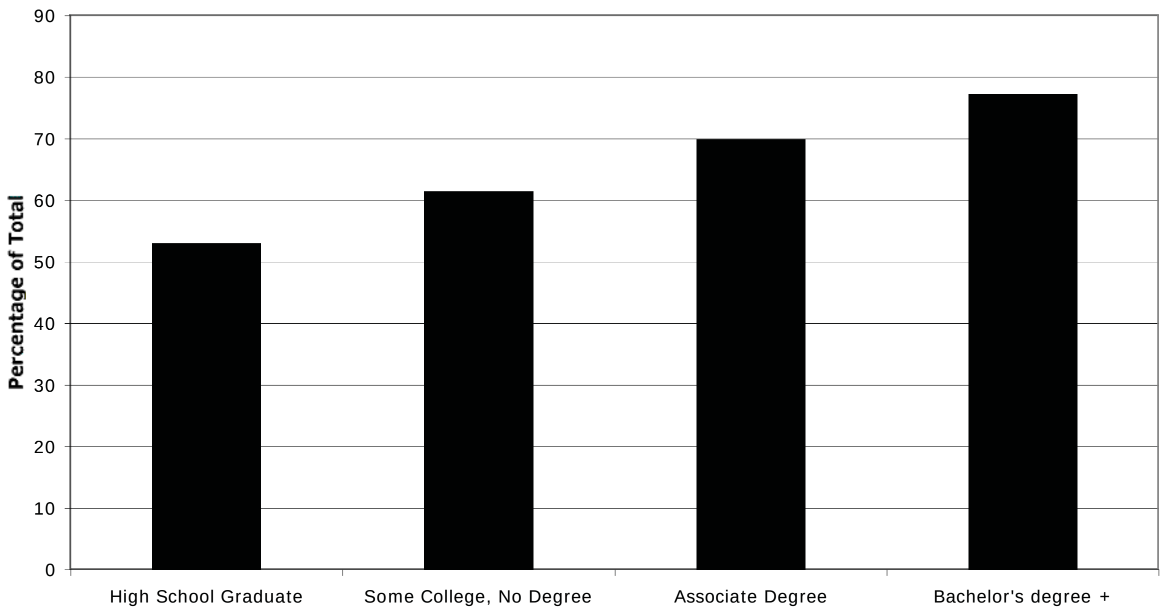
The benefits that accrue to other household members as a result of a household head's educational level are considered private since households form the basis for an individual's work, leisure and consumption decisions. Some studies suggest that there are pecuniary productivity spillovers to other members of the family,

Figure 6.1 Mean Earnings by Educational Attainment, 30 to 34 Years of Age, 2007



Source: U.S. Census Bureau. 2008. *Current Population Survey, Annual Social and Economic Supplement* http://pubdb3.census.gov/macro/032008/perinc/toc.htm

Figure 6.2 Employment-based Insurance Coverage by Educational Attainment, Persons 18 Years and Older, 2007



Source: U.S. Census Bureau. 2008. *Current Population Survey, Annual Social and Economic Supplement*. http://pubdb3.census.gov/macro/032008/health/h01_001.htm

with spouse educational level having a positive effect on the other spouse's earnings level (Wong 1986).

Private Non-pecuniary Benefits

Many private benefits are not as easily expressed in monetary terms because they represent time cost savings or improvements to quality of life. However, one must be careful also not to double count. Improvements in life circumstances that occur as a result of educational investments may already be reflected, at least partially, in increased earnings. For instance, improvements in health contribute to improved earnings because they lead to greater workforce longevity and fewer absences from work.

Some non-pecuniary benefits are obtained in the labor market. Individuals with higher educational achievement enjoy better working conditions and amenities, including a healthier and safer work environment, more flexibility in the amount of hours worked, more employment and income stability, and greater job satisfaction (Oreopoulus and Salvanes 2009; Duncan 1976). They also experience lower work turnover rates which reduces the costs of worker job search, are more likely to migrate in response to employment opportunities, and have more options concerning where to live. Lower job turnover also has a social benefit since it reduces employer recruiting and training costs. (McMahon 2009; Royalty 1998; DaVanzo 1983).

Researchers generally find substantial health benefits to the educational recipient (McMahon 2009; Grossman 2006; Cutler and Lleras-Muney 2006). However, these benefits are proportionate to years of education. Additional benefits are not obtained from completing a degree as earnings studies show (Lleras-Muney 2005). Several mechanisms are likely responsible for health improvement. Higher levels of education improve consumer cognitive skills and enable them to obtain more accurate health information. Consequently, studies show that more educated consumers are more likely to go to the doctor (McMahon 2009), to adhere to their treatment regimen and to take advantage of newer medical technologies (Cutler and Lleras-Muney 2006; Grossman 2006). Education also appears to alter consumer preferences, including preferences for healthier behaviors such as smoking less, keeping proper weight and using seat belts. The effect of maintaining healthier behaviors and seeking appropriate medical treatment in a timely manner leads to greater longevity. Lleras-Muney (2005) estimates that each additional year of education reduces the probability of dying in the following 10 years by at least 3.6 percentage points

Evidence suggests that family non-pecuniary benefits are also important. Couples where one or both spouses are college educated have much lower divorce rates (Oreopoulous and Salvanes 2009). More educated spouses are associated with lower partner mortality rates and healthier behaviors such as abstinence from smoking and drinking (Cutler and Lleras-Muney 2006). Higher maternal educational levels lead to better prenatal care, lower infant mortality, improved child nutrition, and better child health (Grossman 2006; Currie and Moretti 2003). More educated mothers also raise children who are less likely to be held back and obtain more schooling (Grossman 2006; Angrist and Lavy 1996). Several studies also suggest that more educated parents practice better family planning, have better child rearing skills, and invest more time with their children (McMahon 2009; Rosenzweig and Schultz 1989). Their children also are much less likely to become pregnant as teenagers (An et al. 1993).

Education may provide additional hard-to-quantify private benefits. College education is sometimes valued for the direct satisfaction that it provides the recipient as a consumption good (Oreopoulous and Salvanes 2009; Lazear 1977). Students may enjoy learning about new ideas and cultures, participating in extracurricular activities, and attending college entertainment events. Higher education also facilitates additional learning. Information and certainty about higher education opportunities improves with higher education. It also increases the likelihood of engaging in lifelong learning and contributes to an individual's ability to adapt to technological change (McMahon 2009; Wozniak 1987).

Social Pecuniary Benefits

One of higher education's social pecuniary benefits stems from educational spillovers that affect the earnings of residents outside the household. For example, Moretti (2004b) estimates that a 1 percentage point increase in the number of college graduates in a metropolitan area increases the wages of high school drop-outs by 1.9 percent and high school graduates by 1.6 percent. Another of the benefits occurs because of the positive government fiscal impacts that result from the college-educated individual's lower demand for public services and assistance and higher tax contributions (Trostel 2007b). College educated individuals are more likely to be privately insured and exhibit lower reliance on government funded health care programs such as Medicaid. College education is also associated with reduced reliance on public assistance programs such as TANF, food stamps, and housing assistance (Trostel 2007b; Grogger 2004; Jayakody et al. 2000). Furthermore, college educated parents are more likely to raise children who are less reliant on public assistance (An et al. 1993).

Social Non-pecuniary Benefits

Improved community health, increased educational aspirations, lower crime and more community engagement are all examples of social benefits not easily converted to dollar values. Wheeler (2008) presents evidence that there are significant metropolitan area wide educational spillovers related to health—a 5 percent point decrease in the percentage of bachelor's degree graduates is associated with a 14-40 percent increase in resident mortality rates. Possible explanations for this kind of spillover are that less educated residents use the college educated residents as role models and that more educated residents lead to greater demand for health amenities that are available to the entire community such as improved medical facilities, parks and recreation facilities, improved environmental amenities and health food stores.

Education may also create its own spillover effect. Do (2004) finds that the presence of a higher quality local college nearby has a positive effect on the quality of college selected by low-income residents who attend school out of the area. Once again, role models and improved information about higher education opportunities are hypothesized to be important. Residents are more likely to attend college in regions that have larger shares of college graduates even after controlling for distance to higher education institution, family background, and local and regional socioeconomic characteristics (Rephann 2000).

Higher educational attainment leads to a decreased propensity to engage in criminal activity. Lochner and Moretti (2004) find that high school graduates are far less likely to commit crimes than high school dropouts. Descriptive data suggest similar but smaller effects for college degree earners. Lower crime translates into quality of life improvements for the general population and public savings in terms of government and citizen expenditures on crime prevention and target hardening, costs of operating the criminal justice system, and lost earnings and assets.

College education has been found to improve social engagement, community service and environmental stewardship. College graduates are more likely to vote, read the newspaper and support free speech (Dee 2004). Educational attainment is also a predictor of volunteering, participating in clubs and community projects and level of social trust (Oreopoulous and Salvanes 2009; Helliwell and Putnam 2007; Freeman 1997). States with a higher share of the adult population with 4 or more years of college education also experience lower levels of political corruption (Glaeser and Saks 2006). College educated residents are more environmentally aware and more likely to participate in environmental protection efforts such as household waste recycling (Jakus, Tiller, and Park 1997).

Virginia Fiscal Benefits

Public expenditure savings on social programs and new tax revenues are but part of the social benefits obtained from public support for higher education. However, they are a frequent focus when the question of financial returns from public support is discussed. This section follows closely the methodology of Trostel (2007b) to obtain Virginia-specific estimates of state and local government savings and revenues associated with different levels of college education completion.

The U.S. Census Bureau's *Current Population Survey* (CPS) *Annual Social and Economic Supplement* (ASEC) is used to obtain statistics on government program usage levels and state and local tax contributions by level of education attainment for Virginia residents. The ASEC Survey is conducted every year. It is based on a sample of approximately 210,000 non-institutionalized people. The detailed survey contains numerous questions about household, family, and individual characteristics, including state of residence, age, education, housing, employment, sources of income, sources of public assistance, and tax payments. For some public assistance variables (e.g., housing assistance), the CPS imputes the dollar values because a respondent would not ordinarily be expected to know the value.

In order to estimate the public expenditure demands and tax contributions of Virginia residents, we reviewed responses from Virginians only to the CPS survey. The sample is restricted to those between the ages of 19 (the estimated age of a high school graduate entering the workforce) and 78 (the estimated average U.S. resident lifespan). Sampling error was reduced by using three years of data from the most recent surveys (2006, 2007, and 2008) covering the years 2005-2007. In order to conform with our earlier estimates of the economic footprint of public higher education, all earlier monetary figures have been adjusted to 2007 dollars using the Consumer Price Index. Results are tabulated by educational attainment using the categories of (a) high school diploma/GED, (b) associate degree, (c) bachelor's degree, (d) master's degree, and (e) doctorate/professional degree. Doctorate and professional degree recipients were combined into one category because of the relatively small sizes of the sample with those advanced degrees.

The level of public service and assistance use and tax contributions by Virginia high school graduates serves as one baseline for estimating the fiscal surpluses that result from college education. Although family background, prior ability, and other factors play some role in higher education attainment, there are countervailing factors that reduce the need to control for those variables (McMahon 2009; Trostel 2007b). Therefore, the assumption is made that these differences are representative of the actual differences caused by obtaining a college degree.

A number of additional assumptions are made for computational purposes. First, in order to convert the stream of fiscal values over time to present value, a real discount rate of 3 percent is assumed. This rate corresponds to what was used in previous sections of this study and also conforms to several other studies, including Trostel. Second, it is assumed that individuals in each of the educational achievement categories lives 78 years, during which time they pay taxes and draw on public assistance to varying degrees. This is obviously a simplification based on the prior literature review because longevity differs by educational attainment. Third, it is assumed that higher degree achievers spend time out of the labor force during their studies and neither contribute taxes or draw on public assistance during this period. The average time spent out of the workforce is assumed as follows: associate degree – two years (from age 19 to 20); bachelor's degree – four years (from age 19 to 22); master's degree – six years (from age 19 to 24); and professional/doctorate degrees—eight years (from age 19 to 26). Lastly, in computing the fiscal surpluses, the bachelor's degree is used as the baseline for master's and doctorate/professional degrees to show the incremental value of graduate degrees.

Table 6.2 shows estimated lifetime savings of state and local expenditures on various categories of welfare (i.e., food stamps, school lunches, cash assistance, energy assistance, and housing assistance) by education category. The row "lifetime expenditure" shows the sum of total average annual expenditures over a lifetime. The present value discounts the stream of lifetime expenditures and adds it up. "Degree premium" indicates the discounted lifetime savings generated for a particular degree level. It is worth noting that many of these expenditures are ultimately financed by the federal government, with the state government administering the

Table 6.2. Estimated Lifetime State and Local Selected Welfare Expenditures by Educational Achievement

	High School Graduate	Associate	Bachelor's	Master's	Professional/ Doctorate
Food stamps					
Lifetime expenditure	$12,900	$2,014	$619	$732	$0
Present value	$6,129	$921	$273	$311	$0
Degree premium		($5,207)	($5,856)	$38	($273)
School lunches					
Lifetime expenditure	$2,890	$2,689	$1,198	$1,138	$1,670
Present value	$1,373	$1,230	$528	$483	$683
Degree premium		($143)	($845)	($45)	$155
Cash assistance (TANF, etc.)					
Lifetime expenditure	$930	$23	$0	$134	$0
Present value	$442	$10	$0	$57	$0
Degree premium		($432)	($442)	$57	$0
Energy assistance					
Lifetime expenditurew	$351	$93	$22	$13	$96
Present value	$167	$42	$10	$5	$39
Degree premium		($124)	($157)	($4)	$30
Housing subsidy					
Lifetime expenditure	$312	$242	$80	$10	$142
Present value	$148	$111	$35	$4	$58
Degree premium		($38)	($113)	($31)	$23
Total selected welfare					
Lifetime expenditure	$17,383	$5,060	$1,919	$2,028	$1,909
Present value	$8,259	$2,315	$845	$861	$781
Degree premium		($5,944)	($7,413)	$15	($64)

Table 6.3. Estimated Lifetime State and Local Expenditures by Educational Achievement

	High School Graduate	Associate	Bachelor's	Master's	Professional/ Doctorate
Total Welfare					
Lifetime expenditure	$17,383	$5,060	$1,919	$2,028	$1,909
Present value	$8,259	$2,315	$845	$861	$781
Degree premium		($5,944)	($7,413)	$15	($64)
Medicaid					
Lifetime expenditure	$19,936	$11,953	$4,843	$3,983	$0
Present value	$9,471	$5,468	$2,134	$1,691	$0
Degree premium		($4,003)	($7,337)	($443)	($2,134)
Unemployment Compensation					
Lifetime expenditure	$3,756	$3,357	$3,890	$1,222	$977
Present value	$1,784	$1,536	$1,714	$519	$400
Degree premium		($248)	($70)	($1,195)	($1,314)
Workers Compensation					
Lifetime expenditure	$3,124	$2,590	$803	$161	$0
Present value	$1,484	$1,185	$354	$68	$0
Degree premium		($299)	($1,130)	($286)	($354)
Corrections					
Lifetime expenditure	$14,836	$3,427	$1,060	—	—
Present value	$7,049	$1,516	$451	—	—
Degree premium		($5,533)	($6,597)	—	—
Total State and Local Expenditures					
Lifetime expenditure	$59,034	$24,019	$11,454	$7,393	$2,886
Present value	$28,047	$10,955	$5,047	$3,139	$1,181
Degree premium		($16,027)	($22,548)	($1,909)	($3,867)

programs and incurring mainly administrative costs. In the case of Medicaid, the state and federal government split the costs of the program. As a result, not all of the savings are directly realized by state and local governments in Virginia.

The table indicates that a bachelor's degree is associated with approximately $7,400 in welfare savings, with four-fifths of that amount accounted for by food stamps savings. An associate degree results in only slightly smaller savings, suggesting that the bulk of the savings occurs as a result of the initial two years of study. The savings generated by moving from a bachelor's degree to graduate and professional degrees in contrast are negligible.

Table 6.3 shows total welfare savings along with other categories of state expenditures reported in the *Current Population Survey*: Medicaid, unemployment compensation, and workers compensation. Following the methodology of Trostel, corrections savings are estimated using information from two Bureau of Justice Statistics reports (Sabol 2007; Harlow 2003) and the U.S. Census Bureau.[5] State prison incarceration rates by educational level are computed from the former based on U.S. data – 0.81 percent of the adult population who are high school graduates are incarcerated in state prisons versus 0.19 percent for adults with some college (including associate degrees) and

5. U.S. Census Bureau. *State and Local Government Finances*. http://www.census.gov/govs/www/estimate.html (Accessed September 10, 2009).

Table 6.4. Estimated Lifetime State and Local Tax Revenues by Educational Achievement

	High School Graduate	Associate	Bachelor's	Master's	Professional/ Doctorate
Income Taxes					
Lifetime taxes paid	$59,875	$87,227	$138,193	$174,193	$154,188
Present value	$28,446	$39,906	$60,897	$73,955	$65,496
Degree premium		$11,460	$32,450	$13,058	$4,600
Real Property Taxes					
Lifetime taxes paid	$62,700	$79,308	$89,382	$111,028	$112,004
Present value	$29,789	$36,283	$39,387	$47,138	$45,826
Degree premium		$6,494	$9,599	$7,751	$6,438
Sales and Excise Taxes					
Lifetime taxes paid	$72,016	$83,668	$95,844	$105,672	$113,918
Present value	$34,214	$38,278	$42,235	$44,864	$46,609
Degree premium		$4,063	$8,021	$2,629	$4,374
Total State and Local Taxes					
Lifetime taxes paid	$194,591	$250,202	$323,419	$390,893	$380,110
Present value	$92,450	$114,467	$142,519	$165,957	$157,931
Degree premium		$22,018	$50,069	$23,438	$15,412

0.06 percent of those with bachelor's degrees or higher. Using information from the latter two sources on the number of state prisoners (35,344) in December 2005 and FY 2006 state expenditures on corrections ($1.079 billion), an average inmate cost of $30,531 is estimated. Based on these figures and adjusting to 2007 dollars, the average annual expected correction costs for a high school graduate is $254.31, an associate degree graduate $58.74, and a bachelor's degree graduate $18.80.

Results from the table indicate that an associate degree results in total savings of $16,027 and a bachelor's degree in $22,548 compared to a high school diploma. The largest portion of the bachelor's degree savings come from three parts in equal measure, decreased welfare assistance, lower levels of Medicaid use and lower correctional expense. The savings for master's and doctorate/professional degree completion relative to bachelor's degree completion are comparatively much smaller, $1,909 and $3,867 respectively.

Table 6.4 reports average lifetime tax payments by highest educational attainment.[6] The income and property tax figures are drawn from the *Current Population Survey*. Sales and excise taxes were not reported. Therefore, following Trostel, these tax payments were estimated using information on individuals' incomes matched with estimates of average sales and excise tax taxes paid by income quintile provided by the Institute on Taxation and Economic Policy (McIntyre et al. 2003). In present value terms associate degree earners pay 24 percent more in state and local taxes than high school graduates while bachelor's degree recipients pay 54 percent more and doctorate/professional degree holders pay 71 percent more. The additional lifetime tax revenue generated is $22,018 for associate degrees, $50,069 for bachelor's degrees, $23,438 for master's degrees, and $15,412 for doctorate/professional degrees.

The data used to create Tables 6.3 and 6.4 were also used to estimate the state and local government expenditure savings and tax revenues that would be realized with current and additional investment in public higher education. These figures were obtained by estimating the number of degrees by level that would be retained

6. These estimates do not include some state and local taxes such as local personal property tax, the business, professional and occupational license tax (BPOL), the local consumer utility tax, local meals and lodging taxes, the state corporate income tax, and the state tax on public service corporations.

Table 6.5. State and Local Government Expenditures Savings and Revenues Generation from FY 2007 Graduates and Degree Initiative, Net Present Value, Millions of 2007 Dollars

	State and Local Government Expenditure Savings	State and Local Government Revenues
FY 2007 degree production	$350	$1,393
Degree initiative	$358	$1,185

in the state until age 78. The graduating cohorts were subject to an annual 3 percent rate of attrition in the same manner as was assumed elsewhere in this study. Average annual expenditures savings and tax revenue surpluses by educational attainment were multiplied by the corresponding number of degrees, discounted at a 3 percent rate, and summed to arrive at the present values reported in the table. **Table 6.5** reports that approximately $350 million in state and local government expenditures would be saved as a result of the educational attainment of public higher education degree awardees in FY 2007 who continued to reside in Virginia. In other words, public higher education graduates in 2007 will likely require $350 million less in spending for government programs than non-graduates. Moreover, $1.393 billion dollars in additional property, sales, and income taxes would be generated by the FY 2007 graduates. The fiscal impacts of the degree initiative described in Section 5 would include $358 million in state and local government expenditures savings and $1.185 billion in state and local government tax revenue.

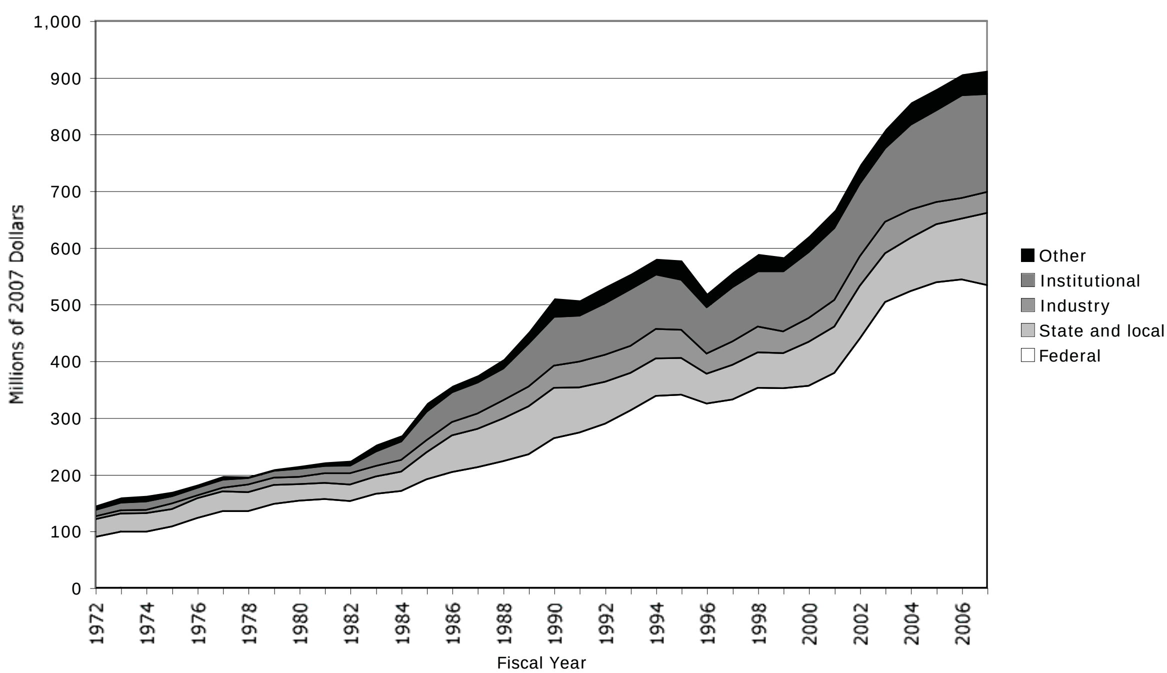
Section 7
Other Economic Development Contributions of Higher Education

In addition to the quantifiable impacts of public higher education outlined in the previous sections, there are other contributions made by the individual institutions that are not always easy to frame in terms of dollars and cents, yet they nevertheless improve the overall economic competitiveness and quality of life in Virginia. For example, public colleges and universities are involved in a variety of public service, agricultural and industrial extension, and business consulting activities. They provide physical infrastructure and business services for business parks and business incubators. University research centers serve as a wellspring for new ideas and innovations within emerging industrial sectors that the state has targeted such as alternative energy and modeling and simulation. Public higher education institutions produce patented technologies that result in licensure revenue and lead to business startups. They work closely with industry to train new workers and enhance the skills of current workers through non-credit workforce programs. They offer economic development leadership by providing staff to serve on important state and local committees, spearhead planning, evaluation, and visioning studies, and assist in industrial recruitment activities. Many are also involved in urban development and neighborhood revitalization efforts. This section catalogues, briefly describes, and attempts to quantify where possible the economic effects of these varied activities.

Research and Development

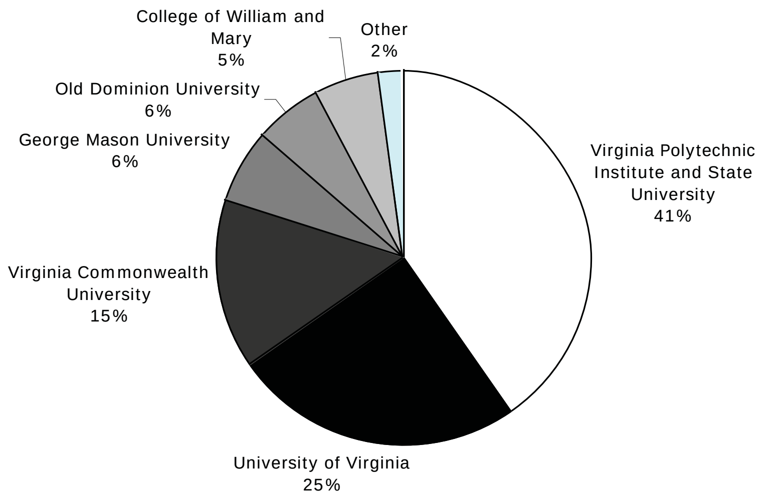
Virginia public higher education has experienced rapid growth in research and development (R&D) expenditures over the past several decades. **Figure 7.1**

Figure 7.1 Academic R&D Expenditures by Source of Funding for Virginia Public Higher Education Institutions, Millions of 2007 Dollars



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

Figure 7.2 Academic R&D Expenditures by Virginia Public Higher Education Institution, FY 2007



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

shows that expenditures for science and engineering expressed in terms of 2007 dollars have increased by more than six-fold since 1972 and by approximately 55 percent in the last 10 years. The bulk of this funding, 58 percent, comes from the federal government, with 19 percent coming from the institutions themselves, 14 percent from state and local government, 4 percent from business and industry, and 5 percent from other sources such as private foundations. The percentage of funding from the federal government began to plateau in 2006 with other sources of funding, particularly state government, helping to pick up the slack. The economic impact of these research expenditures was considered in section four.

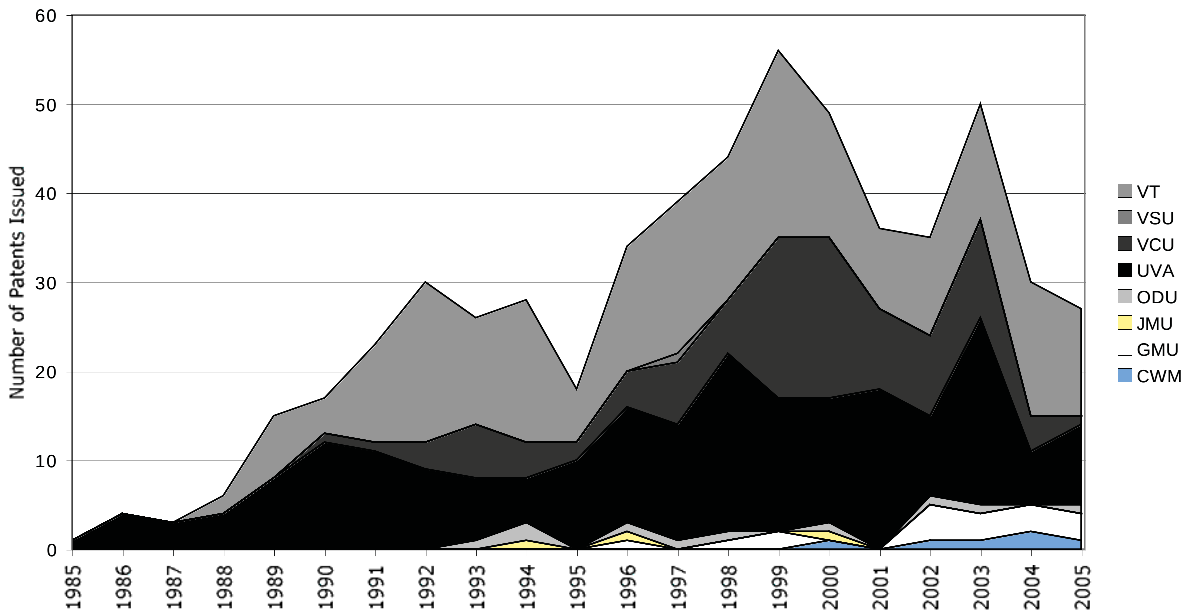
Ninety-eight percent of research spending is concentrated among six flagship institutions (see **Figure 7.2**): Virginia Tech, the University of Virginia, Virginia Commonwealth University, George Mason University, Old Dominion University, and the College of William and Mary. Virginia Tech's R&D expenditures, which include funds for agricultural extension and agricultural experiment stations, rank 42nd highest in the nation.

The huge growth in expenditures correlates with increased university innovation as measured by patent activity. During the 16-year period from 1969 to 1984, a total of 54 patents were issued to Virginia public higher education institutions. **Figure 7.3** shows this growth over the period 1985-2005. During that time, an average of 27 patents have been issued each year for a total of 571 patents. The University of Virginia, Virginia Tech, and Virginia Commonwealth University account for 93 percent of the total.

Virginia public higher education researchers have received recognition and accolades from the national and international community for their prolific and groundbreaking work. Thirty-seven living faculty (**see Appendix A.5**) are listed among the world's most cited and influential researchers according to Thomson Scientific's ISI HighlyCited.com.[1] Nine faculty members belong to the prestigious National Academy of Science, 21 are members of the National Academy of Engineering, and 18 are members of the Institute of Medicine. Furthermore, nine winners of the Nobel prize in the last three decades have had connections with Virginia public higher education (**see Appendix A.6**), including a current professor of economics at George Mason University, James Buchanan, and a professor of chemistry, John Bennett Fenn, at Virginia Commonwealth University.

1. http://hcr3.isiknowledge.com/home.cgi (Accessed September 25, 2009).

Figure 7.3 Patents Awarded by Virginia Public Higher Education Institution, 1985-2005



Source: U.S. Patent and Trademark Office, U.S. Colleges and Universities—Utility Patent Grants, Calendar Years 1969-2005 http://www.uspto.gov/go/taf/univ/org_gr/all_univ_ag.htm

Virginia's top quality public university graduate programs also attract talented graduate students from Virginia, the rest of the nation and the world. Such students provide a ready workforce for new and growing technology-based businesses in the state. The Center for Measuring University Performance (Capaldi et al. 2008) ranks both the University of Virginia and Virginia Tech 37th and 71st respectively, among American research universities. Virginia university graduate programs also score highly among scientific, technical, engineering and math (STEM) disciplines in the 2009 edition of the *U.S. News and World Report* annual survey. In engineering, Virginia Tech is ranked 27th and the University of Virginia 37th. In computer science, University of Virginia is listed 29th, Virginia Tech 46th, and George Mason University 65th. For physics, the University of Virginia is 36th, Virginia Tech is 64th and the College of William and Mary is 68th. In biosciences, the University of Virginia is 42nd and Virginia Tech is 77th; for chemistry, the University of Virginia is 50th and Virginia Tech is 68th; for math, the University of Virginia is 40th and Virginia Tech is 48th. The University of Virginia ranks 24th in medical research while Virginia Tech is 28th in earth science.

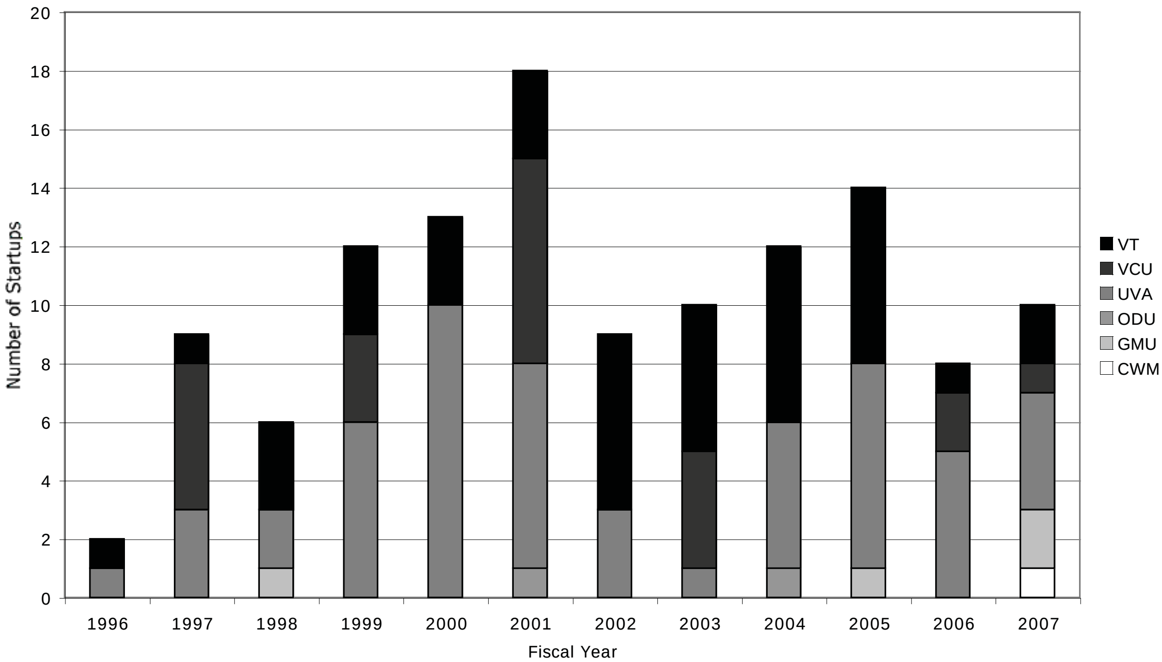
Technology Transfer

Virginia's public colleges and universities have been responsible for hundreds of business spinoffs over the last few decades. Although no declarative count is available of just high this number is and how many jobs have resulted, some information is available from university technology transfer offices on a subset of such firms: companies that were established as a result of licensed university technologies, which are termed "business startups." Unfortunately, this definition excludes many university spinoffs such as Roanoke-based Luna Innovations, which was founded by Virginia Tech professor Kent Murphy and employs over 200 Virginia residents.[2] It also excludes pre-existing Virginia based businesses that expanded as a result of the expertise or licensed technologies they gained from Virginia public higher education institutions.

Figure 7.4 shows the number of business start-ups created during the 12-year period running from 1996

2. Luna Innovations was started with licensed technology obtained from Virginia's Center for Innovative Technology (CIT), a non-profit corporation that had sponsored the research at Virginia Tech that led to the patent. (Correspondence from Mark Coburn, President of Virginia Tech Intellectual Properties, Inc., September 22, 2009).

Figure 7.4 Number of Business Startups by Virginia Public Higher Education Institution, 1996-2007



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

to 2007. During that period, an average of ten firms were created each year for a total of 123 firms. Ninety-four percent of these startups originated from just three universities: the University of Virginia (44 percent), Virginia Tech (32 percent) and Virginia Commonwealth University (18 percent). Not all of these startups are located in Virginia, some have been purchased by other companies, some are now defunct, and a few are relatively small one-person operations. Information collected from university technology transfer offices and matched with employment records from the Virginia Employment Commission and other sources indicates that about half are still in existence and operating in Virginia. Fifty-six business startups begun over the period 1991-2008 have created at least 626 jobs. Seventy percent of these firms belong to 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. **Figure 7.5** shows a breakdown of firm employment by four digit North American Industrial Classification System (NAICS) industry. Over four in ten employees are in the computer systems and design industry, 24 percent are classified as being in the scientific research and development services industry, 20 percent are classified as producing medical equipment or pharmaceuticals and 4 percent for semiconductors and electronic equipment.

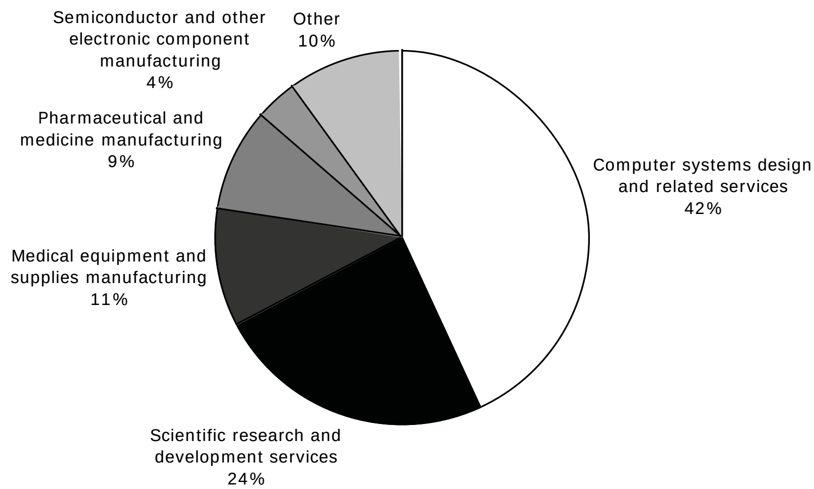
These employment figures and industry classifications were used with REMI PI+ to determine the full economic impact on Virginia. **Table 7.1** shows the results. The 626 direct jobs are responsible for 1,396 total jobs, $124 million in GDP, and $9 million in state revenues.

In addition to creating employment, income and taxes for the Commonwealth, technology transfer generates

Table 7.1 Results of University Start-ups Economic Impact Analysis, Millions of 2007 Dollars

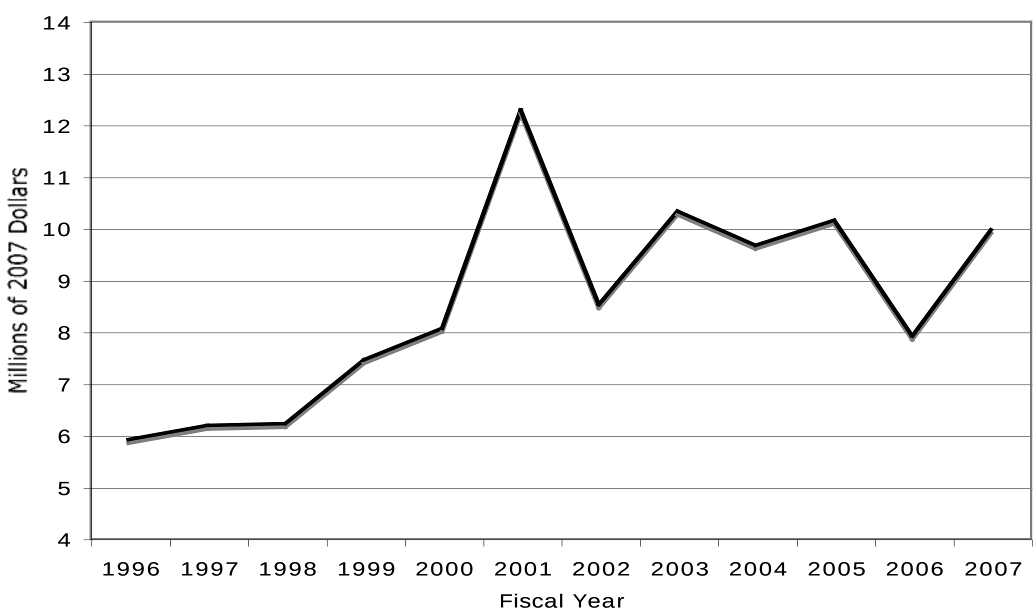
Economic Variable	Amount/Number
Gross domestic product	124
Industrial output	196
Personal income	80
State revenues	9
Total employment	1,396

Figure 7.5 Business Startups at Virginia Public Higher Education Institutions by Industry, 1991-2008



revenue for universities. This revenue is used to fund technology transfer operations, research and development activities and faculty royalties. **Figure 7.6** indicates that licensure revenues have increased by 34 percent since 1996 and have averaged about $9.8 million dollars per year in the last six years. Three universities account for 99 percent of the licensure revenues received during the period (the University of Virginia, 64 percent; Virginia Tech 24, percent; and Virginia Commonwealth University, 11 percent). Virginia public higher education patent foundations also have equity in a number of startup companies.

Figure 7.6 Virginia Institutions of Public Higher Education Licensure Revenue by Year, 1996 to 2007 in 2007 Dollars



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

Agricultural and Industrial Extension

Public higher education provides numerous outreach services to farmers and businesses to enable them to learn about and adopt new business processes and technologies. Virginia Cooperative Extension is based at the state's two land-grant universities: Virginia Tech and Virginia State University. Through a network of 107 extension offices in Virginia counties and cities and 13 agricultural research and extension centers, the extension service provides programming in topics such as agricultural business, finance, and marketing; equipment and new technology; pesticides and chemicals use; environmental issues; youth development; veterinary medicine and husbandry; and health, nutrition, and safety issues among others. Cooperative Extension touches many Virginians in one way or another. In 2008, the extension service reported 823,441 duplicated direct adult contacts (e.g., face to face meetings, workshops, training sections, consultations). **Table 7.2** summarizes some recent data that Cooperative Extension reported on the effectiveness of some of its programs. It shows that extension programs in 2008 boosted the sales and incomes of Virginia farmers by millions of dollars. One comprehensive Virginia study estimates that each dollar invested in agricultural extension generates $3.87 in farm production over an 8 year period" (Norton and Paczkowski 1993).

Virginia public colleges and universities are also heavily involved with the statewide Virginia A. L. Philpott Manufacturing Extension Partnership (MEP), which is part of the national MEP network and funded by the National Institute of Standards and Technology (NIST) and state appropriations. Virginia Tech and the Philpot MEP have partnered to form the Technical Assistance Program (TAP), which provides technical assistance to small and medium sized industrial firms. The Philpot MEP maintains partnerships with the Virginia Applied Technology and Professional Development Center (VATPDC) at Old Dominion University and the Manufacturing Technology Center (MTC) at Wytheville Community College. The MEP reports that it has had a $1.4 billion cumulative impact in Virginia since 2000 and helped to create or retain 4,182 jobs.[3]

Research Centers and Industry Targeting

Virginia public higher education institutions, with the financial assistance of other sponsoring agencies and private donors, support hundreds of research centers, institutes, laboratories and research groups across the Commonwealth. Many of these centers are organized at the college/university level while others may be organized within schools or departments. These entities contribute to the state's technological capabilities and play an important role in economic development.

3. Bottom Line Results; http://www.vpmep.org/bottom-line-results.php (Accessed September 11, 2009).

Table 7.2 Virginia Cooperative Extension, Selected Agricultural Economic Impacts, 2008.

Program	2008 Economic Impact
Organic farming	Increased sales of six farms of between 150-600%.
Alternative enterprises	Eight farmers reported increase in income from 10-100% as result of new alternative enterprise.
Virginia Quality Assured (VQA) program	Farms received $504,802 in additional income from participating in program.
Virginia Beef Quality Assurance (BQA) program	Farms received $1.5 to $2.0 million more income from participating in program.
Lamb marketing	Farms received $125,430 more income than traditional marketing outlets.
Virginia Aqua-farmer Network (VAN)	15 farms received $153,000 in new sales of freshwater shrimp.
Small Farm Outreach and Technical Assistance program	175 limited resource farms earned an additional total of $151,400 income.
Pest management information	Nineteen farms reported yield increases that translate into $819,500 in additional sales.

Source: Compiled based on information from 2008 Virginia Polytechnic Institute & State University and Virginia State University Combined Research and Extension Annual Report of Accomplishments and Results.

The Virginia Economic Development Partnership (VEDP) recognizes the key role that higher education plays in industrial recruitment, expansion and small business creation. The VEDP's business development strategy identifies higher education institutions as key stakeholders whose assets can be leveraged to support the agency's economic development strategy. The Partnership organizes its economic recruitment efforts around the concept of industry clusters. Industry clusters are a geographic concentration of interconnected businesses that share labor, suppliers, consumers, or the services of other institutional assets (such as colleges and universities). Such clusters increase the productivity of firms above and beyond what would be realized in isolation, which enables them to better compete in domestic and international markets.

The VEDP currently focuses on four "verticals" (see **Figure 7.7**) that are conceptually linked to industry clusters identified in state commissioned economic development studies. These verticals include advanced manufacturing, research and science, security and services, and transportation. They form the basis of the Partnership's team marketing efforts. Furthermore, the VEDP has defined six special target areas (or "initiatives") for more intensive marketing and recruitment. They include plastics/polymers, fabricated wood, business solutions, modeling and simulation, energy, and global logistics.

In order to gauge how public higher education research centers align with VEDP goals, a list of active research centers was compiled using base information obtained from the VEDP. This information was updated by adding centers and institutes not listed in the VEDP database and deleting ones that appeared no longer active. There are over 300 research centers at Virginia public universities. A total of 249 active centers were identified from the following research institutions that align with VEDP verticals and/or initiatives: Christopher Newport University; the College of William and Mary; George Mason University; the University of Virginia; Norfolk State University; Old Dominion University; Virginia Commonwealth University; Virginia Military Institute; Virginia State University; and Virginia Tech. The number of centers is an imperfect metric because

Figure 7.7 Virginia Economic Development Partnership Verticals and Initiatives

Advanced Manufacturing
Plastics/Polymers Initiative
Fabricated Wood Initiative
Food Processing
Pharmaceuticals
Natural Resources
Chemicals

Security & Services
Business Solutions Initiative
Modeling & Simulation Initiative
Federal Security Agencies & Providers
Information Technology
Finance, Insurance, HQ
Professional & Business Services

Science & Research
Energy Initiative
Biotechnology/R&D
Nanotechnology
Emerging Industries
Medical/Federal Labs

Transportation
Global Logistics Initiative
Automotive
Aerospace
Global Logistics
Distribution

Table 7.3 Virginia University Research Centers Aligned with VEDP Verticals and Initiatives

Type of Alignment	Number
Verticals	
Advanced manufacturing	24
Security and services	47
Science and research	154
Transportation	30
Initiatives	
Plastics/polymers	9
Fabricated wood	5
Business solutions	6
Modeling and simulation	11
Energy	27
Global logistics	12

it measures quantity rather than size, quality or intensity of research effort. However, in the absence of this other information, it provides an approximation of the amount of intellectual resources available to business and industry.

Table 7.3 shows a breakdown of center alignment with VEDP verticals and initiatives. An individual center may align with one or more vertical or initiative. The science and technology vertical category contains the highest number of associated research centers (154) followed by security and services (47), transportation (30), and advanced manufacturing (24). Among the VEDP initiatives, there are 27 research centers that align with energy, 12 with global logistics, 11 with modeling and simulation, nine with plastics/polymers, six with business solutions, and five with fabricated wood. A number of research centers align with areas not currently emphasized by VEDP. For instance, Virginia public higher education institutions have demonstrated research strengths in the areas of biotechnology with 38 aligned centers, information technology with 25 centers, automobiles with 17 centers, aerospace with 14 centers, and nanotechnology with 11 centers (**see Table 7.4**). There are also distinct regional specializations by universities by research specialty. For instance, Virginia Tech has 16 of the 27 public higher education centers that focus on basic and applied science in the area of energy. The University of Virginia has 15 of the 38 biotechnology centers.

Virginia public universities routinely partner with industry and government to form Cooperative Research and Development Agreements (CRADA) to conduct applied research and development. Universities also sponsor industry university cooperative research centers to encourage industry partnerships (e.g., Old Dominion University's Virginia Modeling, Analysis and Simulation Center, the University of Virginia's Nanostar Partnership and Innovation Program, and Virginia Tech's Advanced Research

Table 7.4 Nanotechnology Research Centers at Virginia Public Universities

Research Center	University
Applied Research Center	Christopher Newport University, College of William and Mary, Norfolk State University, Old Dominion University
Computational Materials Science Center (CMaSC)	George Mason University
Center for Materials Research	Norfolk State University
Institute for Nanoscale and Quantum Scientific and Technological Advanced Research (nanoSTAR)	University of Virginia
Center for Nanoscopic Materials Design	University of Virginia
Center for Lasers and Plasmas	University of Virginia
Wright Virginia Microelectronics Center	Virginia Commonwealth University
Institute for Critical Technology & Applied Science (ICTAS)	Virginia Tech
Carbonaceous Nanomaterials Center	Virginia Tech
Center for Photonics Technology	Virginia Tech
Center for Self Assembled Nanostructures and Devices	Virginia Tech

Institute). Several Virginia university research centers are members of the prestigious National Science Foundation (NSF) funded Engineering Research Centers or Industry-University Cooperative Research Centers. These industry-university partnerships are designed to strengthen U.S. industry and make it more technologically competitive. They feature industry support and collaboration in research and education, applied research that is relevant to the needs of industry and transfer of university technology to industry. **Table 7.5** shows that Virginia Tech, the University of Virginia, Virginia Commonwealth University and Norfolk State University host NSF centers and support industry research links in a number of VEDP targeted areas such as advanced manufacturing, energy, information technology, and modeling and simulation.

One of the most innovative of the research centers is the Virginia Modeling, Analysis, and Simulation Center (VMASC), a multi-disciplinary modeling, simulation, and visualization research center managed by Old Dominion University. The center links university

Table 7.5 Virginia Public University National Science Foundation Engineering Research Centers and Industry-University Cooperative Research Centers

Center	University	Field	University Partners/Affiliates
Center for Lasers and Plasmas for Advanced Manufacturing (LAM)	University of Virginia	Advanced manufacturing	University of Michigan, Southern Methodist University
Center for Precision Forming (CPF)	Virginia Commonwealth University	Advanced manufacturing	Ohio State University
Wood Based Composites Center (WBC)	Virginia Tech	Advanced materials	Oregon State University
Center for Advanced Forestry Systems (CAFS)	Virginia Tech	Biotechnology	North Carolina State University, Oregon State University, Purdue University, University of Florida, University of Georgia, University of Maine, University of Washington
Engineering Research Center for Biorenewable Chemicals	University of Virginia	Energy, sustainability and infrastructure	Iowa State University, Rice University, University of California, Irvine, University of New Mexico, University of Wisconsin-Madison
High Performance Reconfigurable Computing (CHREC)	Virginia Tech	Information, communication and computing	University of Florida, George Washington University, Brigham Young University
Wireless Internet Center for Advanced Technology (WICAT)	Virginia Tech and University of Virginia	Information, communication and computing	Polytechnic University, Auburn University
Engineering Research Center for Integrated Access Networks	Norfolk State University	Microelectonics, sensing and information technology	University of Arizona, California Institute of Technology, Stanford University, Tuskegee University, University of California-Berkeley, University of California-Los Angeles, University of Southern California
Center for e-Design	Virginia Tech	System design and simulation	University of Central Florida, University of Massachusetts
Center for Engineering Logistics and Distribution (CELDi)		System design and simulation	University of Arkansas, University of Oklahoma, University of Louisville, Oklahoma State University, Lehigh University, Texas Tech University, Clemson University, University of Missouri, Arizona State University

programs, research activities, and student in modeling and simulation fields with over a hundred industry, government and educational firms, agencies and institutions to promote economic development in the region. In addition, VMASC offers business accelerator facilities and services to new businesses. The modeling and simulation sector is rapidly growing in Hampton Roads, experiencing a 25.4 percent rate of employment growth from 2004 to 2007 with an average salary of $82,733 (ANGLE Technology 2007). Moreover, continued growth in the industry is expected, with a projected annual rate of growth of 14.5 percent. The sector has an overall economic impact of over 5,000 jobs and $408 million in GDP.

Research Parks

Virginia's public universities sponsor eight regional research or business parks (see **Table 7.6**). They range from the Corporate Research Center in Blacksburg, which was started in 1985 and now has over 140 tenants with 2,200 employees to the newly opened Discovery Business Park in Williamsburg, which forms the cornerstone of the College of William and Mary New Town urban development project.

The parks are used primarily for private and public research and development activities and involve high technology and science based companies as well as university business support services such as business incubators and business accelerators designed to support new businesses. These parks host hundreds of private companies and over 7,500 employees. The parks serve multiple purposes, such as creating quality jobs and improving state and regional economic development, stimulating entrepreneurship, promoting technology transfer and business start-ups, developing collaborative opportunities for university researchers, providing jobs for students and generating revenue to support other institutional activities.

Two of the parks also offer business incubation and accelerator facilities. Virginia Commonwealth University's Virginia BioTechnology Research Park hosts the Virginia Biosciences Development Center, a business incubation facility, as well as the Virginia Biosciences Commercialization Center, an accelerator, that provides services to post-incubation companies with business planning and marketing services to enable them to thrive on their own. VT Knowledgeworks is both an incubator and accelerator located in The Corporate Research Center. Chubby-Brain, an information company that tracks incubator and start-up activity, rates it the 8th most active incubator in the United States[4].

Business Counseling and Support Services

Small Business Development Centers (SBDCs) are important community entrepreneurship training organizations that provide business assistance to existing and prospective small businesses, including information and mentoring on business and business startup and management operations, assistance with development of business and marketing plans, and financial assistance. They are a partnership between the U.S. Small Business Administration (SBA), public higher education, the private sector and local governments.

In Virginia, the SBDC network is administered through the George Mason University-Mason Enterprise Center at the School of Public Policy. There are a total of 29 local SBDCs located across Virginia arranged into five districts. Many of the centers are located on college and community college campuses (Longwood University, George Mason University, James Madison University, University of Mary Washington, Blue Ridge Community College, Germanna Community College, Lord Fairfax Community College, Mountain Empire Community College, Southwest Virginia Community College, Thomas Nelson Community College, and Virginia Highlands Community College) and sometimes draw on college resources and expertise. Approximately half of total funding (cash and in-kind) comes from the SBA with another quarter coming from public higher education and the remainder provided by chambers of commerce, local governments and economic development organizations.

The Virginia SBDC network recently evaluated the economic development impact of its programs. In FY 2007, Virginia SBDCs provided counseling to 938 long-term clients, including 478 current businesses and

4. *Fostering Local Economic Development: The State of United States Incubators* http://www.chubbybrain.com/blog/2009/07/fostering-local-economic-development-the-state-of-united-states-incubators/

Table 7.6 Virginia Public Higher Education Research Parks

Business Park	University	Partners	Location	Size	Date Started	Key Characteristics	Economic Impacts
Corporate Research Center	Virginia Tech		Blacksburg	120 acres; 27 buildings with 956,000 sq. ft.	1985		140 private companies and research centers with 2,200 employees; Park plans another 28 buildings and 950,000 sq.ft. to accommodate 3,000 additional employees
Discovery Business Park	College of William and Mary	James City County; Thomas Nelson Community College	Williamsburg	65 acres	2009		Discovery I and II buildings complete and house university and regional partner functions
Fontaine Research Park	University of Virginia		Charlottesville	54 acres; 8 buildings with 558,000 sq. ft. of office space	1994		Park is fully built out; mostly university tenants; CFA Institute employs 250 at facility
Innovation @ Prince William Technology Park	George Mason University	Prince William County		1,500 acres	1992	Targets: Biotech, life science and related	23 business tenants; 2,700 new jobs and total investment of over $830 million
Innovation Research Park @ ODU	Old Dominion University		Norfolk	75 acres; one 100,000 square foot building with flexible wet/dry lab space	2007	One of only a handful of research parks located on university campus	Currently 12 tenants; second building planned
RISE Campus	Norfolk State University		Norfolk	25 acres; one 12,800 sq. ft. building constructed	2007	University tenants in first building	Five additional buildings planned for full build out. University projects $122 million annual economic impact at full build out (Brod 2004)
University of Virginia Research Park	University of Virginia		North Fork, Albemarle County	562 acres; 8 buildings with 491,000 sq. ft.	1994		15 private sector tenants employ 1,269
Virginia BioTechnology Research Park	Virginia Commonwealth University	City of Richmond; Commonwealth of Virginia	Richmond	34 acres; 1.1 million sq. ft. of office space in 9 buildings	1995	Located next to VCU Medical Center	62 tenants (including VCU institutes, state and federal laboratories); employs over 2,000 scientists, engineers, and researchers; Park collaborates with regional satellite parks to site companies too large for downtown facilities

460 pre-ventures. Eighty-eight percent of these clients found the services provided to be beneficial to their businesses. As a result of these services, $85.8 million in new sales were generated, creating an employment impact of 1,109 jobs. In addition, $52.5 million in sales and 440 employment were prevented from being lost because of counseling (Chrisman 2008).

Several colleges and universities offer additional business training, counseling and networking services. For example, George Mason University sponsors the Business Alliance, which hosts educational and investment forums, networking events and business education seminars. Other examples are the Virginia Tech Business Technology Center, which targets business assistance to technology-based businesses, Virginia Tech's Center for Forest Products Marketing and Management, which assists firms with marketing and operations management in the forest products industry, and the Virginia Electronic Commerce Technology Center (VECTEC) at Christopher Newport University, which provides assistance on business web development. VECTEC's economic impact is illustrative. Information from the center's annual client survey indicated that in FY 2007, they assisted in the creation or retention of 43 jobs with an average annual salary of $29,746. In addition, clients realized sales increases and costs savings amounting to $8.5 million.

Workforce Development

Virginia's public higher education institutions offer a wide range of noncredit coursework, including programs that lead to certification and customized training for individual businesses workforce development needs. The enrollees and program completers are not reflected in the economic outcomes reported elsewhere in this study. Virginia's Community College System is the leading provider of these services, although four-year colleges and universities are also active in professional and continuing education. Community colleges offered 3,334 noncredit courses that were completed by 94,013 people, served 1,305 employers with customized training and enrolled even more students from 3,000 firms in open enrollment courses (Mangum Consulting, Inc 2008). The statewide economic impact of the human capital that resulted from this non-credit training was estimated by Mangum Consulting to be $190.4 million in terms of present value. Many of these programs are supported with funds from the Virginia Jobs Investment Program at the Department of Business Assistance. This program is one of the state's flagship economic development incentives.

State and Regional Economic Development Leadership

The faculty and staff at Virginia's public colleges and universities play important leadership roles in the state and their local communities by serving on planning committees, economic development task forces, and business contact groups. For example, the University Based Economic Development (UBED) Group, an advisory group whose membership is comprised of higher education, state agencies, and economic development organizations, was formed to improve the linkages between business and higher education in support state economic development initiatives.

Virginia public higher education has also played an important role in addressing regional economic development needs. Several recent examples illustrate the level of involvement in different regions of the state:

- Virginia Tech, the University of Virginia and the Virginia Community College System were an instrumental part of the package of incentives used recently to encourage Rolls Royce to locate a state of the art jet engine manufacturing facility which will create 500 high paying jobs and as much as $500 million in new investment in the Petersburg region.[5] The colleges and universities will provide workforce and continuing education services for Rolls Royce and collaborate on research and development projects.

- The University of Virginia and the University of Virginia at Wise have established a formal partnership with the Virginia Coalfield Economic Development Authority (VCEDA), regional community colleges, and local governments to increase economic development in Southwest Virginia.[6] Currently, the partnership is focused on developing the information, education, health care, and energy sectors. As part of

5 http://www.yesvirginia.org/about_us/newsarticle.aspx?newsid=902 (Accessed September 26, 2009).

6 University of Virginia, Partnership with Southwest Virginia, Annual Report Economic Development Action Plan – FY09. http://www.virginia.edu/vpr/industry/southwestva.html (Accessed September 26, 2009)

this focus, it operates the newly opened Southwest Virginia Technology Development Center in Russell County, which was created to support the emerging information technology sector in the region. The provision of this facility and its business and educational support services was an important factor in the attraction of two information technology companies to the county, a Northrop Grumman "help desk" and data backup center and CGI-AMS Inc.'s software development and systems integration facility in 2007. The two firms announced that they planned to create over 700 direct jobs. In 2009, CGI announced its intention to expand and create another 100 jobs.

• SRI International selected Rockingham County for its new Center for Advanced Drug Research (CADRE) in December 2006. James Madison University assisted the Virginia Economic Development Partnership and local government in preparing the proposal that helped to attract the firm. Moreover, SRI International cited the quality of Virginia's research universities in announcing the location decision. The center will employ more than 100 employees in pharmaceutical research in a 40,000 square foot building in the Rockingham Technology Research and Technology Park with options for further expansion.

Urban and Neighborhood Revitalization

Several colleges and universities are involved in substantial urban development activities around their peripheries that are transforming the streetscapes and creating new housing opportunities as well as retail and services to serve the students, faculty, staff, visitors, and members of the community. Some notable examples are as follows:

• The Endowment Association of the College of William and Mary has partnered with C.C. Casey Limited Company to develop a 365-acre mixed-use community called "New Town" adjacent to campus. New Town currently contains over 1.7 million square feet of retail, service, office, and residential space and a several national retailers and restaurants. The previously introduced Discovery Business Park is part of the development. Full build-out for the project is projected in 10 years.

• The Old Dominion University Real Estate Foundation has partnered with the City of Norfolk and Norfolk Redevelopment and Housing Authority on a 75-acre mixed-use development adjacent to campus called University Village. The development has opened with restaurants, retail, service, office, student residential space and a hotel. Also located in University Village are the Innovation Research Park, the University Bookstore and Ted Constant Convocation Center, which hosts university and community events. When fully-built out, total investment is projected to exceed $260 million.

• Norfolk State University's Office of Community and Outreach Services has improved the neighborhoods adjoining its campus by operating the Brambleton Community Outreach Center to expand educational and recreational opportunities to members of the community and by partnering with local organizations to improve housing and employment opportunities. Through a partnership with Plumbline Ministries, the University has built approximately 100 homes in the vicinity. The annual economic impact of this housing initiative on the Hampton Roads Region was estimated to be $1.2 million in output, $500,000 in personal income, and 21 jobs (Brod 2004).

• The Longwood University Real Estate Foundation completed a project with a private developer to redevelop a 5.5 acre site across from the Longwood Campus into a mixed use development. The development, known as Town Square, was opened in 2006. It features 408 student bedrooms and 45,000 square feet of retail/commercial space.

Other Virginia public higher education institutions have similar neighborhood development plans in the works. For example, Virginia Commonwealth University's real estate foundation has purchased property where Ukrop's formerly operated a grocery store at Grace and Harrison streets. The site is being considered as a mixed-used development that would include parking, student housing and retail outlets.

APPENDIX A.1
Institutional Descriptions

Four-year Colleges and Universities.

Christopher Newport University (CNU) is a four-year institution designated as a baccalaureate college in liberal arts by the Carnegie Foundation's classification system. The university is named for Christopher Newport, one of the original founders of the Jamestown settlement. CNU was founded as a two-year branch of the College of William and Mary in 1960 and became independent in 1977. It gained university status in 1992. The university is located on a 260-acre campus in Newport News. It enrolls nearly 5,000 students and offers more than 80 academic majors and programs at the undergraduate and graduate levels.

The College of William and Mary (CWM) is the second-oldest institution of higher education in the United States (Harvard being first). It was founded on February 8, 1693 by a charter from King William III and Queen Mary II of England. The college enrolls approximately 8,000 students in 36 undergraduate programs as well as 12 graduate/professional programs in business, education and law. CWM is categorized as a doctoral and research university-intensive by the Carnegie Foundation.[1] The college has graduated three U.S. presidents: Thomas Jefferson, James Monroe and John Tyler. It is located in Williamsburg on a 1,200-acre campus.

George Mason University (GMU) was started as a two-year branch of the University of Virginia in 1957. It was expanded into a four-year, degree-granting institution in 1966, and it became an independent university in 1972. The university today has an enrollment of over 30,000 students, making it second only to Virginia Commonwealth University in size. GMU is named after George Mason, one of the founding fathers of the United States, who played a key role in the adoption of the Bill of Rights at the U.S. Constitutional Convention. George Mason University's main campus is located in Fairfax County on a 677 acre tract. The university also operates three branch campuses located in Arlington County, Prince William County and Loudoun County. GMU offers more than 100 programs at both the undergraduate graduate and professional levels and is designated as a doctoral and research university-intensive by the Carnegie Foundation.

James Madison University (JMU) is named after former president and founding father James Madison. It was originally established in 1908 as the State Normal and Industrial School for Women at Harrisonburg. The university became the State Teachers College at Harrisonburg in 1924 and continued under that name until 1938, when it was named Madison College. The school officially became coeducational in 1966. In 1977 the university's name was changed to James Madison University. JMU is located on a 655-acre campus in Harrisonburg. James Madison University enrolls over 18,000 students. It offers a total of 106 undergraduate and graduate programs and is categorized as a master's college and university I by the Carnegie Foundation.

Longwood University (LU) is the third oldest public higher education institution in the state after the College of William and Mary and the University of Virginia. It was founded in 1839 as the Farmville Female Seminary Association. In 1860 it was incorporated as the Farmville Female College. The state acquired it in 1884 to establish a Normal School, the first state-sponsored higher education institution for women. Its name was changed twice more before it became Longwood College in 1949. The institution became coeducational in 1976 and achieved university status in 2002. The university's 160-acre campus is located in Farmville. It enrolls approximately 5,000 students. It is categorized by the Carnegie Foundation as a master's college and university I and offers 100 undergraduate majors, minors and concentrations as well as master's programs.

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1 Intensive doctoral and research universities awarded at least 10 doctoral degrees per year across three or more disciplines, or at least 20 doctoral degrees per year overall. Extensive doctoral and research universities awarded 50 or more doctoral degrees across at least 50 disciplines. For the full taxonomy see http://www.carnegiefoundation.org/classification/.

Norfolk State University (NSU) was founded in 1935 as the Norfolk branch of the private Virginia Union University. It became an independent college, Norfolk Polytechnic College, in 1942 and a public two-year branch campus of what is now Virginia State University in 1944 and a four-year branch campus in 1956. The historically black college became an independent college, Norfolk State College, in 1969 and achieved university status in 1979. It is located on a 134-acre campus in Norfolk. It enrolls approximately 6,300 students and offers both undergraduate and graduate programs. The university is classified as a master's college and university I by the Carnegie Foundation.

Old Dominion University (ODU) was founded in 1930 as a division of the College of William and Mary. It became an independent institution, Old Dominion College (based on the state's nickname), in 1962, and gained university status in 1969. It is located in Norfolk on a 188-acre campus. University enrollment is approximately 23,000. The university offers 70 bachelor's, 60 master's and 35 doctoral degree programs. ODU is designated as a doctoral research university - extensive by the Carnegie Foundation. ODU is one of the nation's leading distance learning course providers.

Radford University (RU) was founded in 1910 as the State Normal and Industrial School for Women at East Radford. It merged with the Virginia Polytechnic Institute and State University for a short period beginning in 1943 and became independent once again in 1964 as Radford College. The school became coeducational in 1972 and achieved university status in 1979. Radford University is located in Radford on a 177-acre campus. It enrolls approximately 9,200 students and offers 153 undergraduate and graduate program options, including a doctoral program in physical therapy that began in 2008. RU is designated as a master's college and university I by the Carnegie Foundation.

The University of Virginia at Wise (UVA-W) was founded in 1954 as a two-year campus for the University of Virginia called Clinch Valley College. In 1970 it began to offer baccalaureate degrees and in 1999 it was renamed the University of Virginia at Wise. UVA-W is the only branch of the University of Virginia. The institution is located on a 400-acre campus in the town of Wise. Enrollment is approximately 2,000 students. UVA-W offers 29 majors, 29 minors, seven pre-professional programs and 23 teaching licensures. The institution is categorized as a baccalaureate college in liberal arts by the Carnegie Foundation.

The University of Mary Washington (UMW) was founded in 1908 as the State Normal and Industrial School for Women and renamed in 1938 to honor the mother of George Washington. The institution became the University of Virginia's women's college in 1944. It changed to an independent and coeducational institution in 1972 and achieved university status in 2004. The UMW 176-acre main campus is located in Fredericksburg. A branch campus housing graduate programs is located in Stafford County about seven miles from the main campus. The university enrolls approximately 5,000 students. It offers nearly 40 undergraduate and graduate level programs and is categorized as a master's college and university-II by the Carnegie Foundation.

The University of Virginia (UVA) founded by Thomas Jefferson in 1819, is located on a 1,682-acre campus in Charlottesville. The university enrolls approximately 24,500 students in 51 undergraduate, 84 master's, six educational specialist, two first-professional and 57 doctoral degree programs. UVA is one of three World Heritage Sites in the United States designated by the United Nations Education, Scientific and Cultural Organization (UNESCO). It is classified as a doctoral and research university-extensive by the Carnegie Foundation. Together, the University of Virginia's School of Medicine and Medical Center account for more than half of UVA's salaried employment.

Virginia Commonwealth University (VCU) was formed in 1968 from the merger of the Medical College of Virginia (founded in 1838 as part of the private Hampden-Sydney College but becoming state-sponsored in 1869) and the Richmond Professional Institute (which had been the Richmond branch campus of the College of William and Mary until 1962). The institution is located in downtown Richmond on two campuses totaling 141 acres, the Monroe Park Campus that houses most of its instructional programs and the Medical College of Virginia (MCV) Campus that houses medically related activities, including the VCU Medical Center. VCU also runs programs at Education City in Qatar. The university offers 62 baccalaureate, 71 master, 33 doctorate and 3 first professional degrees. VCU is the largest university in Virginia with an enrollment of over 32,000 students. It is designated as a doctoral and research university-extensive by the Carnegie Foundation.

Virginia Military Institute (VMI) was the nation's first state-supported military college. It has a long history of graduates who went on to distinguished military careers. Unlike U.S. service academies, however, graduates can elect to enlist in the military or enter civilian careers. VMI offers 14 bachelor level programs and is categorized as a baccalaureate college in liberal arts by the Carnegie Foundation. The institute is located in Lexington on a 134-acre campus. It enrolls approximately 1,400 cadets, as the institute calls its students

Virginia Polytechnic Institute and State University (also known as Virginia Tech) (VT) started as the Virginia Agricultural and Mechanical College in 1872, Virginia's first land-grant college. It is also one of six senior military colleges in the United States. It is located in Blacksburg on a 2,600-acre main campus. VT offers 80 bachelor, 76 master and 62 doctoral degree programs. Virginia Tech is designated as a doctoral and research university-extensive by the Carnegie Foundation. It has an enrollment of over 30,000 students.

Virginia State University (VSU) was founded in 1882 as Virginia Normal and Collegiate Institute in Petersburg and was Virginia's first publicly-funded historically black college. It is one of two land grant institutions in the state (the other being Virginia Tech). Renamed Virginia State College for Negroes in 1930, it achieved university status in 1979. This historically black university has 35 undergraduate degree programs, 16 graduate degree programs, 2 doctoral degree programs and 3 certificate programs. It is classified by the Carnegie Foundation as a master's college and university-I. It has an enrollment of approximately 5,000 students.

Two-year Colleges

Richard Bland College (RBC) was founded in 1960 as a two-year branch campus of the College of William and Mary. It is the state's only public junior college and is not part of the Virginia Community College System (VCCS). The college is named after Revolutionary War era Virginia statesman, Richard Bland. The college is located on a 710-acre campus in Petersburg and enrolls approximately 1,600 students in 70 different programs designed for transfer to a four-year college.

Blue Ridge Community College (BRCC) was founded in 1967. It serves the Central Shenandoah Valley, including the counties of Augusta, Highland and Rockingham as well as the cities of Harrisonburg, Staunton and Waynesboro. Its offers courses at a 104-acre main campus located in Weyers Cave and two off-campus centers, the Augusta Center located in Fisherville and the Harrisonburg Center in located in Harrisonburg. The college enrolls approximately 4,500 credit students.

Central Virginia Community College (CVCC) was founded in 1966 and serves the counties of Amherst, Appomattox, Bedford and Campbell and the cities of Lynchburg and Bedford. Its main campus is located in Lynchburg on 107 acres. It operates four centers, the Altavista Center in Altavista, the Brookneal Center in Amherst, the Appomattox Center in Appomattox and the Bedford Center in Bedford. The college enrolls approximately 5,400 credit students.

Dabney S. Lancaster Community College (DSLCC) was founded in 1964 and serves the counties of Alleghany, Bath, the northern portion of Botetourt and Rockbridge counties as well as the cities of Buena Vista, Covington and Lexington and the town of Clifton Forge. It offers courses at a 117-acre campus in Clifton Forge and two centers, the Rockbridge Regional Center in Buena Vista and the Greenfield Education and Training Center at Greenfield. The college is named after Dr. Dabney S. Lancaster, a prominent state educator in the 20th century. The college enrolls approximately 1,300 credit students.

Danville Community College (DCC) traces its beginnings to the Danville Military Institute, founded in 1890. It became the Danville Textile School in 1936 (later the Danville Technical Institute) and hosted the off-campus engineering division of Virginia Polytechnic Institute and the Danville Technical Institute beginning in 1946. In 1968, the two joined to form this community college. Danville Community College serves the city of Danville and the counties of Pittsylvania and Halifax. It is located in Danville on an 86-acre campus. It offers 34 programs and has an enrollment of over 4,000 credit students.

Eastern Shore Community College (ESCC) was founded in 1971. The college occupies a 115-acre site on U.S. Route 13, south of Melfa on the southern end of the Delmarva Peninsula. ESCC has an enrollment of over 900 credit students. It offers more than 20 career and transfer programs.

Germanna Community College (GCC) was established in 1970. It serves the counties of Caroline, Culpeper, King George, Madison, Orange, Spotsylvania and Stafford and the city of Fredericksburg. The name "Germanna" has its roots in a settlement by German miners at the Rapidan River. The college serves over 6,500 credit students and offers more than 20 programs. The college's Fredericksburg 70-acre campus is located in Spotsylvania County. It also offers two other locations, a Locust Grove campus and the Daniel Technology Center in Culpeper.

J. Sargeant Reynolds Community College (JSRCC) is the third largest in the Virginia Community College System and serves the counties of Goochland, Hanover, Henrico, and Powhatan as well as the city of Richmond. It was founded in 1972 and named in honor of former Lieutenant Governor J. Sargeant Reynolds who played a key role in the creation of the community college system. The college has three campus locations. The main campus is located in downtown Richmond. The other two campuses, the Parham Road Academic Campus and the Western Academic Campus, are located in Henrico County and Goochland County, respectively. The school offers over 80 degree and certificate programs and has an enrollment of more than 13,000 credit students.

John Tyler Community College (JTCC) was established in 1967 and serves the counties of Amelia, Charles City, Chesterfield, Dinwiddie, Prince George, Surry and Sussex as well as the cities of Colonial Heights, Hopewell and Petersburg. It is named in honor of President John Tyler who was born in Charles City. It serves over 8,700 credit students at two campuses and offers approximately 60 programs. The main campus is located in Chester on 160 acres and another campus is located in Midlothian.

Lord Fairfax Community College (LFCC) was started in 1970 and serves the counties of Clarke, Fauquier, Frederick, Page, Rappahannock, Shenandoah and Warren and the city of Winchester. It is named after Thomas Lord Fairfax VI, a colonial era landowner who resided in the Shenandoah Valley. Its main facility, the Fauquier Campus, of 120-acres is located in the town of Warrenton. The college has another campus located in Middletown and a center in Luray. The college enrolls over 5,800 credit students and offers more than 75 programs.

Mountain Empire Community College (MECC) was established in 1970 and serves Dickenson, Lee, Scott and Wise counties and the city of Norton in the southwest region. It is located on a 95-acre campus in Big Stone Gap. The college serves over 3,000 credit students.

New River Community College (NRCC) traces its beginnings to a vocational-technical school, the New River Vocational-Technical School created by the localities of Radford City, Pulaski County and Montgomery County. The school came under the jurisdiction of the Virginia Community College System (VCCS) in 1966 and its name was changed to New River Community College in 1969. It serves the counties of Giles, Pulaski, Montgomery and Floyd. The college is located on a 100-acre campus in Dublin. It also offers coursework at a facility in the New River Valley Mall in Christiansburg. NRCC enrolls over 4,800 credit students and offers more than 40 academic programs.

*Northern Virginia Community Colleg*e (NVCC) has an enrollment of over 42,000 credit students, making it the largest higher education institution in the Commonwealth by headcount and the second-largest community college in the nation. The college was established in 1964 in Alexandria. It operates additional campuses in Annandale, (Annandale Campus), Manassas (Manassas Campus), Woodbridge (Woodbridge Campus), Sterling (Loudoun Campus), Springfield (Medical Campus) and centers in Arlington (Arlington Center) and Reston (Reston Center). Its service region includes the cities of Alexandria, Falls Church, Fairfax, Manassas Park and Manassas and the counties of Arlington, Fairfax, Loudoun and Prince William.

Patrick Henry Community College (PHCC) was established in 1962 as a branch of the University of Virginia's School of General Studies. It became an independent junior college in 1964. The college's service region includes the city of Martinsville and the counties of Henry and Patrick and the southern portion of Franklin County. The college is named after Patrick Henry, the first post-colonial governor of Virginia and a founding father. The college is located on a 137-acre campus three miles outside the city of Martinsville. The college also offers coursework at its Franklin County Center in Rocky Mount. PHCC enrolls over 3,100 credit studies and offers more than 90 associate degree and certificate programs.

Paul D. Camp Community College (PDCCC) was founded in 1970 to serve the city of Franklin, most of the city of Suffolk, and the counties of Isle of Wight and Southampton. The college's main campus is located on 99 acres in the city of Franklin. It maintains another campus (Hobbs Suffolk Campus) in Suffolk and a center in Smithfield (PDCCC at Smithfield). The college has an enrollment of over 1,600 credit students.

Piedmont Virginia Community College (PVCC) was established in 1972 and serves the city of Charlottesville and the counties of Albemarle, Buckingham, Fluvanna, Greene, Louisa and Nelson. It is located in Albemarle County close to the city of Charlottesville. College credit enrollment is over 4,800 students, and the college offers 52 associate and certificate programs.

Rappahannock Community College (RCC) was founded in 1969 and serves the Middle Peninsula and Northern Neck regions, including the counties of Essex, Gloucester, King and Queen, King George, King William, Lancaster, Matthews, Middlesex, New Kent, Northumberland, Richmond and Westmoreland. The college has two campuses located near each end of the Rappahannock River, one in Glenns that opened in 1971 and another in Warsaw that opened in 1973. An off-campus center in King George High School also offers selected coursework. The college enrolls more than 3,300 credit students.

Southside Virginia Community College (SSVCC) was established in 1970. It serves the central part of Southern Virginia, including the city of Emporia and the counties of Brunswick, Buckingham, Charlotte, Cumberland, Greensville, Halifax, Lunenburg, Mecklenburg, Nottoway and Prince Edward. The main campus of 207 acres, Christanna Campus, is located near Alberta in Brunswick County. The John H. Daniel Campus is located near Keysville in Charlotte County. SSVCC enrolls over 5,600 credit students and offers more than 80 programs of study.

Southwest Virginia Community College (SWVCC) opened in 1968. It serves the counties of Buchanan, Russell, Tazewell, and part of Dickinson in southwestern Virginia. The college is located on a 100-acre campus near the town of Richlands (population 4,144). It enrolls approximately 4,000 credit students and offers 80 programs.

Thomas Nelson Community College (TNCC) was established in 1967. It serves several localities in the Northern Hampton Roads region, including the cities of Williamsburg, Hampton, Newport News and Poquoson and the counties of James City and York. The college is named after Thomas Nelson, Jr., a Yorktown native who was a post-colonial governor of Virginia and signer of the Declaration of Independence. The college's main 85-acre campus is located in Hampton. Another campus, Historic Triangle, is located near Williamsburg in James City County. The college enrolls over 10,500 credit students.

Tidewater Community College (TCC) was founded in 1968 and serves the Southern Hampton Roads Region, including the cities of Portsmouth, Virginia Beach, Norfolk, Chesapeake and Suffolk. It is made up of four campuses. The first campus in Portsmouth was located at the former site of Frederick College, a four-year liberal arts college that closed its doors in 1968. Three other campuses are located in the cities of Chesapeake, Norfolk and Virginia Beach. This institution enrolls nearly 27,000 credit students, making it the second largest community college in the commonwealth. The college offers over 150 degree and certificate programs.

Virginia Highlands Community College (VHCC) was started in 1967 and serves the city of Bristol, Washington County, and the western part of Smyth County. Its 100-acre campus is located in Abingdon. This campus also hosts the Southwest Virginia Higher Education Center, which offers four-year and graduate degree programs in partnership with other higher education institutions. VHCC has an enrollment of over 2,600 credit students.

Virginia Western Community College (VWCC) was founded in 1966. It serves the cities of Roanoke and Salem and the counties of Roanoke, Craig, the southern portion of Botetourt County and the northern portion of Franklin County. The college is located on a 70-acre campus in the city of Roanoke. The college is the fourth largest community college in the state with an enrollment of 8,500 credit students.

Wytheville Community College (WCC) was founded in 1963 as a two-year branch of Virginia Polytechnic Institute. In 1967 it joined the Virginia Community College System as an independent community college. It serves the counties of Bland, Carroll, Grayson and Wythe, and the eastern portion of Smyth County. The college is located on a 141-acre campus in Wytheville. WCC has an enrollment of over 3,300 credit students.

Appendix A.2
Council on Virginia's Future Regions

Northern Region
Alexandria
Fairfax City
Falls Church
Manassas
Manassas Park
Fredericksburg
Arlington
Clarke
Fairfax
Fauquier
Loudoun
Prince William
Spotsylvania
Stafford
Warren

Eastern Region
Accomack
Essex
King George
Lancaster
Middlesex
Northampton
Northumberland
Richmond
Westmoreland

Hampton Roads Region
Chesapeake
Franklin
Hampton
Newport News
Norfolk
Poquoson
Portsmouth
Suffolk
Virginia Beach
Williamsburg
Gloucester
Isle of Wight
James City
Mathews
Surry
York

Valley Region
Buena Vista
Covington
Harrisonburg
Lexington
Staunton
Waynesboro
Winchester
Alleghany
Augusta
Bath
Frederick
Highland
Page
Rockbridge
Rockingham
Shenandoah

Central Region
Charlottesville
Colonial Heights
Hopewell
Petersburg
Richmond City
Albemarle
Amelia
Buckingham
Caroline
Charles City
Chesterfield
Culpeper
Cumberland
Dinwiddie
Fluvanna
Goochland
Greene
Hanover
Henrico
King & Queen
King William
Louisa
Madison
Nelson
New Kent

Central Region (continued)

Orange
Powhatan
Prince George
Rappahannock
Sussex

Southside Region

Emporia
Danville
Martinsville
Brunswick
Charlotte
Greensville
Halifax
Henry
Lunenburg
Mecklenburg
Nottoway
Patrick
Pittsylvania
Prince Edward
Southampton

West Central Region

Bedford
Lynchburg
Radford
Roanoke City
Salem
Amherst

West Central Region (continued)

Appomattox
Bedford
Botetourt
Campbell
Craig
Franklin
Giles
Montgomery
Pulaski
Roanoke

Southwest Region

Bristol
Galax
Norton
Bland
Buchanan
Carroll
Dickenson
Floyd
Grayson
Lee
Russell
Scott
Smyth
Tazewell
Washington
Wise
Wythe

APPENDIX A.3
Description of Input Data

Employment

The data on higher education employment were 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. Because of large discrepancies between the IPEDS medical school employment reported by the University of Virginia and by Virginia Commonwealth University and IPEDS due to the large role of the UVA Health Services Foundation and the Medical College of Virginia, supplemental employment information on university hospital employment was obtained from the UVA Institutional Assessment and Studies Department and the VCU Center for Institutional Effectiveness. Employment was assigned to the educational services sector in REMI PI+.

Employee Compensation

Employee compensation data were obtained from Part C ("Expenses and Other Deductions") of the IPEDS Finance survey. Supplemental information on medical school compensation was obtained from the UVA Health Services Foundation and the Virginia Commonwealth University Medical Center. 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) were largely reflected in student and visitor expenditures. Employment was assigned to the educational services sector in REMI PI+.

Outlays on Goods and Services

Outlays on goods and services data were obtained from Part C ("Expenses and Other Deductions") of the IPEDS Finance survey. Supplemental information on medical school operations was obtained from the UVA Health Services Foundation and the Medical College of Virginia Foundation. The IPEDS expenditure was obtained by subtracting employee compensation and depreciation from total expense. Depreciation of capital assets was not included because of the use of capital expenditure data elsewhere in the study. Using both depreciation expense and capital expenditures would have caused double counting. In addition, expenses from auxiliary service and scholarship and fellowship expenditures were dropped in order to avoid double counting.

Outlays on goods and services expenditures were assigned to intermediate input demand industry categories using an expenditure vector obtained from a Virginia Tech impact study (Beddow et al. 2000). This expenditure pattern is more representative of the Virginia public higher education sector than the default REMI educational services sector expenditure vector. For university hospital operations expenditures obtained from the UVA Health Services Foundation and Virginia Commonwealth University Medical Center, the REMI PI+ hospitals sector expenditure vector was used.

Capital Expenditures

Capital expenditure data was obtained from Part A ("Plant, Property, and Equipment") of the IPEDS Finance survey. Supplemental information on medical school capital and equipment expenditures was obtained from the UVA Health Services Foundation and Virginia Commonwealth University Medical Center. Construction expenditure from IPEDS was counted as additions to infrastructure and buildings. Additions to equipment and art and library collections were also entered into the model. Construction expenditures were entered as "firm sales" in the construction sector. Equipment purchases were entered in REMI PI+ as industry sales using an equipment translator policy variable. Art and library collections were entered as if they were an operational expenditure for the REMI PI+ industry labeled "Publishing industries, except Internet."

Student Expenditures

Student expenditures data rely on IPEDS Institutional Characteristics (IC) data and student expenditure data used by a recent University of Virginia impact study (Knapp and Shobe 2007). The raw UVA student survey information was re-tabulated to make it appropriate for use in this study. A number of alternatives were considered before deciding to use the UVA student expenditure data (e.g., student expenditures reported in a 2001 Bureau of Labor Statistics *Monthly Labor Review* article, published student expenditure data from other Virginia college and university economic impact studies). The UVA data were selected because of: (a) the currency of the data, (b) the personal consumption category detail of the data, (c) the availability of data for both undergraduates and graduate/professional students, and (d) comparisons which showed that the student expenditure totals were similar to other studies.

Student expenditures were adjusted for regional cost of living differences using total student expenses 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 category 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 exceeded 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, were multiplied by the per student consumer expenditure by consumption category estimates. In-state two-year college students were excluded from the calculation because the vast majority of students are part-time and education is a secondary rather than primary activity. In addition, 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 79 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 *FY2007 Profile of Travel in Virginia* (which is based upon data collected monthly by Taylor Nelson Sofres Group). 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 a recent Longwood University impact study (Longwood University 2008). The UVA survey estimated 9.2 visits per student and an average length of stay of 2.4 days, which works out to 22 visitor-days per student. Similarly, the LU survey estimated 9.4 visits per student and an average length of stay of 2 days, which works out to 18.4 visitor-days per student. The UVA visitor-days per student estimates were multiplied by the number of out-of-state students and an average visitor expenditure of $54 per visitor-day from the Virginia Tourism Corporation to obtain total visitor expenditures. The total expenditure was entered as a REMI PI+ tourism translator policy variable.

Student Enrollment

The model's demographic module treats college students differently than other populations within the model. Since many college students will not remain in the state after graduation, they will not age in place like other residents. Moreover, college students participate in the labor force to a much smaller degree. In order to account for these population and labor market differences, the number of out-of state students for 2007 are entered into the model. It is conjectured that this population would not be in Virginia without public higher education. Enrollment information was obtained from SCHEV enrollment reports.

Graduate Earnings and Productivity

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

In order to approximate the number of graduates likely to enter and be retained in the Virginia workforce, a number of assumptions were made. First, it was assumed that all out-of-state graduates leave Virginia. Such students account for approximately 20 percent of the total number of graduates. In-state graduates are assumed to experience an attrition rate of 3 percent each year due to out-migration. This rate of attrition is based on annual interstate migration rates for U.S. degree earners computed from the American Community Survey.[1] In the 31st year of employment they retire from the workforce.[2] Therefore, aggregate estimates of earnings and productivity added to the Virginia economy decrease each year in real dollars and cease in the year 2038.

These assumptions produce bachelor's degree graduate residency retention rates comparable to nationwide longitudinal studies shown in **Table A.1**. The estimates use estimates of the percentage of graduates originating from in-state and out-of-state and retention rates reported in those studies. Since migration rates tend to stabilize around the 10th year, this method may slightly underestimate attrition due to non-migration factors in earlier years while overestimating attrition in later years. Approximately 53 percent of the graduate earnings and productivity effect is retained by year 15.

Table A.1 Comparison of Residency Retention Rate, Bachelor's Degree Graduates

	Rate (Percent)			
Year	Study Rate	NSLY79[3]	B&B: 93/97[4]	NELS: 88/2000[5]
1	80.7	85	74.0	--
4	73.7	--	68.5	61.9
5	71.4	70	--	--
10	61.4	61	--	--

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 assigned to Standard Occupational Categories (SOC) using a degree-occupational crosswalk (2000 Standard Occupational Classification Crosswalk to 2000 Classification of Instructional Programs) obtained from the National Crosswalk Service Center.[6] Some adjustments were made to the crosswalk in order to assign a handful of unassigned "orphan"

1. U.S. Census Bureau 2005-2007 American Community Survey. http//www.census.gov (accessed July 14, 2009).
2. Thirty years is a conservative estimate of graduate work life. Ciecka et al. (2000) estimate that the average male 25 year-old college graduate works on average 37 years. The average female 25 year-old college graduate works 32 years.
3. Based on Kodrzycki (2001) which used Bureau of Labor Statistics, National Longitudinal Survey of Youth (NSLY79).
4. Based on Perry (2001), which used U.S. Department of Education, National Center for Education Statistics, 1993 Baccalaureate and Beyond Longitudinal Study (B&B: 93/97).
5. Based on Adelman (2004), which used U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS: 88/2000).
6. National Crosswalk Service Center. 2002. 2000 Standard Occupational Classification Crosswalk to 2000 Classification of Instructional Programs. http://www.xwalkcenter.org/index.php?option=com_content&task=view&id=98&Itemid=102 (accessed June 3, 2009).

degrees to occupational categories. In addition, liberal arts and general studies graduates from associate and bachelor degree programs were assigned away from the occupational category of "Postsecondary Teaching" to other categories based on the educational requirements of the occupations and the national employment distribution for the occupations. Next, the occupational totals were assigned to industries using occupational-industry employment weights from the 2006 National Industry-Occupation Employment Matrix.[7] Lastly, the graduates by educational level were multiplied by the corresponding mean earnings differentials observed between educational

Table A.2 Mean Earnings by Educational Attainment, Population 18 and Older

Education	Mean Earnings, 2007
High school graduate	$31,286
Some college	$33,009
Associate degree	$39,746
Bachelor's degree	$57,181
Master's degree	$70,186
Professional degree	$120,978
Doctorate	$95,565

Source: U.S. Census Bureau (2009)

levels from the Current Population Survey (CPS) *2008 Annual Social and Economic Supplement* to approximate the earnings increments that would occur as a result of obtaining the degree (see **Table A.2**).[8] For associate and bachelor's degree recipients, the differential was computed as the difference between the degree and a high school degree ($31,286). For master's, professional, and doctorate degrees, the differential was computed as the difference between the degree and a bachelor's degree ($57,181).[9]

To compute the productivity improvements per graduate, econometric estimates of the effect of workforce educational attainment on productivity in manufacturing and non-manufacturing industries from a study by Black and Lynch (1996) were used. The study relied on firm-level data from the U.S. Census Bureau's *Annual Survey of Manufacturers*. The study suggests that a 1 percent increase in firm education stocks would increase productivity .85 percent in manufacturing and 1.27 percent in non-manufacturing industries. In order to convert the econometric estimates into productivity per graduate, the existing stock of educational attainment in the Virginia labor force was estimated. The percentage addition to educational attainment resulting from the flow of new in-state graduates was then calculated. Using estimates of population by age and educational attainment and of labor force participation by age from the 2005-2007 American Community Survey 3-year estimates, it was computed that the Virginia labor force embodies 53,816,012 years of education. One year of additional education as a proportion of this labor force human capital stock multiplied by the production gain from a 1 percent increase in years of education multiplied by Virginia industry output (measured by GDP) provides an estimate of sectoral productivity increase for an additional year of education: $537 for manufacturing and $8,262 for non-manufacturing (see **Table A.3**).

Productivity improvements resulting from Virginia public higher education graduates were assigned to industries used in the REMI PI+ in two steps. First, the two computed industry productivities per year of education were

7. National Crosswalk Service Center. (2008). National Industry-Occupation Employment Matrix. http://www.xwalkcenter.org/ (accessed June 3, 2009).
8. U.S. Census Bureau. 2008. Annual Social and Economic Supplement. Current Population Survey. http://www.census.gov/hhes/www/macro/032008/perinc/toc.htm (Accessed July 8, 2009)
9. While it is sometimes argued that earnings and productivity differences should be adjusted by a small ability bias (Resek et al. 2000; Beck et al. 1995), some researchers have shown that there are offsetting biases due to comparative advantage and measurement error (McMahon 2009). Therefore, no adjustments were made in the differentials computed from the CPS used here.

assigned to the appropriate industries: the manufacturing productivity to North American Industrial Classification System manufacturing industries and the non-manufacturing productivity figure to all others. Next, the productivity per year of additional higher education figure was multiplied by 2 for associate and master's degrees, and 4 for bachelor's, doctorate and professional degrees (the educational years of achievement increments assumed for completing these programs). Next, the number of graduates by educational level assigned to each industry in the manner described above was multiplied by the degree-industry productivity increments. Lastly, aggregate productivity estimates were decreased by 3 percent each year to reflect attrition in the resident graduate workforce.

Table A.3 Estimated Productivity Impact of Virginia Public Higher Education

	One Year as Ratio to Total Virginia Human Capital Stock	Productivity Gain from 1% Increase in Years of Education	Gross Domestic Product ($ Billions)	Productivity per Year of Higher Education
Manufacturing	1/53,816,012	0.85	34.019	$537
Non-manufacturing	1/53,816,012	1.27	350.113	$8,262

APPENDIX A.4
Description of Degree Initiative Analysis Input Data

This simulation considers the effect of increasing degree production from a baseline of approximately 57,600 degrees in 2010 based on SCHEV's 2009 demand projections to a total of 70,450 degrees by the year 2020.[1] Only associate, bachelor's, master's, doctorate and professional degrees are counted. Certificates are not included. It is assumed that the total number of associate and bachelor's level degrees will increase by an increment of 1,005 each year and graduate/professional degrees by 280 each year for a total of 1,285. It is also assumed that the graduate to enrollment ratio remains the same (0.14635) throughout the period.

The model impacts stem from three expenditure sources. The first source is tuition payments made by out-of-state students. The second source is the expenditures of out-of-state students and visitors on other goods and services. It is assumed that the in-state enrollment percentage remains the same as it was in 2006-07 based on State Council of Higher Education data (94.5 percent for two-year schools, 80.7 percent for undergraduates at four-year schools, 71.9 percent for graduate students, and 59.7 percent for first professional students). The third source is grants and gifts, primarily from the federal government. The simulation assumes that out-of-state revenues per student remains the same as the level of 2006-07 throughout the period. Therefore, increased student enrollments are associated with more out-of-state contributions.

In modeling the labor market/human capital effects, the analysis assumes that the program degree production patterns by degree level are maintained from a 2006-07 baseline. The degree to industry crosswalk is conducted in the same manner as described in Appendix A.3. Also, the same method of determining earnings and productivity additions and attrition is used. Because there are ten different graduating cohorts (2011-2020), they will "retire" from the workforce at different times, with the first cohort retiring in 2041 and the last in 2050. The simulation is conducted out to the year 2050, which is the last year available in the REMI PI+ model. The data underlying the simulation results are reported in **Table A.4**.

1. State Council on Higher Education in Virginia (2009)

Table A.4 Data Supporting Degree Initiative in 2007 Dollars

	Out-of-State				
Year	Tuition Revenue	Grant & Gift Revenue	Visitors Expenditures	Earnings	Productivity
2011	14,403,250	22,844,740	1,534,516		
2012	28,784,117	45,689,480	3,066,647	21,204,248	25,650,282
2013	43,187,367	68,534,220	4,601,163	62,995,144	76,203,751
2014	57,579,425	91,378,960	6,134,486	124,773,079	150,935,072
2015	71,971,483	114,223,699	7,667,810	205,955,904	249,140,033
2016	86,363,542	137,068,439	9,201,133	305,978,428	370,134,939
2017	100,755,600	159,913,179	10,734,457	424,291,924	513,256,005
2018	115,158,850	182,757,919	12,268,973	560,363,643	677,858,779
2019	129,550,908	205,602,659	13,802,296	713,676,355	863,317,577
2020	143,942,967	228,447,399	15,335,620	883,727,898	1,069,024,946
2021				1,070,030,730	1,294,391,121
2022				1,038,864,786	1,256,690,408
2023				1,008,606,589	1,220,087,775
2024				979,229,698	1,184,551,238
2025				950,708,444	1,150,049,746
2026				923,017,907	1,116,553,151
2027				896,133,891	1,084,032,185
2028				870,032,903	1,052,458,433
2029				844,692,139	1,021,804,303
2030				820,089,456	992,043,013
2031				796,203,355	963,148,556
2032				773,012,966	935,095,686
2033				750,498,025	907,859,889
2034				728,638,859	881,417,368
2035				707,416,368	855,745,018
2036				686,812,008	830,820,405
2037				666,807,775	806,621,753
2038				647,386,189	783,127,915
2039				628,530,281	760,318,364
2040				610,223,574	738,173,169
2041				592,450,071	716,672,980
2042				566,458,375	685,231,433
2043				532,487,848	644,138,083
2044				490,770,885	593,674,049
2045				441,533,110	534,112,265
2046				384,993,575	465,717,714
2047				321,364,953	388,747,659
2048				250,853,723	303,451,874
2049				173,660,348	210,072,858
2050				89,979,455	108,846,040

Appendix A.5
Highly Cited Researchers at Virginia Public Higher Education Institutions

Name	Institution	Discipline
Jagadish Shukla	George Mason University	Geosciences
Vernon L. Smith	George Mason University	Economics/business
Duc T. Nguyen	Old Dominion University	Engineering
Ahmed K. Noor	Old Dominion University	Engineering
Janis Antonovics	University of Virginia	Ecology/environment
John C. Bean	University of Virginia	Materials science
Roger A. Chevalier	University of Virginia	Space sciences
Bernard Jackson Cosby	University of Virginia	Ecology/environment/engineering
Victor H. Engelhard	University of Virginia	Immunology
James Neville Galloway	University of Virginia	Ecology/environment/geosciences/ engineering
William A. Knaus	University of Virginia	Clinical medicine
Irena Lasiecka	University of Virginia	Mathematics
Michael L. Pace	University of Virginia	Plant & animal science
William R. Pearson	University of Virginia	Biology & biochemistry/microbiology
Thomas A.E. Platts-Mills	University of Virginia	Immunology
Timothy A. Salthouse	University of Virginia	Psychology/psychiatry
Herman H. Shugart	University of Virginia	Ecology/environment
John A. Stankovic	University of Virginia	Computer science
Edgar A. Starke, Jr.	University of Virginia	Materials science
Robert M. Strieter	University of Virginia	Immunology
Michael O. Thorner	University of Virginia	Biology & biochemistry
Roberto Triggiani	University of Virginia	Mathematics
Stuart A. Wolf	University of Virginia	Materials science
Lindon J. Eaves	Virginia Commonwealth University	Psychology/psychiatry
Kenneth S. Kendler	Virginia Commonwealth University	Neuroscience/psychology/psychiatry/ clinical medicine
Hadis Morkoç	Virginia Commonwealth University	Materials science/physics/engineering
Michael C. Neale	Virginia Commonwealth University	Psychology/psychiatry
Lawrence B. Schwartz	Virginia Commonwealth University	Immunology
Robert John Bodnar	Virginia Tech	Geosciences
E. Ann Dunnington	Virginia Tech	Plant & animal science
Dick P. H. Hasselman	Virginia Tech	Materials science
Michael Hughes	Virginia Tech	Psychology/psychiatry
David G.I. Kingston	Virginia Tech	Agricultural sciences
David S. Lindsay	Virginia Tech	Plant & animal science
Paul B. Siegel	Virginia Tech	Plant & animal science
Yue J. Wang	Virginia Tech	Engineering
Garth L. Wilkes	Virginia Tech	Materials science

Appendix A.6
Nobel Prize Winners with Virginia Public Higher Education Connections

Name	Field	Year	Connection
Barry Marshall	Physiology or Medicine	2005	University of Virginia. Former Professor of Medicine. He taught and carried out his research in Virginia for over a decade, establishing the International Research Foundation for Helicobacter and Intestinal Immunology.
John Bennett Fenn	Chemistry	2002	Virginia Commonwealth University. Dr. Fenn joined VCU in 1994 as professor of analytical chemistry.
Vernon Lomax Smith	Economics	2002	George Mason University professor, 2001-2008. Dr. Smith remains a research scholar at the Interdisciplinary Center for Economic Science and a Fellow at The Mercatus Center at George Mason University
Ferid Murad	Physiology or Medicine	1998	University of Virginia. Professor 1970-81.
Robert Coleman Richardson	Physics	1996	Virginia Polytechnic Institute and State University. He received a B.S. in 1958 and a M.S. in 1960 at Virginia Tech.
Alfred G. Gilman	Physiology or Medicine	1994	University of Virginia professor of pharmacology in the School of Medicine, 1971-1980.
Ronald Coase	Economics	1991	University of Virginia. Professor of economics 1958-1964.
James M. Buchanan	Economics	1986	University of Virginia, Virginia Tech and George Mason University. He founded the Thomas Jefferson Center at the University of Virginia and the Center for the Study of Public Choice at Virginia Tech. In 1983 he moved the Center for Public Choice to its new home at George Mason University.
Baruj Benacerraf	Physiology or Medicine	1980	Virginia Commonwealth University. He obtained the degree of Doctor of Medicine from the Medical College of Virginia.

GLOSSARY OF TERMS

Business Startup A company that depended upon a technology license from a university to begin operation. This definition is used by the Association of University Technology Managers (AUTM) and university technology transfer offices for reporting purposes.

Discount Rate The rate of interest used to convert a stream of future cash flows to present values in order to represent them in current dollars. For this study the value of the discount rate is assumed to be three percent.

Economic Footprint The total economic activity associated with a project or investment. An economic footprint does not consider whether expenditures used to generate the economic activity might have alternatively been used elsewhere in the economy to generate similar impacts. For example, some students currently attending public higher education institutions would choose to attend private for-profit or non-profit colleges in the state if public higher education were not available. A state economic footprint analysis would still count the expenditures of these students in computing the economic effect.

Economic Impact The net additional economic activity that can be attributed to a project or investment. Economic impact subtracts economic activity that would have occurred anyway because expenditures and investment might have been redirected from elsewhere in the economy. For example, some students currently attending public higher education institutions would choose to attend in-state private for-profit or non-profit colleges if public higher education were not available. A state economic impact analysis would not count such internally redirected expenditures in computing the economic impact.

Export Expenditures That portion of total expenditures for public higher education derived from out-of-state sources, such as out-of-state students, visitors, and foundations and the federal government.

GDP Gross Domestic Product is the value of goods and services produced in the economy for final demand.

Human Capital The stock of knowledge and skills embodied in labor as a result of training and education that improves labor productivity.

Industry Cluster A geographic concentration of interconnected businesses that share labor, suppliers, consumers, or the services of other institutional assets (such as colleges and universities). Industry clusters increase the productivity of firms above and beyond what would be realized in isolation and enable them to better compete in domestic and international markets.

Industrial Output The total value of goods and services produced in the economy for intermediate use (i.e., inputs to produce other inputs or goods for final demand) and final demand. This measure of output is much larger than gross domestic product.

IPEDS The Integrated Postsecondary Education Data System is a post-secondary data collection program of the federal government. Information is collected on institutional characteristics, enrollment, graduation, employment, financial characteristics, and financial aid for each postsecondary institution that participates in federal student financial aid programs.

Present Value The amount that a future stream of cash flows is worth today given a specified discount rate.

Private Non-pecuniary Benefit A benefit received by the individual (or member of same household) who receives education in a form that cannot easily be converted to a monetary value such as better working conditions, improved health, or improved child educational attainment.

Private Pecuniary Benefit A benefit received by the individual (or member of same household) who receives education in the form of financial remuneration (e.g., wages and salaries, stocks, payments for health insurance, contribution to pension plan).

REMI PI+ Regional Economic Models, Incorporated Policy Insight Plus is personal computer-based regional economic modeling software incorporating modeling concepts such as input-output, econometric, and computable general equilibrium to generate realistic market economy simulations of the economic impact of different public policy actions.

Social Non-pecuniary Benefit A benefit not easily expressed in monetary values received outside the original household where a degree is received (e.g., neighborhood, city, state, country). For instance, an increase in a city's college-educated population may improve the health and educational aspirations of residents who have not attended college. Alternatively, a college graduate may be less likely to draw on welfare and commit crimes which imposes lower costs on other members of the community.

Social Pecuniary Benefit A benefit expressed in monetary values received outside the original household where a degree is received (e.g., neighborhood, city, state, country). For instance, an increase in a city's college-educated population may improve the productivity and earnings of workers who did not attend college.

State Revenue State revenues include revenues generated from sales taxes, excise taxes, license taxes, individual and corporate income taxes, liquor store revenue and intergovernmental revenue from the federal government.

University Research Park A property that is owned or managed by one or more research class higher education institutions for the purpose of promoting university research and development through industry partnerships, university business spinoffs, and technology-based economic development in a region. The park is designed for private/public research and development facilities, high technology and science based companies, and business support services. This definition is used by the Association of University Research Parks (AURP) in categorizing research parks.

Visitor Expenditures The expenditures of visitors to students of public higher education institutions. They may include parents, siblings, friends or others.

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