NDSU | NORTH DAKOTA STATE UNIVERSITY

Economic Contribution of NORTH DAKOTA STATE UNIVERSITY

MAIN REPORT

Analysis of Investment Effectiveness and Economic Growth

NOVEMBER 2012

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CONTENTS

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INTRODUCTION

STUDY OVERVIEW

NORTH Dakota State University (NDSU) generates a wide array of benefits. Students benefit from higher personal income, and society benefits from cost savings associated with reduced welfare and unemployment, improved health, and reduced crime. Education, however, requires a substantial investment on the part of students and taxpayers. All of the education stakeholders, therefore, want to know if they are getting their money's worth. In this study, NDSU investigates the attractiveness of its returns as a public training provider relative to alternative public investments. The following two analyses are presented: 1) investment analysis, and 2) economic growth analysis.

The investment analysis captures private and public benefits that accrue to students and taxpayers in return for their educational support. Private benefits include higher income of students, while public benefits include growth in income plus an assortment of positive externalities such as improved health and lifestyle habits, reduced crime, and fewer claims for social assistance. All of these annual benefits continue and accrue into the future for as long as students are in the workforce. To determine the feasibility of the investment, the model projects benefits into the future, discounts them back to the present, and compares them to present costs. Results are displayed in the four following ways: 1) net present value, 2) rate of return, 3) benefit/cost ratio, and 4) payback period.

The economic growth analysis focuses on the role NDSU plays in promoting economic development by increasing consumer spending and raising the skill level of the labor force. This in turn leads to more jobs, increased business efficiency, greater availability of public investment funds, and eased tax burdens. In general, university-linked income falls under the following four categories: 1) income generated by annual NDSU operating expenditures, 2) income generated by the spending of NDSU students; 3) income generated by the spending of NDSU visitors; and, 4) income generated by the skills of former NDSU students who are still active in the regional workforce.

ORGANIZATION OF THE REPORT

This report has five chapters and seven appendices. Chapter 1 provides an overview of NDSU and the regional economy. Chapter 2 presents the investment analysis results from the students' and taxpayers' perspectives. Chapter 3 considers the impact of NDSU on economic growth in the NDSU Service Area. Chapter 4 discusses NDSU's unique role as an active supporter of research, technology, and business development. Finally, Chapter 5 provides sensitivity analyses of some of the softer variables.

The appendices include a list of resources and references in Appendix 1, a glossary of terms in Appendix 2, a discussion of the EMSI input-output model in Appendix 3, a detailed explanation of the shutdown point (an adjustment factor) in Appendix 4, an overview of the data and assumptions used in calculating the non-economic (*i.e.*, social) benefits of education in Appendix 5, a short primer on the investment analysis results in Appendix 6, and an explanation of the alternative education variable in Appendix 7.

A note of importance: although the reports generated for NDSU are similar to those prepared for other educational institutions, the institutional results differ widely. *These differences, however, do not necessarily indicate that some institutions are doing a better job than others.* Results are a reflection of location, student body profile, and other factors that have little or nothing to do with the relative efficiency of the institutions. For this reason, comparing results between institutions or using the data to rank institutions is strongly discouraged.

Chapter 1

PROFILE OF NDSU AND THE REGIONAL ECONOMY

INTRODUCTION

NORTH Dakota State University (NDSU) is a land-grant research university with a dual focus of preparing students for in-demand, high-tech fields such as engineering and cultivating a growing research portfolio. Located in Fargo and founded in 1890, NDSU is one of two flagship universities in North Dakota and serves approximately 12,000 undergraduate students and 2,500 graduate and professional students each semester. In 2011 the Carnegie Commission on Higher Education ranked it as one of the top 108 public and private universities in the U.S. among institutions with very high research activity. NDSU's annual research expenditures have grown almost threefold since 2000, and over the same time, the institution has seen substantial enrollment increases, with out-of-state and international students making up much of the growth.

NDSU has seven colleges, a graduate school offering 46 doctoral degrees, and extensive continuing and cooperative education programs. A fifth of NDSU students are enrolled in the College of Engineering and Architecture, and many of those go on to work in the region's flourishing tech sector. Meanwhile, NDSU's 55-acre Research and Technology Park houses nearly 20 tech-related companies and exemplifies the institution's entrepreneurial focus.

Estimating the benefits and costs of NDSU requires the following three types of information: (1) the profile of the University and its student body, (2) the economic profile of the region and the state, and (3) statistics relating education to improved social behavior. For the purposes of this study, information on the University and its students was obtained from NDSU; data on the regional and state economy were drawn from public databases; and statistics on social behavior were provided by national studies and surveys.

UNIVERSITY PROFILE

Revenues

Table 1.1 shows NDSU's annual revenues by funding source—a total of $383 million in FY 2010–11. These data are critical in identifying annual costs of educating the student body from the perspectives of students and taxpayers alike. As indicated, tuition and fees comprised 23% of total revenue, state government revenue another 33%, revenue from federal government revenue 22%, and all other revenue (i.e., auxiliary revenue, sales and services, interest, and donations) the remaining 22%.

Table 1.1: NDSU revenue by source, FY 2010–11 ($ thousands)

SOURCE	TOTAL	%
Tuition and fees	$88,521	23%
State government revenue	$126,500	33%
Federal government revenue	$82,636	22%
All other revenue	$85,337	22%
Total revenues	$382,994	100%

Source: Data supplied by NDSU.

Expenditures

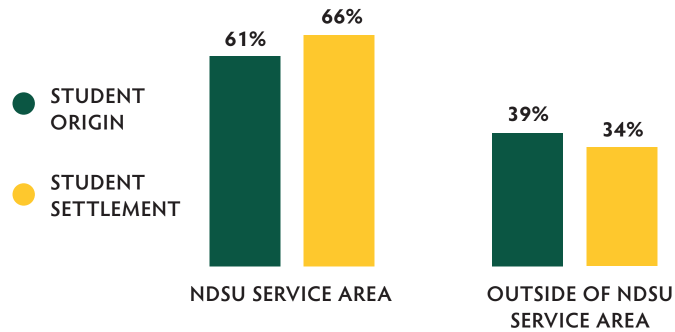
NDSU employed 2,570 full and part-time faculty and staff in the 2010–11 reporting year. The combined payroll at NDSU amounted to $229.5 million. Other expenditures, including

Table 1.2: NDSU expenses by function, FY 2010–11 ($ thousands)

SOURCE	TOTAL	%
Salaries, wages, and benefits (including student workers)	$229,477	65%
Capital expenditures (amortized)	$25,904	7%
All other non-pay expenditures	$95,233	27%
Total expenses	$350,614	100%

Source: Data supplied by NDSU.

Figure 1.1: Student origin and settlement patterns



capital and purchases of supplies and services, made up $121.1 million. These budget data appear in Table 1.2.

STUDENT PROFILE

Demographics

NDSU served 16,960 credit students and 41 non-credit students in the 2010–11 reporting year, a total of 17,001 students (unduplicated). The breakdown of the student body by gender was 55% male and 45% female. The breakdown of the student body by ethnicity was 81% whites and 19% minorities, while the students' overall average age was 23.

Just over half of NDSU's students come from outside North Dakota. Many of these out-of-state students originate from an 18-county region in Minnesota that is within a 100-mile radius of Fargo, where the NDSU campus is located. This 18-county region together with the entire state of North Dakota comprises the NDSU Service Area. Approximately 61% of the entire student population comes from this region, as shown in Figure 1.1. The remaining NDSU students originate from the rest of the U.S. or are non-resident aliens.

Also shown in Figure 1.1 are the students' settlement patterns, whether inside or outside the NDSU Service Area. As indicated, 66% of students remain in the NDSU Service Area, and 34% of students settle outside the region.

Achievements

Table 1.3 summarizes the breakdown of student achievements by degree level. As indicated, NDSU served 184 PhD graduates, 356 master's degree graduates, 1,783 bachelor's

NDSU Welcomes
OUT-OF-STATE STUDENTS

Faced with a declining population base and fewer high school students graduating in the state, NDSU—as part of the statewide Higher Education Roundtable—made an aggressive push at the turn of the century to attract out-of-state students.

More than a decade later, nearly half of NDSU students are from outside North Dakota, and a good percentage of nonresident students stay after they graduate because of the abundance of jobs and quality of life.

"I think it's a valuable asset that the universities bring to our state that doesn't get much credit," said Nancy Johnson, a NDSU alumna and state representative from Dickinson. "It helps bring knowledge to our state."

With its combination of affordable tuition, respected programs, and scenic campus in Fargo, NDSU draws students from more than just neighboring states such as Minnesota and South Dakota. The University has gained momentum in attracting students from all corners of the nation, as well as from other countries.

Since 2000, when the Roundtable's first report was released, NDSU's enrollment has increased 44% and its number of degree offerings—including doctorate programs—has surged.

degree graduates, and 18 certificate graduates in the 2010–11 reporting year. A total of 14,641 continuing students pursued but did not complete a credential during the reporting year.

Table 1.3: NDSU student achievements by education level, 2010–11

CATEGORY	HEAD-COUNT	TOTAL CHES	AVG. CHES
PhD graduates	184	3,904	21.2
Master's degree graduates	356	3,668	10.3
Bachelor's degree graduates	1,783	40,453	22.7
Certificate graduates	18	176	9.8
Continuing students	14,641	336,098	23.0
Workforce and all other students	19	131	6.9
Total/average	17,001	384,430	22.6

Source: Data supplied by NDSU.

Workforce and professional education students comprised the remaining 19 students.

Altogether, NDSU students completed 384,430 credit hour equivalents (or CHEs) during the 2010–11 reporting year. The average number of CHEs per student was 22.6.

REGIONAL PROFILE

NDSU serves a region that comprises all counties in the state of the North Dakota and the following 18 counties in Minnesota: Becker, Beltrami, Clay, Clearwater, Douglas, Grant, Hubbard, Mahnomen, Marshall, Norman, Otter Tail, Pennington, Polk, Red Lake, Stevens, Traverse, Wadena, and Wilkin. All Minnesota counties are within a 100-mile radius of Fargo, North Dakota, where NDSU's main campus is located.

Higher Education Roundtable
SPURS COLLABORATION BETWEEN NDSU, STATE INSTITUTIONS

Authorized by the North Dakota State Legislature in 1999, the Higher Education Roundtable brought together business leaders, educators, and legislators, all of whom had one overarching goal.

"What can we do to take the education system to the next level?" recalled Jim Roers, a onetime member of the Roundtable and real estate developer in Fargo.

The Roundtable encouraged collaboration between the 11 campuses of the state university system—and between industry and higher education in developing curriculum and programs to make North Dakota more economically competitive. The results have been increased college enrollment across the state (including a nearly 50% jump at NDSU) and stronger programs during a time of economic prosperity for the state.

"Educators were just amazed what they could learn, and how they could tailor their programs to better meet the needs of businesses right here in the state," said Roers, now a state senator and member of the NDSU Development Foundation Board.

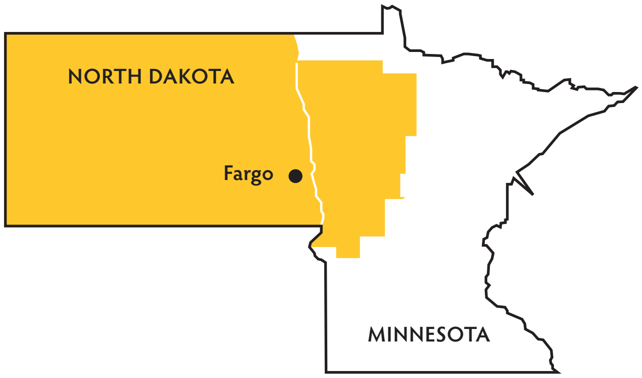
Nancy Johnson, a NDSU alumna and state representative from Dickinson, said the Roundtable looked at the needs of state residents rather than protecting the needs of individual institutions. She credited the Roundtable for making it easier for students to transfer between colleges and universities in the state.

"With the start of the Roundtable, it's been more of a collaborative process," Johnson said. "We want the campuses to work together."

The state's two flagship universities, NDSU and the University of North Dakota, have exemplified this partnering spirit. In a joint 2011 editorial, NDSU President Dean Bresciani and UND President Robert Kelley celebrated the joint efforts of the research universities in contributing to the state's economy and bringing new and better resources to North Dakota.

"That's been by the purposeful design, vision and support of civic, business and legislative leaders provided years ago through the Higher Education Roundtable," Bresciani and Kelley wrote.

North Dakota State University Service Area



Since NDSU first opened its doors to students in 1890, the University has been serving the regional community by creating jobs and income, providing area residents with easy access to higher education opportunities, and preparing students for highly-skilled, technical professions. The availability of quality education and training in the NDSU Service Area also attracts new industry to the region, thereby generating new businesses and expanding the availability of public investment funds.

Table 1.4 summarizes the breakdown of the NDSU Service Area economy by major industrial sector, with details on labor and non-labor income. Labor income refers to wages, salaries, and proprietors' income; non-labor income

*Table 1.4: Labor and non-labor income by major industrial sector in NDSU Service Area, 2011 ($ millions)**

INDUSTRY SECTOR	LABOR INCOME	NON-LABOR INCOME	TOTAL INCOME	% OF TOTAL
Agriculture, forestry, fishing and hunting	$1,471	$1,120	$2,591	6%
Mining	$1,829	$1,928	$3,756	8%
Utilities	$494	$1,440	$1,934	4%
Construction	$2,262	$173	$2,436	5%
Manufacturing	$2,277	$1,654	$3,932	8%
Wholesale trade	$2,047	$1,630	$3,677	8%
Retail trade	$2,047	$1,317	$3,365	7%
Transportation and warehousing	$1,585	$500	$2,086	4%
Information	$565	$714	$1,279	3%
Finance and insurance	$1,543	$1,857	$3,400	7%
Real estate and rental and leasing	$552	$1,724	$2,277	5%
Professional and technical services	$1,229	$338	$1,567	3%
Management of companies and enterprises	$406	$73	$479	1%
Administrative and waste services	$600	$142	$742	2%
Educational services	$207	$21	$229	<1%
Health care and social assistance	$3,760	$425	$4,186	9%
Arts, entertainment, and recreation	$132	$59	$192	<1%
Accommodation and food services	$735	$413	$1,148	2%
Other services, except public administration	$770	$111	$881	2%
Federal government	$1,395	$619	$2,014	4%
State and local government	$4,343	$396	$4,739	10%
Total	$30,251	$16,657	$46,908	100%

* Data reflect the most recent year for which data are available. EMSI data are updated quarterly.
† Numbers may not add due to rounding.
Source: EMSI.

refers to profits, rents, and other income. Together, labor and non-labor income comprise a region's total gross regional product, or GRP.[1]

As shown in Table 1.4, the NDSU Service Area's GRP is approximately $46.9 billion, equal to the sum of labor income ($30.3 billion) and non-labor income ($16.7 billion). In Chapter 3, we use the NDSU Service Area's gross regional product as the backdrop against which we measure the relative impacts of the University on economic growth in the region.

CONCLUSION

This chapter presents the broader elements of the database used to determine the results. Additional detail on data sources, assumptions, and general methods underlying the analyses are conveyed in the remaining chapters and appendices. The core of the findings is presented in the next two chapters—Chapter 2 looks at NDSU as an investment, while Chapter 3 considers NDSU's role in economic growth. The appendices detail a collection of miscellaneous theory and data issues.

1 See the glossary of terms in Appendix 2 for a full definition of GRP.

Chapter 2

INVESTMENT ANALYSIS

INTRODUCTION

INVESTMENT analysis is the process of evaluating total costs and measuring these against total benefits to determine whether or not a proposed venture will be profitable. If benefits outweigh costs, then the investment is worthwhile. If costs outweigh benefits, then the investment will lose money and is thus considered infeasible.

In this chapter, we consider NDSU as an investment from the perspectives of students and taxpayers, the major stakeholders. The backdrop for the analysis is the entire state of North Dakota.

Table 2.1: Expected income in NDSU Service Area at midpoint of individual's working career by education level, with level to level differences

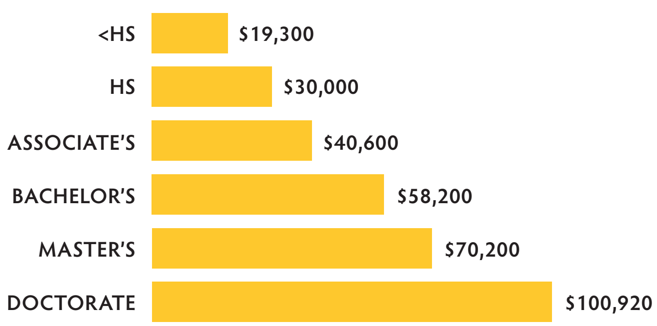
EDUCATION LEVEL	INCOME	DIFFERENCE
Less than high school	$19,300	n/a
High school or equivalent	$30,000	$10,700
Associate's degree	$40,600	$10,600
Bachelor's degree	$58,200	$17,600
Master's degree	$70,200	$12,000
Professional/doctoral degree	$100,920	$30,720

Source: Derived from data supplied by EMSI industry data and the U.S. Census Bureau. Figures are adjusted to reflect average earnings per worker in the NDSU Service Area.

STUDENT PERSPECTIVE

NDSU served 16,960 credit students and 41 non-credit students (unduplicated) in 2010–11. Analyzing the benefits and costs of education from the perspective of students is the most obvious—they give up time and money to go to the University in return for a lifetime of higher income. The benefit component of the analysis thus focuses on the extent to which student incomes increase as a result of their education, while costs comprise the monies they put up.

Figure 2.1: Average income at career midpoint



Linking education to earnings

The correlation between education and earnings is well documented and forms the basis for determining the benefits of education. As shown in Table 2.1, mean income levels at the midpoint of the average-aged worker's career increase for individuals who have attained higher levels of education. These numbers are derived from EMSI's industry data on average income per worker in the NDSU Service Area,[2] broken out by gender, ethnicity, and education level using data supplied by the U.S. Census Bureau.

2 It is important to note that wage rates in the EMSI model combine state and federal sources to provide earnings that reflect proprietors, self-employed workers, and others not typically included in state data, as well as benefits and all forms of employer contributions. As such, EMSI industry earnings-per-worker numbers are generally higher than those reported by other sources.

The differences between income levels define the marginal value of moving from one education level to the next. For example, students who move from a high school diploma to a bachelor's degree may expect approximately $28,200 in higher annual income. The difference between a high school diploma and the attainment of a master's degree is even greater—up to $40,200 in higher income.

Of course, several other factors such as ability, socioeconomic status, and family background also positively correlate with higher earnings. Failure to account for these factors results in what is known as an "ability bias." A literature review by Chris Molitor and Duane Leigh indicates that the upper limit benefits should be discounted by 10%.[3] As such, we adjust the gross increase in income downward by 10%.

Determining the value per credit hour equivalent

Not all students who attended NDSU in the 2010–11 reporting year obtained a degree in the course of the year. Some may have returned the following year to complete their education goals, while others may have taken a few courses and entered the workforce without achieving a credential. As such, the only way to measure the value of the students' achievement is through their credit hour equivalents, or CHEs. By using CHEs we are able to calculate the benefits to all students, not just to those who earn an award.

In the model, we calculate the value of the students' CHE production through a complex process that involves dividing the education ladder into a series of individual steps, each equal to one credit. We then spread the income differentials from Table 2.1 over the steps required to complete each education level, assigning a unique value to every step in the ladder.[4] Next, we apply a continuous probability distribution to map the students' CHE production to the ladder, depending on their level of achievement and the average number of CHEs they achieve. Finally, we sum the number of CHEs earned at each step and multiply them by their corresponding value to arrive at the students' average annual increase in income.

Table 2.2: Aggregate higher income of NDSU students at career midpoint and average value per CHE

	TOTAL/ AVG
Higher annual income, aggregate (thousands)	$87,395
Total credit hour equivalents (CHEs)	384,430
Average value per CHE	$227

Source: EMSI impact model.

Table 2.2 displays the aggregate annual higher income for the 17,001 students served by NDSU in 2010–11. Also shown are the total CHEs generated by students and the average value per CHE. Note that, although each step in the education ladder has a unique value, for the sake of simplicity, only the total and average values are displayed.

Here a qualification must be made. Research shows that earnings levels do not remain constant; rather, they start relatively low and gradually increase as the worker gains more experience. Research also indicates that the earnings increment between educated and non-educated workers grows through time. This means that the aggregate annual higher income presented in Table 2.2 will actually be lower at the start of the students' career and higher near the end of it, gradually increasing at differing rates as the students grow older and advance further in their careers. To model this change in earnings, we use the well-known and well-tested Mincer function, which we discuss more fully in the next section.

Generating a benefits stream

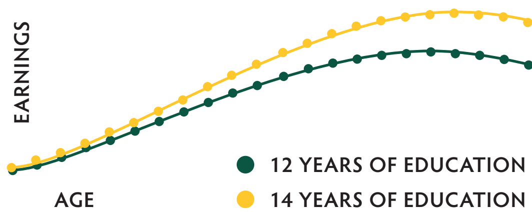
The two names most often associated with human capital theory and its applications are Gary Becker and Jacob Mincer.[5] The standard human capital earnings function developed by Mincer appears as a three-dimensional surface with the key elements being earnings, years of education, and experience. Figure 2.2 shows the relationship between earnings and age, with age serving as a proxy for experience.

3 Chris Molitor and Duane Leigh, "Estimating the Returns to Schooling: Calculating the Difference Between Correlation and Causation" (Pullman, WA: March 2001). Report available upon request.

4 Students who obtain a degree during the reporting year are granted a "ceremonial boost" in the calculations in recognition of the fact that an award has greater value than the individual steps required to achieve it.

5 See Gary S. Becker, *Human Capital: A Theoretical Analysis with Specific Reference to Education* (New York: Columbia College Press for NBER, 1964); Jacob Mincer, "Schooling, Experience and Earnings" (New York: National Bureau of Economic Research, 1974); and Mincer, "Investment in Human Capital and Personal Income Distribution," *Journal of Political Economy,* vol. 66 issue 4, August 1958: 281–302.

Figure 2.2: Earnings for 12 vs. 14 years of education



Note that, since we are using the graph strictly for illustrative purposes, the numbers on the axes are not shown.

Figure 2.2 illustrates several important features of the Mincer function. First, earnings initially increase at an increasing rate, later increase at a decreasing rate, reach a maximum somewhere after the midpoint of the working career, and then decline in later years. Second, at higher levels of education, the maximum level of earnings is reached at an older age. And third, the benefits of education, as measured by the difference in earnings for two levels, increase with age.

In the model, we employ the Mincer function as a smooth predictor of earnings over time,[6] for as long as students remain active in the workforce. Using earnings at the career midpoint as our base (Table 2.1), we derive a set of scalars from the slope of the Mincer curve to model the students' increase in earnings at each age within their working careers. The result is a stream of projected future benefits that follows the same basic shape as the Mincer curve, where earnings gradually increase from the time students enter the workforce, come to a peak shortly after the career midpoint, and then dampen slightly as students approach retirement at age 65.

The benefits stream generated by the Mincer curve is a key component in deriving the students' rate of return. However, not all students enter the workforce at the end of the reporting year, nor do all of them remain in the workforce until age 65. To account for this, we discount the students' benefit stream in the first few years of the time horizon to allow time for those who are still studying at the University to complete their educational goals and find employment. Next, we discount the entire stream of benefits by the estimated number of students who will die, retire, or become unemployed over the course of their working careers.[7] The likelihood that students will leave the workforce increases as they age, so the older the student population is, the greater the attrition rate applied by the model will be.

Having calculated the students' benefits stream and adjusted for attrition, we next turn to student costs. These are discussed more fully in the next section.

Calculating student costs

Student costs comprise tuition and fees, books and supplies, and the opportunity cost of time. Tuition and fees amount to $88.5 million (see Table 1.1). Full-time students also spend an average of $1,000 per year on books, supplies, and equipment. Because not all students attend NDSU full time, however, we need to convert the students' total production of credit hour equivalents (CHEs) to full-time equivalents (FTEs). We do this by dividing the total number of CHEs (384,430 from Table 1.3) by a factor of 30, assuming that 30 CHEs are equal to a full year of study. This calculation yields 12,814 FTEs. We then multiply the FTEs by the $1,000 average full-time student cost of books and supplies to arrive at approximately $12.8 million in spending during the 2010–11 reporting year.

Opportunity cost is the most difficult component of student costs to calculate. It refers to the value of time and earnings forgone by students who choose to attend college rather than work full-time. We derive opportunity costs by establishing the full earning potential of students at their current age (23) and education level, and then comparing this to what they are actually earning while attending the University.

We begin with the average annual incomes by education level from Table 2.1 and weight these according to the

6 The Mincer equation is computed based on estimated coefficients presented in Robert J. Willis, "Wage Determinants: A Survey and Reinterpretation of Human Capital Earnings Function" in *Handbook of Labor Economics*, Vol. 1 (Amsterdam: Elsevier Science Publishers, 1986): 525–602. These are adjusted to current year dollars in the usual fashion by applying the GDP implicit price deflator. The function does not factor in temporary economic volatility, such as high growth periods or recessions. In the long run, however, the Mincer function is a reasonable predictor.

7 These data are provided by a variety of sources, including the Center for Disease Control and Prevention (CDC), the Social Security Administration (SSA), and the Bureau of Labor Statistics (BLS).

students' education level at the start of the reporting year.[8] However, recall that Table 2.1 displays earnings at the midpoint of the individual's working career, not immediately upon exiting the University. To arrive at the full earning potential of students while enrolled, we must condition the earnings levels to the students' age, which we accomplish simply by applying a scalar derived from the Mincer curve described above.

Another important factor to consider is the time that students actually spend at the University, as this is the only part of the year that they would potentially be required to give up earnings as a result of their education. We use the students' CHE production as a proxy for time, under the assumption that the more CHEs students earn, the less time they have to work, and, consequently, the more earnings they potentially have to forgo while attending school.

Note that the opportunity cost calculations only apply to students who are economically active, i.e., those who work or are seeking work. NDSU estimates that 71% of its students are employed while attending.[9] For those who are not working, we assume that they are either seeking work or will seek work once they complete their educational goals.

The differentiation between working and non-working students is important because they are treated differently in the model. Non-working students are assumed to give up their entire earning potential while enrolled. Working students, on the other hand, are able to maintain all or part of their income, so their opportunity cost is not as high. However, many of them give up a significant portion of their leisure time,[10] while others hold jobs that pay less than statistical averages (usually because they can only find work that fits their course schedule). To account for both of these factors, we assume that working students give up 67% of their full earning potential while attending the University, depending on their age and education level.[11]

Table 2.3: NDSU student costs, 2010–11 ($ thousands)

	TOTAL
EDUCATION COST	
Tuition and fees	$88,521
Books and supplies	$12,814
OPPORTUNITY COST	
Working students	$113,892
Non-working students	$68,955
ADJUSTMENTS	
Less grants & scholarships refunded to students	-$7,185
Total student costs	$276,998

Source: Based on data supplied by NDSU and outputs of the EMSI impact model.

Total opportunity cost for working and non-working students appears in Table 2.3. Also shown are the cost of tuition and fees and the cost of books and supplies, less grants and scholarships refunded to students (these funds represent a gain and not a cost to students). Total student costs for all 17,001 students served by NDSU in 2010–11 thus come to $277 million, as shown in the bottom row of Table 2.3. This translates to an average of $21,616 in cost per full-time student (equal to $277 million in cost divided by 12,814 FTEs generated by NDSU students during the 2010–11 reporting year).

Return on investment

Having calculated the students' future benefits stream and the associated costs, the next step is to discount the results to the present to reflect the so-called time value of money. For the student perspective we assume a discount rate of 4% (see the "Discount Rate" box on the following page). Present values of benefits are then collapsed down to one number and compared to student costs to derive the investment analysis results, expressed in terms of benefit/cost ratios, rates of return, and payback periods. The investment is feasible if returns match or exceed the minimum threshold values, i.e., a benefit/cost ratio greater than 1, a rate of return that exceeds the discount rate, and a reasonably low payback period.

As shown in Table 2.4, higher student income is pro-

8 Based on the number of students who reported their entry level of education to NDSU.

9 Based on the number of students who reported their employment status to NDSU.

10 See James M. Henderson and Richard E. Quandt, *Microeconomic Theory: A Mathematical Approach* (New York: McGraw-Hill Book Company, 1971).

11 This assumption is based on the following: (1) the value of leisure time, assumed to have a value equal to 20% of students' full earning potential, and (2) the percent of earnings forgone by students who work at jobs that pay less than statistical averages while enrolled. This latter assumption, equal to 47%, is derived from data supplied by approximately 200 institutions previously analyzed by EMSI. For more information on the value of leisure time, see Becker, 1964.

DISCOUNT RATE

The discount rate is a rate of interest that converts future costs and benefits to present values. For example, $1,000 in higher earnings realized 30 years in the future is worth much less than $1,000 in the present. All future values must therefore be expressed in present value terms in order to compare them with investments (i.e., costs) made today. The selection of an appropriate discount rate, however, can become an arbitrary and controversial undertaking. As suggested in economic theory, the discount rate should reflect the investor's opportunity cost of capital, i.e., the rate of return one could reasonably expect to obtain from alternative investment schemes. In this study we assume a 4% discount rate from the student perspective and a 3% discount rate from the taxpayer perspective. The discount rate from the taxpayer perspective is lower because governments are large and can therefore spread their risks over a larger and more diverse investment portfolio than the private sector can.

jected across the working life of students, discounted to the present, and added together to yield a cumulative sum of $1.4 billion, the present value of all of the future income increments. This may also be interpreted as the gross capital asset value of the students' higher income stream. Accordingly, the aggregate 2010–11 student body is rewarded with a capital asset valued at $1.4 billion as a result of their attendance at NDSU.

Next, we compare the benefits to the associated costs to judge whether attending the University is a good investment. Costs are provided in the second row of Table 2.4, equal to $277 million. Note that costs only occur in the single reporting year and are thus already in current year dollars, so their present value equals what is reported in Table 2.3. Comparing costs with the present value of benefits yields a student benefit/cost ratio of 5.23 (equal to $1.4 billion in benefits divided by $277 million in costs). This means that for every dollar invested in NDSU education, students receive a cumulative of $5.23 in higher future income over their working careers.

The rate of return is perhaps the most recognized indicator of investment effectiveness. Given the cost of education and the stream of associated future benefits, the rate of return indicates how much a bank would have to pay a depositor of like amount to yield an equally rewarding stream of future payments.[12] Table 2.4 shows NDSU students earning average returns of 14.4% on their investment of time and money. This is indeed an impressive return compared, for example, to 1% on a standard bank savings account, or approximately 7% on stocks and bonds (thirty-year average return).

Table 2.4: Present value of benefits and costs, NDSU student perspective ($ thousands)

	TOTAL
A: Present value of future benefit stream	$1,449,185
B: Present value of costs	$276,998
Net present value (A – B)	$1,172,188
Benefit/cost ratio (A / B)	5.23
Internal rate of return	14.4%
Payback period (no. of years)	10.6

Source: EMSI impact model.

The payback period is defined as the length of time it takes to entirely recoup the initial investment.[13] Beyond that point, returns are what economists would call "pure costless rent." As indicated in Table 2.4, students at NDSU see, on average, a payback period of 10.6 years on their forgone earnings and out-of-pocket costs.[14]

12 Rates of return are computed using the familiar "internal rate of return" calculation. Note that, with a bank deposit or stock market investment, the depositor puts up a principal, receives in return a stream of periodic payments, and then recovers the principal at the end. An education investor, on the other hand, receives a stream of periodic payments that include the recovery of the principal as part of the periodic payments, but there is no principal recovery at the end. These differences notwithstanding, comparable cash flows for both bank and education investors yield the same internal rate of return.

13 Payback analysis is generally used by the business community to rank alternative investments when safety of investments is an issue. Its greatest drawback is that it takes no account of the time value of money.

14 The payback period is calculated by dividing the cost of the investment by the net return per period. In this study, the cost of the investment includes tuition and fees plus the opportunity cost of time—it does not take into account student living expenses or interest on loans.

SOCIAL PERSPECTIVE

Any benefits that impact the state as a whole—whether students, employers, taxpayers, or whoever else stands to benefit from the activities of NDSU—are counted as benefits under the social perspective. We subdivide these benefits into the following two main components: (1) increased income in the state, and (2) social externalities stemming from the improved lifestyles of students, such as better health, reduced crime, and fewer incidences of unemployment (see the "Beekeeper Analogy" box).

BEEKEEPER ANALOGY

A classic example of positive externalities (sometimes called "neighborhood effects") in economics is the private beekeeper. The beekeeper's intention is to make money by selling honey. Like any other business, the beekeeper's receipts must at least cover his operating costs. If they don't, his business will shut down.

But from society's standpoint, there is more. Flower blossoms provide the raw input bees need for honey production, and smart beekeepers locate near flowering sources such as orchards. Nearby orchard owners, in turn, benefit as the bees spread the pollen necessary for orchard growth and fruit production. This is an uncompensated external benefit of beekeeping, and economists have long recognized that society might actually do well to subsidize positive externalities such as beekeeping.

Educational institutions are in some ways like beekeepers. Strictly speaking, their business is in providing education and raising people's incomes. Along the way, however, external benefits are created. Students' health and lifestyles are improved, and society indirectly enjoys these benefits just as orchard owners indirectly enjoy benefits generated by beekeepers. Aiming at an optimal expenditure of public funds, the impact model tracks and accounts for many of these external benefits and compares them to public costs (what taxpayers agree to pay) of education.

Increased income

Income growth occurs as the higher earnings and added skills of NDSU students stimulate the production of income in the state. Students earn more because of the skills they learned while attending the University, and businesses earn more because student skills make capital more productive (i.e., buildings, machinery, etc.). This in turn raises profits and other business property income. Together, increases in labor and capital income are considered the effect of a skilled workforce.

Estimating the effect of NDSU on income growth in the state begins with the projected higher student income from Table 2.4. Not all of these benefits may be counted as benefits to the public, however. Some students leave the state during the course of their careers, and any benefits they generate leave the state with them. To account for this dynamic, we combine student settlement data from NDSU with data on migration patterns from the U.S. Census Bureau to estimate the number of students who leave the state workforce over time.

Once we have adjusted for regional attrition, we derive a stream of earnings benefits that accrue to the public. These comprise the direct effect of NDSU on state income growth. Indirect effects occur when students spend more money on consumer goods, while the increased output of businesses that employ them also creates a demand for inputs and, consequently, input spending. The effect of these two spending items (consumer and business spending) leads to still more spending and more income creation, and so on. To quantify the impact of these several rounds of spending, we apply a multiplier[15] derived from EMSI's specialized input-output (IO) model, described more fully in Appendix 3.

With an increase in labor income (both direct and indirect) comes an increase in capital investment,[16] thereby generating even more growth in the non-labor (or "non-earnings") share of the economy. Non-labor income consists of monies gained through investments, including dividends, interests, and rent. To derive the growth in non-labor income, we

15 Multipliers are common to economic impact analysis and are used to measure how money cycles through the economy.

16 In the production process, skilled labor and capital complement each other (i.e., they have a relatively low elasticity of substitution). Accordingly, an increase in skilled labor increases the productivity and income of existing capital while encouraging additional capital investment.

Table 2.5: Aggregate added state income at the career midpoint of NDSU students ($ thousands)

	TOTAL
Labor income	$57,661
Non-labor income	$25,988
Total added state income	$83,649

Source: EMSI impact model.

multiply the direct and indirect labor income figures by a ratio of North Dakota's gross state product (equal to labor income plus non-labor income) to total labor income in the state.

Table 2.5 summarizes the average annual increase in state income due to the higher earnings of the 17,001 students served by NDSU in 2010–11. Note that, for the sake of consistency with the annual student benefits discussed earlier in this chapter, the table only shows the aggregate increase in state income at the midpoint of the students' careers. As before, these figures must be projected out into the future and discounted to the present before weighing them against the costs. Before doing so, however, we must first turn to the social externalities, as these comprise another key component of the benefits that accrue to the public.

Social externalities

In addition to higher income, education is statistically correlated with a variety of lifestyle changes that generate social savings, also known as external or incidental benefits of education. These social savings represent avoided costs that would have otherwise been drawn from private and public resources absent the education provided by NDSU.

It is important to note that calculating social externalities is not a straightforward task of counting actual monies saved. The process is difficult because of the uncertainties about what data to include, what methodologies to employ, and what assumptions to make. Because of this, results should not be viewed as exact, but rather as indicative of the impacts of education on health and well-being.

Data relating education to improved social behavior are available from a variety of sources, including the U.S. Census Bureau, the U.S. Department of Labor, and national studies and surveys analyzing the impacts of substance abuse, crime, and unemployment on society. Data on social costs are also relatively abundant. By combining these data sets, we are able to quantify how education contributes to the lowering of social costs and, ultimately, improves quality of life.

Social benefits break down into three main categories: 1) health savings, 2) crime savings, and 3) welfare and unemployment savings. Health savings include avoided medical costs associated with tobacco and alcohol abuse. Crime savings consist of avoided police, incarceration, prosecution, and victim costs, as well as benefits stemming from the added productivity of individuals who would have otherwise been incarcerated. Welfare and unemployment benefits comprise avoided costs due to the reduced number of social assistance and unemployment insurance claims.

In the model, we quantify the effect of social externalities first by calculating the probability at each education level that individuals will have poor health, commit crimes, or claim welfare and unemployment benefits. Deriving the probabilities involves assembling data at the national level, breaking them out by gender and ethnicity and adjusting them from national to state levels. We then spread the probabilities across the education ladder and multiply the marginal differences by the students' corresponding production of credit hour equivalents (CHEs) at each step. The sum of these effects counts as the upper bound measure of the number of individuals who, due to the education they received at NDSU, will not have poor health, commit crimes, or claim welfare and unemployment benefits.

Of course, there are other influences that impact an individual's behavior, and separating these out from the non-economic benefits of education is a challenging task. For the purpose of this analysis, we dampen the results by the "ability bias" adjustment discussed earlier in this chapter to account for other influences besides education that correlate with an individual's quality of life, such as socioeconomic status and family background.

The final step is to express the results in dollar terms by multiplying them by the associated costs per individual, based on data supplied by national studies and surveys.[17] These comprise the overall savings to society. Results of the

17 For more information on the data and assumptions used in estimating the social externalities, please see Appendix 5 and the resources and references list in Appendix 1.

Table 2.6: Aggregate avoided social costs at the career midpoint of NDSU students ($ thousands)

	TOTAL
HEALTH	
Smoking-related savings	$11,197
Alcohol-related savings	$5,340
Total health savings	$16,537
CRIME	
Incarceration savings	$49
Crime victim savings	$56
Added productivity	$136
Total crime savings	$240
WELFARE/UNEMPLOYMENT	
Welfare savings	$46
Unemployment savings	$201
Total unemployment savings	$247
Total avoided social costs	$17,024

Source: EMSI impact model.

analysis are displayed in Table 2.6. As before (and again for the sake of consistency), only the estimated savings that occur at the students' career midpoint are shown.

Smoking- and alcohol-related savings amount to $16.5 million, including avoided social costs due to a reduced demand for medical treatment and social services, improved worker productivity and reduced absenteeism, and a reduced number of vehicle crashes and alcohol or smoking-induced fires. Since the probability that individuals will manifest poor health habits is greater than the probability that they will be incarcerated or become unemployed, the savings associated with health are also considerably greater.

Crime savings sum to $239,900. These reflect avoided social costs associated with a reduced number of crime victims, added worker productivity, and reduced expenditures for police and law enforcement, courts and administration of justice, and corrective services. Finally, welfare and unemployment savings amount to $247,000, stemming from a reduced number of persons in need of income assistance.

All told, aggregate avoided social costs at the career midpoint of the 17,001 students served by NDSU in 2010–11 equal approximately $17 million. These savings accrue for years out into the future, for as long as students remain in the workforce.

Total benefits to the public

By combining our income growth calculations with the social externalities, we are able to estimate the total benefits to the public. To this we apply a reduction factor to account for the students' alternative education opportunities. The assumption is that any benefits generated by students who could have received an education elsewhere, even if NDSU and the other publicly funded institutions in the state did not exist, cannot be counted as new benefits to the public.[18] For this analysis, we assume an alternative education variable of 26%, meaning that 26% of the student population at NDSU would have generated benefits anyway even without the University. For more information on the calculation of the alternative education variable, please see Appendix 7.

We also apply an adjustment called the "shutdown point," which is designed to net out benefits that are not directly linked to the state government costs of supporting the University. As with the alternative education variable, the purpose of this adjustment is to account for benefits that would accrue to the public anyway. To estimate the shutdown point, we apply a sub-model that simulates the students' demand curve for education by reducing state support to zero and progressively increasing student tuition and fees. As student tuition and fees increase, enrollment declines. For NDSU, the analysis shows that the University could not operate without state government support, and thus no discount applies. For more information on the theory and methodology behind the estimation of the shutdown point, please see Appendix 4.

Having accounted for the adjustments just described, we discount all benefits to the present using a discount rate of 3%. This yields a present value of $1.3 billion due to income growth, as indicated in Table 2.7 on the following page. Also shown is a present value of $251.7 million due to future savings to the public. Altogether, the present value of all public benefits equals roughly $1.5 billion.

State government support of NDSU also appears in Table 2.7, listed as the present value of total costs. While this is technically correct, it is important to note that, unlike

18 A situation in which there are no public institutions in the state is virtually impossible. The adjustment is entirely hypothetical and is used merely to examine NDSU in standard investment analysis terms by accounting for benefits that would have occurred anyway, even if the University did not exist.

Table 2.7: Present value of benefits and costs, social perspective ($ thousands)

	TOTAL
BENEFITS	
Present value of future added income	$1,276,661
Present value of future avoided social costs	$251,700
A: Total benefits, present value	$1,528,361
COSTS	
B: Total state government costs, present value	$126,500
Net present value (A – B)	$1,401,861
Benefit/cost ratio (A / B)	12.08

Source: EMSI impact model.

Table 2.8: Aggregate taxpayer benefits at the career midpoint of NDSU students ($ thousands)

	TOTAL
Added tax revenue	$7,505
REDUCED GOVERNMENT EXPENDITURES	
Health savings	$992
Crime savings	$57
Unemployment savings	$7
Total reduced government expenditures	$1,056
Total taxpayer benefits	$8,561

Source: EMSI impact model.

streams of benefits that go on into the future, the state government contribution of $126.5 million was made in the single reporting year. Its present value and nominal dollar value are thus the same.

Having now defined present values of costs and benefits, the model forms a benefit/cost ratio of roughly 12.08 (= $1.5 billion worth of benefits ÷ $126.5 million worth of state government support). Recall that this ratio reflects the measure of all benefits generated regardless of those to whom they may accrue. Students are the beneficiaries of higher income, employers are beneficiaries of lower absenteeism and increased worker productivity, still others are beneficiaries of improved health, and so on. These are widely dispersed benefits that do not necessarily return to taxpayers, who pay costs at full measure. Inasmuch as investors and beneficiaries are not the same individuals, measures common to standard investment analyses such as rate of return, payback period, and net present value no longer apply. From the social perspective, therefore, the benefit/cost ratio should be viewed strictly as a comparison between public benefits and taxpayer costs.

TAXPAYER PERSPECTIVE

From the taxpayer perspective, the situation is different, since investors and beneficiaries are one and the same. The pivotal step here is to limit overall public benefits shown in Tables 2.5 and 2.6 to those that specifically accrue to state and local governments. For example, benefits resulting from income growth are limited to increased state and local tax payments. Similarly, savings related to improved health, reduced crime, and fewer welfare and unemployment claims are limited to those received strictly by state and local governments. In all instances, benefits to private residents, local businesses, or the federal government are excluded.

Table 2.8 presents taxpayer benefits at the students' career midpoint. Added tax revenue appears in the first row. These figures are derived by multiplying the income growth figures from Table 2.5 by the prevailing state and local government tax rates in the state. For the social externalities, we claim only those benefits where the demand for government-supported social services is reduced, or where the government benefits from improved productivity among government employees. The total undiscounted value of future tax revenues and avoided social costs at the career midpoint thus comes to approximately $8.6 million.

Projecting the benefits in Table 2.8 out to the future and then discounting them back to the present gives the time value of all future benefit increments that accrue strictly to state and local governments. Results appear in Table 2.9. As indicated, the future stream of benefits provides an overall asset value of $130.2 million stemming from a year's support of NDSU. Costs, on the other hand, come to only $126.5 million, equal to the annual contribution of state government to NDSU (note that this number is also in Table 2.7). In return for their public support, therefore, taxpayers are rewarded with an investment benefit/cost ratio of 1.03 (= $130.2 million ÷ $126.5 million), indicating a most profitable investment.

At 3.1%, the rate of return to state and local taxpayers

Table 2.9: Present value of benefits and costs, taxpayer perspective ($ thousands)

	TOTAL
BENEFITS	
Present value of future added tax revenue	$114,546
Present value of future reduced government expenditures	$15,616
A: Total benefits, present value	$130,161
COSTS	
B: Total state government costs, present value	$126,500
Net present value (A – B)	$3,661
Benefit/cost ratio (A / B)	1.03
Internal rate of return	3.1%
Payback period (no. of years)	25.5

Source: EMSI impact model.

is also favorable. Economists typically assume a 3% rate of return when dealing with government investments and public finance issues. This is the return governments are assumed to be able to earn on generally safe investments of unused funds, or alternatively, the interest rate for which governments, as relatively safe borrowers, can obtain funds. A rate of return of 3% would mean that the University just pays its own way. In principle, governments could borrow monies used to support NDSU and repay the loans out of the resulting added taxes and reduced government expenditures. A rate of return of 3.1% on the other hand, means that NDSU not only pays its own way, but it also generates a small surplus that state and local governments can use to fund other programs. It is unlikely that other government programs could make such a claim.

Note that returns reported in Table 2.9 are real returns, not nominal. When a bank promises to pay a certain rate of interest on a savings account, it employs an implicitly nominal rate. Bonds operate in a similar manner. If it turns out that the inflation rate is higher than the stated rate of return, then money is lost in real terms. In contrast, a real rate of return is on top of inflation. For example, if inflation is running at 3% and a nominal percentage of 5% is paid, then the real rate of return on the investment is only 2%. In Table 2.9, the 3.1% taxpayer rate of return is a real rate. With an inflation rate of 3.1% (the average rate reported over the past 20 years as per the U.S. Department of Commerce, Consumer Price Index), the corresponding nominal rate of return is 6.2%, substantially higher than what is reported in this analysis.

With and without social benefits

Earlier in this chapter, social benefits attributable to education (reduced crime, lower welfare, lower unemployment, and improved health) are defined as externalities that are incidental to the operations of the University. Some would question the legitimacy of including these benefits in the calculation of rates of return to education, arguing that only direct benefits, i.e., higher income, should be counted. Tables 2.7 and 2.9 are inclusive of social benefits reported here as attributable to NDSU. Recognizing the other point of view, Table 2.10 shows rates of return for both the social and taxpayer perspectives exclusive of social benefits. As indicated, returns dip slightly below the threshold values, but they still confirm that the taxpayers receive value from investing in NDSU, beyond typical public investments.

Table 2.10: Social and taxpayer perspectives with and without social externalities ($ thousands)

	SOCIAL PERSPECTIVE WITH SOCIAL SAVINGS…		TAXPAYER PERSPECTIVE WITH SOCIAL SAVINGS…	
	INCLUDED	EXCLUDED	INCLUDED	EXCLUDED
Net present value	$1,401,861	$1,150,161	$3,661	-$11,955
Internal rate of return	n/a	n/a	3.1%	2.5%
Benefit/cost ratio	12.08	10.09	1.03	0.91
Payback period (no. of years)	n/a	n/a	25.5	27.7

Source: EMSI impact model.

CONCLUSION

This chapter has shown that NDSU is an attractive investment to its major stakeholders—students as well as taxpayers. Rates of return to students invariably exceed alternative investment opportunities. At the same time, state and local governments can take comfort in knowing that the expenditure of taxpayer funds creates a wide range of positive social benefits and, perhaps more importantly, actually returns more to government budgets than it costs. Without these increased tax receipts and avoided costs provided by NDSU education, state and local governments would have to raise taxes to make up for lost revenues and added costs.

Chapter 3

ECONOMIC GROWTH ANALYSIS

INTRODUCTION

THE NDSU Service Area comprises all counties in the state of the North Dakota and 18 counties in Minnesota that are within a 100-mile radius of Fargo, where the university campus is located. NDSU promotes economic growth in the the NDSU Service Area in a variety of ways. The University is an employer and a buyer of goods and services. In addition, NDSU is a primary source of education to area residents and a supplier of trained workers to local industry.

The economic impact of education may be calculated in different ways. The approach we use in this study is to express results in terms of income rather than sales, the more common measurement. The reason for this is that measuring impacts in sales terms does not account for monies that leave the economy, which makes results appear larger than they really are. Income, on the other hand, presents a more accurate picture of the University's actual impacts.

Results of the economic growth analysis are broken down according to the following four effects: (1) the university operations effect, stemming from NDSU's payroll and purchases; 2) the student spending effect, due to the spending of students for room and board and other personal expenses; (3) the visitor spending effect, resulting from the expenditures of visitors for lodging, food, transportation, etc.; and, finally, (4) the productivity effect, comprising the income growth that occurs as NDSU's former students deepen the economy's stock of human capital.

UNIVERSITY OPERATIONS EFFECT

All employees of NDSU live in the NDSU Service Area. Faculty and staff earnings become part of the region's overall income, while their spending for groceries, apparel, and other household expenditures help support local businesses.

In addition to being an employer, NDSU is also a purchaser of supplies and services. Many of NDSU's vendors are located in the NDSU Service Area, creating a ripple effect that generates additional jobs and income throughout the economy.

Calculating the impacts

The impact of NDSU operations is subdivided into the following two main effects: the direct effect and the indirect effect. The direct effect, equal to $229.5 million, comprises the University's payroll and employee benefits (see Table 3.1). The indirect effect refers to the additional income created in the economy as NDSU employees and the University's vendors and contractors spend money in the region to purchase even more supplies and services.

Estimating the indirect effect requires use of a specialized input-output (IO) model that shows the interconnection of industries, government, and households in the area. The factor of change that occurs in a region's industries as a result of economic activity in another industry is most commonly known as the multiplier. In this study, the IO model uses common "data-reduction" techniques to generate multipliers that are similar in magnitude to those of other popular regional IO modeling products, such as the IMPLAN and RIO models. For more information on the EMSI IO model, please see Appendix 3.

Table 3.1: NDSU operations effect, 2010–11 ($ thousands)

	LABOR INCOME	NON-LABOR INCOME	TOTAL	% OF TOTAL
Total income in service region	$30,251,367	$16,656,751	$46,908,119	
Direct effect of payroll	$229,477	$0	$229,477	0.5%
Indirect effect	$32,071	$16,287	$48,358	0.1%
Gross total	$261,548	$16,287	$277,835	0.6%
Adjust for alternative fund uses	-$50,056	-$26,603	-$76,659	<0.1%
Net total	$211,492	-$10,316	$201,176	0.4%

Source: EMSI impact model.

To calculate the multiplier effects, we take NDSU's payroll and purchases, map them to the 21 top-level industry sectors of the IO model, and adjust them to account for spending that occurs locally.[19] We then run the data through the model's multiplier matrix to estimate how the University's spending affects the output of other industries in the area. Finally, we convert the sales figures to income by means of earnings-to-sales and value added-to-sales ratios, also provided by the IO model.

Here a qualification must be made. It has been argued that multiplier effects, such as those just described, overstate net effects. The reason is that while the economy is stimulated and incomes increase, factors of production receiving these increased incomes abandon lower paying next-best opportunities. At some level, low-level jobs may be left undone and unused capital may go to waste; or jobs may be outsourced and capital will be used overseas or elsewhere. The result is that gross multiplier effects need to be reduced to reflect this opportunity cost of taking a newly created job. Accordingly, the model applies a downward adjustment suggested by the literature and discards all but 33% of the indicated indirect impact.

The direct and indirect effects of NDSU operations are displayed in Table 3.1. The gross total impact amounts to $277.8 million, equal to the direct effect of the University's payroll plus the indirect effect of off-campus spending. These monies make up a part of the NDSU Service Area's overall gross regional product. The lower section of the table shows the adjustment for alternative use of funds, which we discuss more fully in the following section.

Adjusting for alternative uses of funds

NDSU received an estimated 59% of its funding from sources within the NDSU Service Area. This funding may have come from state and local government, from private donors living in the region, from resident students, from local businesses, or from other state and local sources of funding. Devoting local funds to NDSU means that they are not available for other uses, e.g., consumer spending on the part of students or public projects on the part of government. Monies that are injected into the economy on the one hand are thus withdrawn on the other. Because of this, a portion of NDSU's impact on the economy cannot be considered as new monies brought to the region.

To determine the "net" impact of NDSU operations, we take the estimated portion of NDSU funding that originated from local sources and convert it to spending. We then bridge the spending figures to the individual sectors of the IO model, calculate the multiplier effect, and convert the amounts to income. The result, $76.7 million, allows us to see what impacts would have occurred in the NDSU Service Area anyway, even if NDSU did not exist. This value is subtracted from the gross effect of NDSU to arrive at the true or "net" impact of university operations in the 2010–11 reporting year—a total of $201.2 million.

STUDENT SPENDING EFFECT

NDSU drew 5,659 of its students from outside the NDSU

19 We used regional purchase coefficients (RPCs) to estimate the percent of university expenditures that occur locally. RPCs are a measure of the proportion of the total demand for a good or service that is supplied by vendors in the region. An RPC of 0.6, for example, means that 60% of the demand for that commodity is met by local vendors, while the remaining 40% of the demand is met by imports.

Service Area in the 2010–11 reporting year (based on Fall 2011 headcount). Of these students, approximately 87% took up residence in the region while attending and generated expenditures for room and board, personal expenses, and transportation. The average annual living expenses of out-of-region students appear in Table 3.2.

Based on the figures in the table, we estimate that the gross (*i.e.*, unadjusted) off-campus spending generated by out-of-region students was $49.6 million. This appears in the fourth row of Table 3.3. Note that the $49.6 million does not include expenses for books, supplies, and equipment. Many of these monies are paid to the University and are thus already reflected in the operations effect discussed in the previous section. We also exclude the expenses of online students and in-commuters, as these students spend very little in the region compared to students who live in the NDSU Service Area.

The bottom section of Table 3.3 displays the net spending of out-of-region students, a total of $32 million. This figure reflects an adjustment to account for wages paid to out-of-region students who work on campus. This is because student wages and their associated impacts are captured in the operations effect, so we exclude them to avoid double-counting. We further adjust the off-campus spending to account for monies that leak from the region's trade industry sectors (i.e., retail trade and wholesale trade) to cover the cost of manufacturers that are located outside the region.[20]

Estimating the impacts generated by the $32 million in net off-campus student spending follows a procedure similar to that of the operations effect described above. We begin with the direct effect, which we calculate by mapping the $32 million in sales to the industry sectors in the IO model, and then converting them to income through the application of earnings-to-sales and value added-to-sales ratios.

The indirect effect comprises the additional income that is created as the businesses patronized by NDSU students also spend money in the region. We derive this effect by running the net sales figure through the multiplier matrix, and again applying earnings-to-sales and value added-to-

20 In arranging data for inclusion in the impact model, only the trade margin is allocated to the trade sector. Modelers customarily assume a 25% mark-up. Accordingly, an item with a retail selling price of $100 but costing the retailer $80 will enter the economic model as $20 (= $80 x 25%) to the retail trade sector, and $80 to the manufacturer of the item. If the manufacturer is located outside the region, only the $20 trade margin is added. In this case the $80 is spending that is said to "leak" from the regional economy.

Table 3.2: Average annual student cost of attendance, 2010–11

SPENDING ITEM	TOTAL
Room and board	$6,714
Personal expenses	$1,875
Transportation	$1,425
Total expenses per student (actual value)	$10,014

Source: Data supplied by NDSU.

Table 3.3: Off-campus spending of non-local students, FY 2010–11

	TOTAL
Number of out-of-region students	5,659
Number of students who live in region but off-campus	4,950
Average expenses per student	$10,014
Total gross spending	$49,569,300
Less wages paid to out-of-region students	($4,966,600)
Less leakage	($12,595,100)
Total net spending	$32,007,500

Source: Derived from data supplied by NDSU and outputs of the EMSI impact model.

Table 3.4: NDSU student spending effect, 2010–11 ($ thousands)

	LABOR INCOME	NON-LABOR INCOME	TOTAL	% OF TOTAL
Total income in service region	$30,251,367	$16,656,751	$46,908,119	
Direct effect	$7,306	$14,249	$21,554	<0.1%
Indirect effect	$2,237	$1,288	$3,525	<0.1%
Total	$9,543	$15,537	$25,079	<0.1%

Source: EMSI impact model.

sales ratios from the IO model to convert the results to income.

Summing together the direct and indirect effect yields a total of $25.1 million in added income generated in the NDSU Service Area due to the spending of out-of-region students. This result is presented in Table 3.4 on the previous page.

VISITOR SPENDING EFFECT

Each year, NDSU draws thousands of visitors who attend the events and activities hosted by the University. Visitors come to tour the campus, watch games and athletic events, listen to orchestras and concerts, and attend orientation and commencement. Based on information provided by NDSU, approximately 354,400 visitors came to the University in FY 2010–11. While the majority of these visitors were local residents, visitors who traveled from outside the region spent an estimated 37,900 nights at local hotels.

Table 3.5 presents the average daily expenditures of overnight visitors for lodging, eating and drinking, transportation, retail, and other personal expenses. These data are estimates based on information supplied by NDSU. Based on these figures, we estimate that the total sales generated by visitor spending in FY 2010–11 was $5.4 million, net of monies paid to the University for ticket sales, gifts and souvenirs, and food.

Calculating the net increase in regional income as a result of visitor spending requires use of the IO model. As before, we begin by discounting the gross sales figures to account for leakage in the trade sector and bridging the net figures to the sectors of the IO model. We then convert the sales

Table 3.5: Average daily expenditures of overnight visitors, FY 2010–11

SPENDING ITEM	EXPENSES
Lodging	$55
Eating and drinking	$30
Retail	$21
Misc. (parking, gas, entertainment, etc.)	$44
Daily rate	$150

Source: Derived from data supplied by NDSU.

NDSU Athletics

A SOURCE OF PRIDE IN FARGO AND BEYOND

On Saturdays in the fall, North Dakota State football is a big deal in Fargo and throughout the state. NDSU has won nine national championships and is the reigning champion at the NCAA Division I Football Championship Subdivision level.

NDSU's athletic success, however, extends beyond football. The Bison women's basketball program won four consecutive Division II championships in the 1990s, the wrestling program also has four national titles, and the men's basketball program is nationally competitive.

The University's athletic achievements help unite alumni, increase the visibility of the institution, and give a boost to local businesses when visitors come into Fargo for sporting events.

"Athletics has always been important at NDSU," said Don Morton, a former NDSU football coach who now is site leader for Microsoft at its Fargo campus. "Football has always kind of been the king there, though men's basketball [and] women's basketball have had great years there. Football is very important to the community here. And because of athletics, people start out supporting athletics and they get engaged in the University and they start supporting the engineering college and math department [etc.]."

"The face of a university is the football team," said Paul Steffes, a NDSU alumnus and CEO of Steffes Corp. "Being a football powerhouse right now, it certainly helps with that."

Steve Scheel, another prominent alumnus, donated $5 million in 2010 to NDSU to help renovate and expand Bison Sports Arena, which houses the basketball, wrestling, and track teams. The donation was part of a $32 million campaign geared toward athletics.

"We give 10% of our profits back to the local community," said Scheel, who oversees a major sporting goods retailer that goes by his family's last name. "We just really enjoy NDSU. A strong NDSU [makes for] a better community."

Table 3.6: Visitor spending effect, FY 2010–11 ($ thousands)

	LABOR INCOME	NON-LABOR INCOME	TOTAL	% OF TOTAL
Total income in service region	$30,251,367	$16,656,751	$46,908,119	
Direct effect	$1,578	$790	$2,368	<0.1%
Indirect effect	$357	$200	$557	<0.1%
Total	$1,935	$990	$2,925	<0.1%

Source: EMSI impact model.

figures to income to arrive at the direct effect, and run the net sales figures through the multiplier matrix to arrive at the indirect effect. With this methodology, we estimate that the net impact of visitor spending on regional income amounted to $2.9 million in FY 2010–11 (see Table 3.6). The majority of these impacts occur in Fargo, where NDSU is located and where most of NDSU's non-local visitors stay overnight.

PRODUCTIVITY EFFECT

NDSU's impact on the economy is most prevalent in its capacity to provide education, skills training, and career enhancement opportunities to area residents. Since NDSU was established, students have studied at the University and entered the workforce, bringing with them the skills

NDSU College of Engineering & Architecture

GRADUATES IN HIGH DEMAND

Great Plains Software started in the 1980s as a small Fargo-based firm. By 2001, it employed 2,400 people worldwide and was bought by Microsoft for $1.1 billion. Today it's still going strong as one of the region's largest employers.

"NDSU and UND and the schools in the region were a big part of that growth," said Don Morton, the former CEO of Great Plains and now the site leader of Microsoft's Fargo campus.

Fargo serves as a large research and development center for Microsoft, as well as a major technical support center. The site has hundreds of software engineers, code testers, etc.

Morton said NDSU's well-respected College of Engineering and Architecture—where one in five of the University's students are enrolled—is one of Microsoft's go-to sources for talent. In fact, NDSU engineering graduates have been recruited by companies in Fargo and around the Midwest for decades, noted NDSU alumnus and entrepreneur Barry Batcheller.

"The type and caliber of people that tend to go to NDSU are ready to go work and committed to put in the time," said Batcheller, a 1977 graduate in electrical and electronic engineering. "In the mid '70s, North Dakota engineers were highly recruited. People would hire North Dakota engineering graduates because they came to the office ready to go work."

Microsoft typically recruits the top 8-10% of engineering grads in any given year, Morton said. The company targets NDSU graduates every year, but it also looks elsewhere to the University of Nebraska, Iowa State University, and other big institutions given the large number of software engineers it hires.

Morton praised NDSU for having a computer science curriculum that's both rigorous and technical. And he has appreciated the willingness of university administrators to work with Microsoft and other industry leaders.

"We're very proactive on our part; they're proactive on their part," said Morton, who coached the NDSU football team from 1979 to 1984. "President [Dean] Bresciani has been especially helpful since he's come on board; he's really accelerated that. Their new provost [Dr. J. Bruce Rafert] has really accelerated that. But it's very much a partnership."

they acquired while in attendance. Over time, the skills of former NDSU students have accumulated, steadily increasing the training level and experience of the NDSU Service Area workforce.

As the skills embodied by former NDSU students stockpile, a chain reaction occurs in which higher student incomes generate additional rounds of consumer spending, while new skills and training translate to increased business output and higher property income, causing still more consumer purchases and regional multiplier effects. The sum of all these direct and indirect effects comprises the total impact of student productivity on regional income.

Should NDSU cease to exist, former students who remain actively engaged in the workforce would continue to contribute to the economic growth of the region through their added skills. This is what sets the productivity effect apart from the effect of university operations, which would disappear immediately, should NDSU hypothetically need to shut down. Without replenishment, however, the supply of NDSU skills in the workforce would gradually dissipate over time, and the student productivity effects would disappear along with it.

Calculating the direct effect

Assigning a dollar value to the direct effect of student productivity requires an estimation of the number of NDSU skills still active in the workforce, with credit hour equivalents serving as a proxy for skills. To calculate this, we begin with the historical student headcount at the University (both completers and non-completers) over the past 30-year period, from the 1981-82 reporting year to the 2010–11 reporting year.[21]

Of course, not all students remain in the workforce until retirement age, nor do all students enter the workforce immediately upon exiting the University. Other students leave the NDSU Service Area and find employment outside the region. In the model, we adjust for these factors by applying yearly attrition rates derived from the probability that individuals will die, retire, or become unemployed over the course of their working careers. To these we combine migration data supplied by the University and the U.S. Census Bureau to estimate the number of students who leave the NDSU Service Area over time. This allows us to estimate the net number of NDSU completers and non-completers who were still active in the NDSU Service Area workforce in the 2010–11 reporting year.

Table 3.7: Number of NDSU CHEs still active in regional workforce and direct added labor income

	TOTAL
Number of CHEs in workforce, gross	3,697,690
Adjust for alternative education opportunities	26%
Number of CHEs in workforce, net	2,725,755
Average value per CHE (actual value)	$227
Direct labor income	$619,663,099
Adjust for substitution effects	50%
Direct labor income, net	$309,831,549
Direct non-labor income	$175,376,004
Total direct income	$485,207,553

* Numbers may not add due to rounding.
Source: EMSI impact model.

The next step is to multiply the net number of former students who are still working in the NDSU Service Area by the average number of credit hour equivalents (CHEs) achieved per student per year (see Table 1.3). Using this methodology, the estimated number of NDSU CHEs in the regional workforce comes to 3.7 million (see the top row of Table 3.7). These are the CHEs that accumulated in the workforce over the past 30-year period and that were still active in the 2010–11 reporting year.

Recall from Chapter 2 that we reduce the benefits to taxpayers by the estimated amount of benefits that would have occurred anyway even if the publicly funded training providers in the state did not exist. We apply the same adjustment here, reducing the gross number of active CHEs by 26%. This yields a net of 2.7 million CHEs that are currently embodied by former NDSU students in the regional workforce.

The second half of Table 3.7 demonstrates how we arrive at the direct labor income added to the regional economy due to NDSU's historical CHE production. This is a simple calculation that begins by taking the average value per CHE from Table 2.2 ($227) and multiplying it by the 2.7 million CHEs in the workforce. This yields a gross value of $619.7

21 Where historical enrollment data were not available, we projected the numbers backward based on the average annual change in headcount.

Table 3.8: NDSU student productivity effect, 2010–11 ($ thousands)

	LABOR INCOME	NON-LABOR INCOME	TOTAL	% OF TOTAL
Total income in service region	$30,251,367	$16,656,751	$46,908,119	
Direct effect	$309,832	$175,376	$485,208	1.0%
Indirect effect	$111,175	$59,026	$170,202	0.4%
Total	$421,007	$234,402	$655,409	1.4%

Source: EMSI impact model.

million in added labor income. We then adjust this figure downward by 50% to account for substitution effects, i.e., the substitution of out-of-area workers for in-area workers.[22] The reason for this is that if NDSU did not exist and there were fewer skilled workers in the region, businesses could still recruit and hire some of their employees from outside the NDSU Service Area. With the 50% adjustment, the net labor income added to the economy thus comes to $309.8 million, as shown in Table 3.7.

But there is more. Added to the direct effect on labor income is another $175.4 million in non-labor income, representing the higher property values and increased investment income stemming from the direct income of students and enhanced productivity of the businesses that employ them. Non-labor income attributable to past student skills is obtained by disaggregating higher student income to the industrial sectors of the IO model and multiplying it by the associated value added-to-earnings ratios.[23] Summing labor and non-labor income together gives a direct effect of past student productivity equal to approximately $485.2 million in 2010–11.

Calculating the indirect effect

Economic growth stemming from a skilled workforce does not stop with the direct effect. To calculate the indirect effect, the model allocates increases in regional income to specific industrial sectors and augments these to account for both demand-side and supply-side multiplier effects. Demand-side effects refer to the increased demand for consumer goods and services as the higher incomes of skilled workers and their employers are spent in the local economy. For example, the increased output of businesses is associated with an increased demand for inputs, which in turn produces a set of regional economic multiplier effects that are all captured as part of demand-side indirect effects. In the model, these are estimated by converting higher student income into direct increased industry sales, running these through an indirect multiplier matrix, and converting them to regional income by applying earnings-to-sales and value added-to-sales ratios supplied by the regional IO model.

Supply-side effects occur through a process of "cumulative causation," or "agglomeration," whereby growth becomes in some degree self-perpetuating. The presence of one industry, for example, attracts other industries that use the first industry's outputs as inputs, which produces subsequent rounds of industry growth, and so on.[24] To estimate agglomeration effects, the model converts the direct income of past students to industry value added and applies this to a set of supply-driven multipliers provided by the regional IO model. To increase the plausibility of this assumption, the model applies only direct effects associated with industries in the highest stages of development.[25]

The sum of demand-side and supply-side effects con-

22 The 50% adjustment is an assumption—there is no way to determine precisely how many workers could have been recruited from outside the region if NDSU did not exist. For a sensitivity analysis of the substitution variable, please see Chapter 5.

23 There are twenty-one top-level industry sectors in the EMSI IO model. Disaggregating direct student earnings in this fashion avoids aggregation error. See chapter 5 in Ron Miller and Peter Blair, *Input-Output Analysis: Foundations and Extensions* (Englewood Cliffs, NJ: Prentice Hall, 1985).

24 For a more complete discussion of agglomeration and cumulative causation, see Masahisa Fujita, Paul Krugman, and Anthony Venables, *The Spatial Economy: Cities, Regions, and International Trade* (Cambridge: Massachusetts Institute of Technology, 1999).

25 Parr (1999) describes the following four stages of economic development: primary production, process manufacturing, fabricative manufacturing, and producer services and capital export. The model applies "development scores" to Parr's stages, i.e., low scores for lower stage sectors and higher scores for higher development sectors. Only those industries with the highest scores are applied to the supply-driven multipliers of the IO model. For additional detail on the use of this approach for classifying industries by industrial stage, see Rutgers *et al*, 2002.

stitutes the indirect effect of NDSU education, equal to $111.2 million of all labor income and approximately $59 million of all non-labor income (Table 3.8). Adding these to the direct effects of student productivity yields a grand total of $655.4 million in added income attributable to the accumulation of NDSU skills in the regional workforce. This figure appears in the bottom row of Table 3.8.

Note that the $655.4 million omits the effect of educated workers on innovation and technical progress. This effect is generally labeled as "external" because it is uncertain in nature and spills beyond businesses employing skilled workers. For this reason it is excluded from the analysis. To the extent there are such effects, and theory suggests that there are, the overall results can be considered conservative.

CONCLUSION

Table 3.9 displays the grand total of NDSU's impact on the NDSU Service Area in 2010–11, including the university operations effect, the student spending effect, the visitor spending effect, and the student productivity effect.

These results demonstrate several important points. First, NDSU promotes regional economic growth through its own operations spending and through the increase in productivity as former NDSU students remain active in the regional workforce. Second, the student productivity effect is by far the largest and most important impact of NDSU, stemming from higher incomes of students and their employers. And third, regional income in the NDSU Service Area would be substantially lower without the educational activities of NDSU.

Table 3.9: NDSU total effect, 2010–11 ($ thousands)

	TOTAL	% OF TOTAL
Total income in service region	$46,908,119	
University operations effect	$201,176	0.4%
Student spending effect	$25,079	<0.1%
Visitor spending effect	$2,925	<0.1%
Student productivity effect	$655,409	1.4%
Total	$884,590	1.9%

Source: EMSI impact model.

Chapter 4

RESEARCH, TECHNOLOGY, AND BUSINESS INNOVATION

INTRODUCTION

As one of the flagship universities of the North Dakota University System, NDSU's charge is to educate students from within the state and abroad and to strengthen North Dakota's economic and workforce development. Its mission, however, does not end there. Groundbreaking research takes place across many different disciplines at NDSU, from agriculture to the physical sciences. And it thrives in large part because of the University's infrastructure and emphasis on "marrying discovery with development."

NDSU is one of the nation's top 108 public and private universities in the elite category of universities with very high research activity, as recognized by the Carnegie's Commission on Higher Education. It is the first and only North Dakota institution to earn the Carnegie status. In 2009, the National Science Foundation (NSF) ranked NDSU 40th among 572 research universities without a medical school based on research expenditures. According to NSF, NDSU ranks in the top 100 in total research expenditures in agricultural sciences, chemistry, physical sciences, and social sciences.

The full impact of cutting-edge research, however, is not felt unless it is applied in real-world settings and translated to new technology and new economic opportunities. With this in mind, NDSU has a vibrant Research and Technology Park (RTP), which is home to 19 high-growth tech companies and fosters a host of partnerships between NDSU and regional businesses. NDSU's eight research extension centers through the North Dakota Agricultural Experiment Station (NDAES) play a key role in the continuing growth of the Fargo-Moorhead economy's agricultural sector. Further, NDSU's Research Foundation helps commercialize intellec-

NDSU Helps the Agricultural Sector

IN RED RIVER VALLEY AND BEYOND TO BLOSSOM

The Fargo-Moorhead economy has grown in diversity in recent years, but in many ways, the cornerstone of the region remains agriculture. Fargo is located in the fertile Red River Valley, which stretches from the Canadian border to the South Dakota border. The region is a huge producer of sugar beets, potatoes, corn, spring wheat, barley, and many other crops. NDSU, through its research and educational programs as the state's land grant university, has played a key role in the continuing growth of the area's agriculture sector.

"The ag sector has enjoyed a very strong and vibrant growth here over the past 15 years or so," said Barry Batcheller, an NDSU alumnus and entrepreneur. "NDSU has a very good reputation in ag areas."

NDSU's North Dakota Agricultural Experiment Station does basic and applied agriculture-related research with eight Research Extension Centers across the state. It also houses the Northern Crops Institute, a collaborative that supports the promotion and market development of crops grown in North Dakota, Minnesota, and Montana.

Research at NDSU has led to the production of stronger varieties of wheat, corn, and other crops that can withstand droughts and grow in a variety of climates. Record yields have coincided with the oil boom in western North Dakota, helping the state lead the nation in personal income growth in 2011.

Table 4.1: NDSU research awards by source, FY 2006–07 to FY 2010–11 ($ thousands)

FISCAL YEAR	FEDERAL GOV'T	STATE / OTHER GOV'T	FOUNDATION / NON-PROFIT	INDUSTRY / COMMODITY	OTHER	TOTAL
2007	$50,531	$3,595	$735	$4,200	$5	$59,066
2008	$45,419	$4,877	$889	$5,295	$331	$56,811
2009	$49,415	$6,289	$1,377	$4,997	$102	$62,180
2010	$52,964	$4,927	$1,377	$6,664	$102	$66,034
2011	$65,178	$5,732	$3,157	$6,585	$231	$80,883

Source: Data supplied by NDSU.

tual property, and the University's Office of Research, Creative Activities and Technology Transfer (RCATT) provides support for researchers and encourages business development and industry relationships. All of this helps to create and sustain small businesses and is a driving force for business innovation, entrepreneurship, and economic development in North Dakota.

Table 4.2: NDSU research expenditures by function, FY 2010–11 ($ thousands)

EXPENSE ITEM	TOTAL
Payroll	$63,499
Equipment	$5,111
Other	$23,126
Subrecipients	$8,871
Facilities and administration	$33,457
Total	$134,064

Source: Data supplied by NDSU.

IMPACT OF RESEARCH EXPENDITURES

With ongoing emphasis from the administration and new opportunities in various technology and engineering-related avenues, NDSU's total sponsored research awards vaulted from $59.1 million in FY 2006–07 to $80.9 million in 2010–11. The Federal government was the leading source of research funding in FY 2010–11, accounting for over 80% of all research funds awarded. The state of North Dakota was the second-biggest source at 7%, while foundations and other sources comprised the remainder of research funds.

As with the university operations effect discussed in Chapter 3, NDSU's research activities impact the economy by employing people and purchasing equipment and other supplies and services. Table 4.2 shows NDSU's research expenditures in FY 2010–11 by function, a total of $134.1 million. This figure includes payroll, equipment, subrecipients (i.e., outgoing awards to other entities), facilities and administration, and other research and development-related activities. Note that, since NDSU's research expenditures are part of the University's overall budget, the payroll and expenses shown in Table 4.2 are already implicitly included in Table 1.2.

To calculate the effects of research expenditures, we employ the same methodology used to derive the impacts of university operations in Chapter 3. We begin by mapping total research expenditures in FY 2010–11 to the industry sectors of the IO model, removing the spending that occurs outside the region, running the net local spending figures through the multiplier matrix, and then converting the sales figures to income by applying earnings-to-sales and value added-to-sales ratios from the IO model. As with the university operations effect, we also adjust the gross impacts to account for the monies withdrawn from the state and local economy to support NDSU research, whether through state-sponsored research awards or private donations.

Direct and indirect effects of NDSU research appear in Table 4.3, along with the associated adjustment for the alternative use of funds. Total gross impacts (direct plus indirect labor and non-labor income effects) come to $81.4 million, while net impacts come to $74.8 million once we account for the alternative uses of the state and local funds. Note that this $74.8 million in net impacts is a sub-set of the total university operations effect presented in Table 3.1 and should not be added to those effects as a separate measure.

Table 4.3: Effect of NDSU research, 2010–11 ($ thousands)

	LABOR INCOME	NON-LABOR INCOME	TOTAL	% OF TOTAL
Total income in service region	$30,251,367	$16,656,751	$46,908,119	
Direct effect of payroll	$63,499	$0	$63,499	0.1%
Indirect effect	$11,975	$5,970	$17,945	<0.1%
Gross total	$75,474	$5,970	$81,444	0.2%
Adjust for alternative fund uses	-$4,333	-$2,303	-$6,636	<0.1%
Net total	$71,141	$3,667	$74,808	0.2%

Source: EMSI impact model.

IMPACT OF BUSINESS INNOVATION

There is little doubt that research universities can be instrumental to the economic growth of their regions. The key, however, is harnessing new discoveries and new knowledge and bringing them out of the laboratories and into the marketplace. NDSU patents inventions that come from the University's wide-ranging research efforts and licenses them to companies who want to develop the new technology and create a marketable product. This research has produced significant results that have helped NDSU flourish when it comes to university-centered business and technology development.

One measure of innovative capacity and future profitability is the total amount of invention disclosures and license revenue received by the University due to the com-

NDSU Tech Transfer, Start-ups Lead to

JOBS AND INNOVATION

NDSU has fostered an entrepreneurial climate for years, something that manifests itself at the university's Research and Technology Park (RTP) and elsewhere. Founded in 2001, the RTP is home to 19 high-growth tech companies. The first major firm at the Park was Phoenix International Corp., a John Deere company that manufactures integrated electronics for the agricultural and industrial sectors.

"The incubator continues to thrive, and the number of startups is consistent," said Tony Grindberg, Executive Director of the RTP. "It's a sign of being entrepreneurial." Grindberg said the Park plays off the core strengths of NDSU, namely technology- and engineering-related research. The RTP gives companies interested in long-term technology development a place to grow.

Barry Batcheller, a 1977 NDSU graduate in electrical and electronic engineering, launched Phoenix International in 1987. He has since started three other companies, including a fast-growing aerospace company called Appareo Systems, LLC that is also located in the RTP.

For each of his startups, Batcheller focuses on finding the right talent. It helps, he said, to have smart, hard-working NDSU graduates to choose from, including a large supply of engineering graduates. "I really concentrate on people—getting very talented people of good intellect and high passion—and [I] try to concentrate on core competencies that are relevant in a number of different areas."

Batcheller currently sits on the RTP Board and received a NDSU Alumni Achievement Award in 2012. His latest project, related to developing a receiver for unmanned aircraft systems, has brought together electronics researchers, students, and faculty at NDSU and aerospace experts at the University of North Dakota.

Table 4.4: NDSU invention disclosures, patent applications, licenses, and license income, FY 2006–07 to FY 2010–11 ($ thousands)

FISCAL YEAR	INVENTION DISCLOSURES RECEIVED	NEW U.S. PATENT APPLICATIONS FILED	LICENSES & OPTIONS EXECUTED	ADJUSTED GROSS LICENSE INCOME RECEIVED
2007	50	21	83	$1,324
2008	46	29	122	$1,488
2009	41	22	96	$1,540
2010	49	29	94	$1,884
2011	70	41	91	$1,930
Total	256	142	486	$8,166

Source: Data supplied by NDSU.

Table 4.5: NDSU start-up companies, FY 2001–02 to FY 2010–11

COMPANY	LOCALE	NAICS CODE	PRODUCT
Treeminer, Inc.	Boyds, MD	541511	Data Mining Software
Elinor Specialty Coatings, LLC	Fargo, ND	332812	Bronze Coating
Packet Digital	Fargo, ND	335314	Advanced Power Management for Portable Electronic Devices and Embedded Systems
Myriad Devices	Fargo, ND	541511	Custom Application Development in the Mobile Realm
WoWiWe Instruction Co. LLC	Fargo, ND	541511	Educational Media
Krisara Engineering LLC	Fargo, ND	541712	Technology for Delivery of Electronic Stimuli (Bio-Med)

Source: Data on company name, locale, and product supplied by NDSU. NAICS codes provided by EMSI.

mercialization of its technology. From FY 2006–07 to FY 2010–11, NDSU received 256 invention disclosures, filed 142 new U.S. patent applications, and produced 486 licenses (see Table 4.4). Total license income over the same five-year time period grew from $1.3 million in FY 2006–07 to $1.9 million in FY 2010–11, a nearly 46% increase.

The capitalized value of the $1.9 million stream of license revenue in FY 2010–11 works out to approximately $64.3 million. This is calculated following standard practice by dividing the income stream by the going rate of interest, in this case assumed to be 3%. Accordingly, $1.9 million divided by 3% yields a capitalized value of $64.3 million.

Since FY 2001-02, NDSU research has led to six start-up companies in industries such as advanced manufacturing and computer systems design. A list of these companies appears in Table 4.5, along with the corresponding locations, primary product, and six-digit NAICS code[26] of each business. Note that, due to privacy reasons, job numbers for the individual companies are not shown.

The overall job and earnings impacts of the start-up companies listed in Table 4.5 include the direct jobs reported by the individual businesses, plus added jobs and earnings felt elsewhere in the region as a result of multiplier effects. Table 4.6 presents data on the number of "direct" jobs collected from the companies themselves, a total of 46 jobs. Next, the table shows the number of jobs that are created "indirectly" by the companies, equal to 28 jobs. This figure comes from the IO model and represents the jobs generated through business inputs and the consumer spending of the start-up companies' employees. Altogether, the grand total job creation is 74 jobs, equal to the direct plus indirect jobs created by the companies. The overall jobs multiplier (i.e., total effect divided by the direct effect) is 1.63.

Also shown in Table 4.6 are the corresponding earnings effects of the start-up companies. Direct earnings amount to $2 million, which consists of the estimated total salaries

26 North American Industry Classification System (NAICS).

paid by the companies to their employees. This information was not available from NDSU, so it is calculated based on average earnings by six-digit industry in the region. Indirect earnings amount to $1 million and comprise the salaries paid by businesses in economically-linked industries that provide goods and services as inputs to the start-up companies. These latter businesses are linked to the start-up companies by virtue of the multiplier effects. In all, the earnings effect of the NDSU start-up companies (i.e., direct plus indirect) comes to $3 million, with an earnings multiplier of 1.51.

Table 4.6: Jobs and earnings impacts of NDSU start-up companies ($ thousands)

	JOBS	EARNINGS
Direct effect	46	$1,988
Indirect effect	28	$1,009
Total effect (direct + indirect)	74	$2,997
Multiplier (total / direct)	1.63	1.51

Source: EMSI impact model.

CONCLUSION

The overall picture indicated by EMSI's assessment of NDSU's research activities is one of strong economic performance, job and income creation, and substantial contributions to business growth and development. Further increases in NDSU's research activities will contribute not only to the growth of the Fargo economy, but elsewhere in the surrounding area through regional economic multiplier effects.

Chapter 5

SENSITIVITY ANALYSIS

INTRODUCTION

THIS study concludes with a sensitivity analysis of some key variables on both the student and taxpayer investment sides. The purpose of the sensitivity analysis is to set the approach apart from "advocacy" education impact analyses that promote education. These studies often use assumptions that do not stand up to rigorous peer scrutiny and generate results that overstate benefits. The approach here is to account for relevant variables in calculating benefits and costs as reflected in the conservatively estimated base case assumptions laid out in Chapters 2 and 3.

The sensitivity tests include the following: a) the impacts associated with changes in the student employment variables for the investment analysis, b) the sensitivity of results associated with the alternative education variable, and c) the sensitivity of results associated with the substitution variable.

STUDENT EMPLOYMENT VARIABLES

Student employment variables are difficult to estimate either because many students do not report their employment status or because universities generally do not collect this kind of information. Employment variables include the following: 1) the percentage of students employed, and 2) of those employed, what percentage they earn relative to earnings they would have received if they were not attending NDSU. Both employment variables relate to earnings forgone by students, i.e., the opportunity cost of time; and they affect the investment analysis results (net present value, rate of return, benefit/cost ratio, and payback period).

Percent of students employed

Students incur substantial expense by attending NDSU because of the time they spend not gainfully employed. Some of that cost is recaptured if students remain partially (or fully) employed while attending. It is estimated that 71% of students who reported their employment status are employed, based on data provided by NDSU. This variable is tested in the sensitivity analysis by changing it first to 100% and then to 0%.

Percent of earnings relative to full earnings

The second opportunity cost variable is more difficult to estimate. For NDSU, it is estimated that students working while attending classes earn only 53%, on average, of the earnings they would have statistically received if not attending NDSU. This suggests that many students hold part-time jobs that accommodate their NDSU attendance, though it is at an additional cost in terms of receiving a wage that is less than what they might otherwise make. The model captures these differences and counts them as part of the opportunity cost of time. As above, this variable is tested in the sensitivity analysis by changing the assumption to 100% and then to 0%.

Results

The changed assumptions generate results summarized in Table 5.1, with "A" defined as the percent of students employed and "B" defined as the percent that students earn relative to their full earning potential. Base case results appear in the shaded row—here the assumptions remain unchanged, with A equal to 71% and B equal to 53%. Sensitivity analysis results are shown in non-shaded rows. Scenario 1 increases A to 100% while holding B constant, Scenario 2 increases B to 100% while holding A constant, Scenario 3 increases both A and B to 100%, and Scenario 4 decreases both A and B to 0%.

Scenario 1: Increasing the percent of students employed (A) from 71% to 100%, the rate of return, benefit/cost ratio, and payback period results improve to 15.1%, 5.7, and 10.2 years, respectively, relative to base case results. Improved results are attributable to a lower opportunity cost of time—all students are employed in this case.

Scenario 2: Increasing earnings relative to statistical averages (B) from 53% to 100%, the rate of return, benefit/cost ratio, and payback period results improve to 17.4%, 7.4, and 9.1 years, respectively, relative to base case results—a strong improvement, again attributable to a lower opportunity cost of time.

Scenario 3: Increasing both assumptions A and B to 100% simultaneously, the rate of return, benefit/cost ratio, and payback period results improve yet further to 20.9%, 10.2, and 7.8 years, respectively, relative to base case results. This scenario assumes that all students are fully employed and earning full salaries (equal to statistical averages) while attending classes.

Scenario 4: Finally, decreasing both A and B to 0% reduces the rate of return, benefit/cost ratio, and payback period results to 12.9%, 4.4, and 11.6 years, respectively, relative to base case results. These results are reflective of an increased opportunity cost—none of the students are employed in this case.[27]

It is strongly emphasized in this section that base case results are very attractive in that results are all above their threshold levels, and payback periods are short. As is clearly demonstrated here, results of the first three alternative scenarios appear much more attractive, although they overstate benefits. Results presented in Chapter 2 are realistic, indicating that investments in NDSU generate excellent returns, well above the long-term average percent rates of return in stock and bond markets.

27 Note that reducing the percent of students employed to 0% automatically negates the percent they earn relative to full earning potential, since none of the students receive any earnings in this case.

ALTERNATIVE EDUCATION VARIABLE

The alternative education variable (26%) is characterized as a "negative benefit" used to account for students who can obtain a similar education elsewhere absent the publicly funded training providers in the state. Given the difficulty in accurately specifying the alternative education variable, the obvious question is the following: how great a role does it play in the magnitude of the results?

Variations in the alternative education assumption are calculated around base case results listed in the middle column of Table 5.2 on the following page. Next, the model brackets the base case assumption on either side with a plus or minus 17%, 33%, and 50% variation in assumptions. Analyses are then redone introducing one change at a time, holding all other variables constant. For example, an increase of 17% in the alternative education assumption (from 26% to 31%) reduces the taxpayer perspective rate of return from 3.1% to 2.8%. Likewise, a decrease of 17% (from 26% to 22%) in the assumption increases the rate of return from 3.1% to 3.4%.

Based on this sensitivity analysis, the conclusion can be drawn that NDSU investment analysis results from the taxpayer perspective are not very sensitive to relatively large variations in the alternative education variable. As indicated,

Table 5.1: Sensitivity analysis of NDSU student perspective

VARIABLES	RATE OF RETURN	BENEFIT/COST	PAYBACK
Base case: A = 71%, B = 53%	14.4%	5.2	10.6
Scenario 1: A = 100%, B = 53%	15.1%	5.7	10.2
Scenario 2: A = 71%, B = 100%	17.4%	7.4	9.1
Scenario 3: A = 100%, B = 100%	20.9%	10.2	7.8
Scenario 4: A = 0%, B = 0%	12.9%	4.4	11.6

Note: A = percent of students employed; B = percent earned relative to statistical averages

Table 5.2: Sensitivity analysis of alternative education variable, taxpayer perspective ($ millions)

	-50%	-33%	-17%	BASE CASE	17%	33%	50%
Alternative education variable	13%	18%	22%	26%	31%	35%	39%
Net present value	$26.9	$19.1	$11.4	$3.7	-$4.1	-$11.8	-$19.5
Rate of return	4.0%	3.7%	3.4%	3.1%	2.8%	2.5%	2.2%
Benefit/cost ratio	1.2	1.2	1.1	1.0	1.0	0.9	0.8
Payback period (years)	23.2	23.9	24.6	25.5	26.4	27.4	28.6

Table 5.3: Sensitivity analysis of substitution variable on student productivity ($ millions)

	-50%	-33%	-17%	BASE CASE	17%	33%	50%
Substitution variable	25%	33%	42%	50%	58%	67%	75%
Student productivity effect	$182.3	$243.1	$303.8	$364.6	$425.4	$486.1	$546.9
Total effect	$408.8	$469.5	$530.3	$591.1	$651.8	$712.6	$773.4
Percent of regional income	0.8%	1.0%	1.1%	1.2%	1.3%	1.4%	1.6%

results dip below their threshold levels (net present value greater than 0, benefit/cost ratio greater than 1, and rate of return greater than the discount rate of 3%), but only by a narrow margin (relative to the base case scenario). The conclusion is that although the assumption is difficult to specify, its impact on overall investment analysis results for the taxpayer perspective is not very sensitive.

SUBSTITUTION VARIABLE

The substitution variable only affects the student productivity calculation in Table 3.8. In the model we assume a substitution variable of 50%, which means that we claim only 50% of the direct labor income generated by increased worker productivity. The other 50% we assume would have occurred even if NDSU did not exist. This is because, if there were no NDSU students to hire, some businesses could have recruited similarly qualified individuals from outside the region.

Table 5.3 presents the results of the sensitivity analysis for the substitution variable. As above, the assumption increases and decreases relative to the base case of 50% by the increments indicated in the table. Impacts on the results are more pronounced. Student productivity effects attributable to NDSU, for example, range from a high of $546.9 million at 50% to a low of $182.3 million at a -50% variation from the base case assumption for this variable. This means that if the substitution variable were to decrease, the number of benefits that we claim also decreases; hence, the income attributable to NDSU decreases accordingly.

It is important to note that, even under the most conservative assumptions, the total effect of NDSU—including the effects of university operations, student spending, visitor spending, and student productivity—still remains a sizeable factor in the NDSU Service Area economy. The university operations effect, the student spending effect, and the visitor spending effect are kept constant for this sensitivity analysis, so the variations in the total effect are caused solely by the changes to student productivity in the second row. The last row of the table shows the percent of total regional income that is attributable to NDSU and its students.

CONCLUSION

The results of this study demonstrate that NDSU is a sound investment from multiple perspectives. The University enriches the lives of students and increases their lifetime incomes. It benefits taxpayers by generating increased tax revenues from an enlarged economy and reducing the demand for taxpayer-supported social services. Finally, it contributes to the vitality of both the local and state economies.

Appendix 1

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Appendix 2

GLOSSARY OF TERMS

Alternative education A "with" and "without" measure of the percent of students who would still be able to avail themselves of education absent the publicly funded educational institutions in the state. An estimate of 10%, for example, means that 10% of students do not depend directly on the existence of the University in order to obtain their education.

Alternative use of funds A measure of how monies that are currently used to fund the University might have been used if the University did not exist.

Asset value Capitalized value of a stream of future returns. Asset value measures what someone would have to pay today for an instrument that provides the same stream of future revenues.

Attrition rate Rate at which students leave the local region due to out-migration, retirement, or death.

Benefit/cost ratio Present value of benefits divided by present value of costs. If the benefit/cost ratio is greater than 1, then benefits exceed costs, and the investment is feasible.

Credit hour equivalent Credit hour equivalent, or CHE, is defined as 15 contact hours of education if on a semester system, and 10 contact hours if on a quarter system. In general, it requires 450 contact hours to complete one full time equivalent, or FTE.

Demand Relationship between the market price of education and the volume of education demanded (expressed in terms of enrollment). The law of the downward-sloping demand curve is related to the fact that enrollment increases only if the price (student tuition and fees) is lowered, or conversely, enrollment decreases if price increases.

Direct effect Jobs and income directly generated by the University and its students.

Discounting Expressing future revenues and costs in present value terms.

Economics Study of the allocation of scarce resources among alternative and competing ends. Economics is not normative (what ought to be done), but positive (describes what is, or how people are likely to behave in response to economic changes).

Elasticity of demand Degree of responsiveness of the quantity of education demanded (enrollment) to changes in market prices (student tuition and fees). If a decrease in fees increases total revenues, demand is elastic. If it decreases total revenues, demand is inelastic. If total revenues remain the same, elasticity of demand is unitary.

Externalities Impacts (positive and negative) for which there is no compensation. Positive externalities of education include improved social behaviors such as lower crime, reduced unemployment, and improved health. Educational institutions do not receive compensation for these benefits, but benefits still occur because education is statistically proven to lead to improved social behaviors.

Gross Regional Product Measure of the final value of all goods and services produced. Alternatively, GRP equals the combined incomes of all factors of production, i.e., labor, land and capital. These include wages, salaries, proprietors' incomes, profits, rents, and other.

Indirect effect Jobs and income that result from the direct spending of the University and its students.

Input-output analysis Relationship between a given set of demands for final goods and services, and the implied amounts of manufactured inputs, raw materials, and labor that this requires. In an educational setting, when universities pay wages and salaries and spend money for supplies in the local region, they also generate earnings in all sectors of the economy, thereby increasing the demand for goods and services and jobs. Moreover, as students enter or rejoin the workforce with higher skills, they earn higher salaries and wages. In turn, this generates more consumption and spending in other sectors of the economy.

Internal rate of return Rate of interest which, when used to discount cash flows associated with investing in education, reduces its net present value to zero (i.e., where the present value of revenues accruing from the investment are just equal to the present value of costs incurred). This, in effect, is the breakeven rate of return on investment since it shows the highest rate of interest at which the investment makes neither a profit nor a loss.

Labor income Income which is received as a result of labor, i.e., wages.

Multiplier The number of times a dollar cycles through the economy, generating additional income and jobs, before leaving the economy. Therefore, a multiplier of 1.7 estimates that a dollar will generate an additional $0.70 in the economy before leaving.

Net cash flow Benefits minus costs, i.e., the sum of revenues accruing from an investment minus costs incurred.

Net present value Net cash flow discounted to the present. All future cash flows are collapsed into one number, which, if positive, indicates feasibility. The result is expressed as a monetary measure.

Non-labor income Income which is received from investments (such as rent, interest, and dividends) and transfer payments (payments from governments to individuals).

Opportunity cost Benefits forgone from alternative B once a decision is made to allocate resources to alternative A. Or, if an individual chooses not to attend the University, he or she forgoes higher future earnings associated with education. The benefit of education, therefore, is the "price tag" of choosing not to attend the University.

Payback period Length of time required to recover an investment—the shorter the period, the more attractive the investment. The formula for computing payback period is:

Payback period = cost of investment/net return per period

Appendix 3

EMSI INPUT-OUTPUT MODEL

INTRODUCTION AND DATA SOURCES

EMSI's input-output model represents the economic relationships among a region's industries, with particular reference to how much each industry purchases from each other industry. Using a complex, automated process, we can create regionalized models for geographic areas comprised by counties or ZIP codes in the United States.

Our primary data sources are the following:

- The Industry Economic Accounts from the Bureau of Economic Analysis (BEA); specifically the "make" and "use" tables from the annual and benchmark input-output accounts.
- Regional and national jobs-by-industry totals, and national sales-to-jobs ratios (from EMSI's industry mployment and earnings data process).
- Proprietor earnings from State and Local Personal Income Reports (BEA).

CREATION OF THE NATIONAL Z MATRIX

The BEA "make" and "use" tables (MUTs) show which industries make or use which commodity types. These two tables are combined to replace the industry-commodity-industry relationships with simple industry-industry relationships in dollar terms. This is called the national "Z" matrix, which shows the total amount ($) each industry purchases from others. Industry purchases run down the columns, while industry sales run across the rows.

Table 1: Sample "Z" matrix ($ millions)

	INDUSTRY 1	INDUSTRY 2	. . .	INDUSTRY N
Industry 1	3.3	1,532.5	. . .	232.1
Industry 2	9.2	23.0	. . .	1,982.7
. . .	. . .	. . .	. . .	. . .
Industry N	819.3	2,395.6	. . .	0

The value 1,532.5 in Table 1 means that Industry 2 purchases $1,532,500,000 worth of commodities and/or services from Industry 1. The whole table is basically an economic double-entry accounting system, configured so that all money inflows have corresponding outflows elsewhere.

In addition to regular industries (such as "oil and gas extraction," "machinery manufacturing," "food and beverage stores," "hospitals," and so on), there are three additional rows representing labor earnings, profits, and business taxes, which together represent industry "value added" and account for the fact that industries do not spend all of their income on inputs from other industries. There are also three rows and columns representing federal, state, and local government (we later separate federal government into civilian and military sectors).

We create two separate Z matrices since there are two sets of MUTs—annual and benchmark. The benchmark data are produced every five years with a five-year lag and specify up to 500 industry sectors; annual data have a one-year lag but specify only 80 industrial sectors.

The basic equation is as follows:

$$Z = V\hat{O}^{-1}U$$

where V is the industry "make" table, $\hat{O}^{-1}$ is a vector of total gross commodity output, and U is the industry "use" table.

In reality, this equation is more complex because we also need to “domesticate” the Z matrix by removing all imports. This is needed because we are creating a “closed” type of national model.

In addition, there are a number of modifications that need to be made to the BEA data before the calculations can begin. These are almost all related to the conversion of certain data in BEA categories to new categories that are more compatible with other data sets we use in the process, and describing them in detail is beyond the scope of this appendix.

DISAGGREGATION OF THE NATIONAL Z MATRIX

The previous step resulted in two national Z matrices—one based on the benchmark BEA data (five years old, approximately 500 industries) and the other based on the annual BEA data (one year old, but only about 80 industries). These initial national Z matrices are then combined and disaggregated to 1,125 industry sectors. Combining them allows us to capitalize on both the recency of the annual data and the detail of the benchmark data. The disaggregation is performed for each initial Z matrix using probability matrices that allow us to estimate industry transactions for the more detailed sectors based on the known transactions of their parent sectors. The probability matrix is created from detailed EMSI industry earnings data, which are available for all 1,125 sectors and are created using a separate process.

CREATION OF THE NATIONAL A MATRIX

The national disaggregated Z matrix is then “normalized” to show purchases as percentages of each industry’s output

Table 2: Sample “A” matrix

	INDUSTRY 1	INDUSTRY 2	. . .	INDUSTRY 1125
Industry 1	.001	.112	. . .	.035
Industry 2	.097	0	. . .	.065
. . .	. . .	. . .	. . .	. . .
Industry 1125	.002	.076	. . .	0

rather than total dollar amounts. This is called the national “A” matrix.

Each cell value represents the percentage of a column industry’s output that goes toward purchasing inputs from each row industry. Thus, the cell containing .112 in Table 2 means that Industry 2 spends 11.2% of its total output to obtain inputs from Industry 1.

At this point, our additional rows representing earnings, profits, and business taxes are removed. However, we will use them in a different form later.

REGIONALIZATION OF THE A MATRIX

To create a regional input-output model, we regionalize the national A matrix using that region’s industry mix. The major step in the process is the calculation of per-industry out-of-region exports. This is performed using a combination of the following standard techniques that are present in the academic literature:

- Stevens regional purchase coefficients (RPCs)
- Simple location quotient of value added sales
- Supply/demand pools derived from the national A matrix
-

We try to maximize exports in order to account as fully as possible for “cross-hauling,” which is the simultaneous export and import of the same good or service to/from a region, since it is quite common in most industries.

Another major part of the process is the regionalization of consumption, investment, and local government “row industries” (rows referring to the rows of the A matrix). These represent the percentage of each industry’s sales that end up going toward consumption, capital purchases, and taxes to local government, respectively. They are created from the “value added” rows that we removed earlier. Consumption is calculated using each industry’s earnings and profits, as well as a constant called “the average propensity to consume,” which describes the approximate percentage of earnings and profits that are spent on consumption. Investment and local government rows are calculated by distributing the known total investment and endogenous local government for the entire region to individual industries proportionally to their value added.

The A-matrix regionalization process is automated for any given region for which industry data are available. Although partially derived from national figures, the regional A matrix offers a best possible estimate of regional values without resorting to costly and time-consuming survey techniques, which in most cases are completely infeasible.

CREATING MULTIPLIERS AND USING THE A MATRIX

Finally, we convert the regional “A” matrix to a “B” matrix using the standard Leontief inverse $B = (I-A)^{-1}$. The “B” matrix consists of inter-industry sales multipliers, which can be converted to jobs or earnings multipliers using per-industry jobs-to-sales or earnings-to-sales ratios.

The resulting tables and vectors from this process are then used in the actual end-user software to calculate regional requirements, calculate the regional economic base, estimate sales multipliers, and run impact scenarios.

Appendix 4

SHUTDOWN POINT

INTRODUCTION

The investment analysis weighs benefits of enrollment (measured in terms of credit hour equivalents, or CHEs) against the support provided by state government. This adjustment factor is used to establish a direct link between the costs of supporting the University and the benefits it generates in return. If benefits accrued without taxpayer support, then it would not be a true investment.[28]

The overall approach includes a sub-model that simulates the effect on student enrollment should the University lose its state funding and have to raise student tuition and fees in order to stay open. If the University can still operate without state support, then any benefits it generates at that level are discounted from total benefit estimates. If the simulation indicates that the University cannot stay open, however, then benefits are directly linked to costs, and no discounting applies. This appendix documents the procedure for making these adjustments.

Figure 1

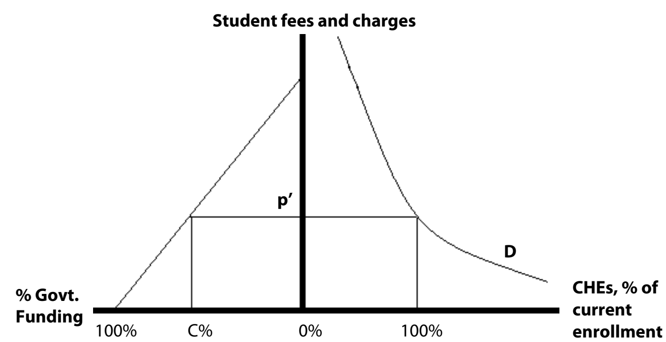
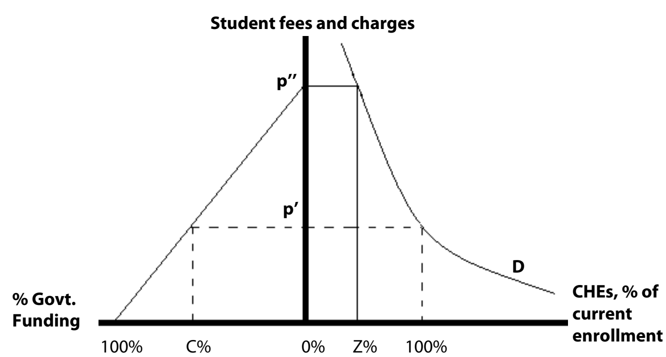


Figure 2



STATE GOVERNMENT SUPPORT VERSUS STUDENT DEMAND

Figure 1 presents a simple model of student demand and state government support. The right side of the graph is a standard demand curve (D) showing student enrollment as a function of student tuition and fees. Enrollment is measured in terms of total CHEs generated and expressed as a percentage of current CHE production. Current student tuition and fees are represented by p', and state government support covers C% of all costs. At this point in the analysis, it is assumed that the University has only two sources of revenues: (1) student tuition and fees, and; (2) state government support.

Figure 2 shows another important reference point in the

28 Of course, as a public training provider, NDSU would not be permitted to continue without public funding, so the situation in which it would lose all state support is entirely hypothetical. The purpose of the adjustment factor is to examine NDSU in standard investment analysis terms by netting out any benefits it may be able to generate that are not directly linked to the costs of supporting it.

model—where state government support is 0%, student tuition and fees are increased to p”, and enrollment is Z% (less than 100%). The reduction in enrollment reflects price elasticity in the students’ education vs. no-education decision. Neglecting for the moment those issues concerning the University’s minimum operating scale (considered below in the section called “Shutdown Point”), the implication for the investment analysis is that benefits of state government support must be adjusted to net out benefits associated with a level of enrollment at Z% (i.e., the University can provide these benefits absent state government support).

FROM ENROLLMENT TO BENEFITS

This appendix focuses mainly on the size of enrollment (i.e., CHE production) and its relationship to student versus state government funding. However, to clarify the argument it is useful to briefly consider the role of enrollment in the larger benefit/cost model.

Let B equal the benefits attributable to state government support. The analysis derives all benefits as a function of student enrollment (i.e., CHE production). For consistency with the graphical exposition elsewhere in this appendix, B is expressed as a function of the percent of current enrollment (i.e., percent of current CHE production). Accordingly, the equation

1) B = B (100%)

reflects the total benefits generated by enrollments at their current levels.

Consider benefits now with reference to Figure 2. The point at which state government support is zero nonetheless provides for Z% (less than 100%) of the current enrollment, and benefits are symbolically indicated by the following equation:

2) B = B (Z%)

Inasmuch as the benefits in (2) occur with or without state government support, the benefits appropriately attributed to state government support are given by the following equation:

3) B = B (100%) – B (Z%)

SHUTDOWN POINT

University operations cease when fixed costs can no longer be covered. The shutdown point is introduced graphically in Figure 3 as S%. The location of point S% indicates that the University can operate at an even lower enrollment level than Z% (the point of zero state funding). At point S%, state government support is still zero, and student tuition and fees have been raised to p”’. With student tuition and fees still higher than p”’, the University would not be able to attract enough students to keep the doors open, and it would shut down. In Figure 3, point S% illustrates the shutdown point but otherwise plays no role in the estimation of taxpayer benefits. These remain as shown in equation (3).

Figure 4 illustrates yet another scenario. Here the shutdown point occurs at an enrollment level greater than Z% (the level of zero state government support), meaning some minimum level of state government support is needed for the University to operate at all. This minimum portion of overall funding is indicated by S’% on the left side of the chart, and as before, the shutdown point is indicated by

Figure 3

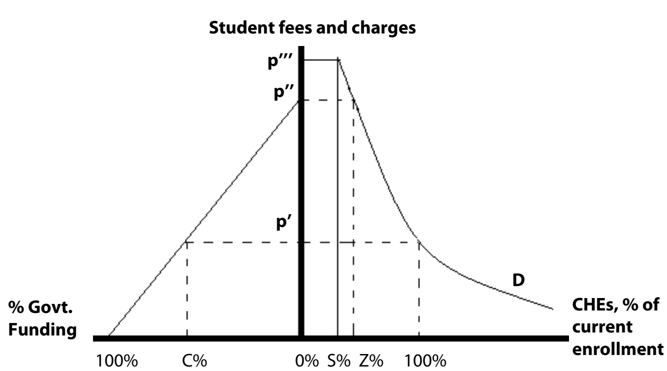
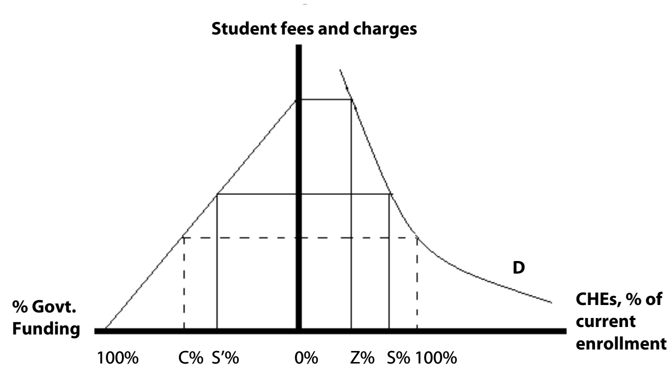


Figure 4



S% on the right side of chart. In this case, state government support is appropriately credited with all the benefits generated by enrollment, or B = B (100%).

ADJUSTING FOR ALTERNATIVE EDUCATION OPPORTUNITIES

Because some students may be able to avail themselves of an education even without the publicly funded training providers in the state, the benefits associated with these students must be deducted from the overall benefit estimates. The adjustment for alternative education is easily incorporated into the simple graphic model. For simplicity, let A% equal the percent of students with alternative education opportunities, and let N% equal the percent of students without an alternative. Note that N% + A% = 100%.

Figure 5 presents the case where the University could operate absent state government support (i.e., Z% occurs at an enrollment level greater than the shutdown level S%). In this case, the benefits generated by enrollments absent state government support must be subtracted from total benefits. This case is parallel to that indicated in equation (3), and the net benefits attributable to state government support are given by the following equation:

4) B = B (N% × 100%) – B (N% × Z%)

Finally, Figure 6 presents the case where the University cannot remain open absent some minimum S'% level of state government support. In this case, taxpayers are credited with all benefits generated by current enrollment, less only the percent of students with alternative education opportunities. These benefits are represented symbolically as B (N% × 100%).

Figure 5

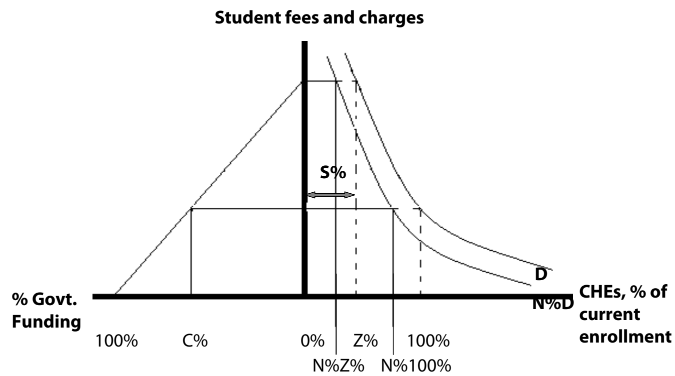
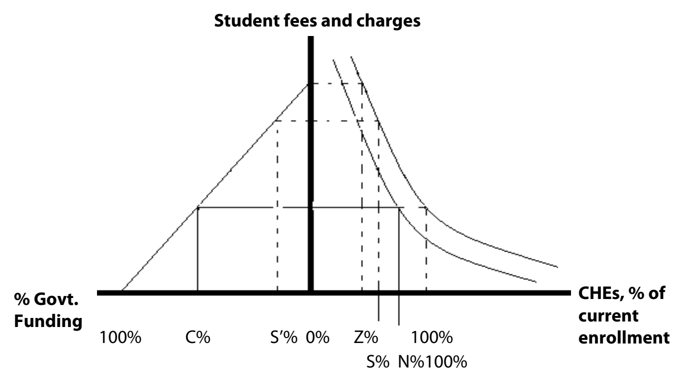


Figure 6



Appendix 5

SOCIAL EXTERNALITIES

INTRODUCTION

Education has a predictable and positive effect on a diverse array of social benefits. These, when quantified in dollar terms, represent significant avoided social costs that directly benefit the public as whole, including taxpayers. In this appendix we discuss the following three main benefit categories: 1) improved health, 2) reductions in crime, and 3) reductions in unemployment and welfare.

It is important to note that the data and estimates presented here should not be viewed as exact, but rather as indicative of the positive impacts of education on an individual's quality of life. The process of quantifying these impacts requires a number of assumptions to be made, creating a level of uncertainty that should be borne in mind when reviewing the results.

HEALTH

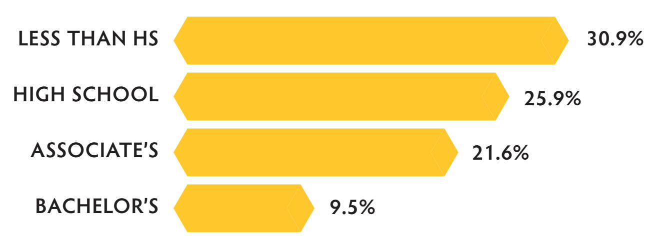
Statistics clearly show the correlation between increases in education and improved health. The manifestations of this are found in two health-related variables, smoking and alcohol. There are probably several other health-related areas that link to educational attainment, but these are omitted from the analysis until we can invoke adequate (and mutually exclusive) databases and are able to fully develop the functional relationships.

Smoking

Despite declines over the last several decades in the percentage of the U.S. population who smoke, a sizeable percentage of the U.S. population still use tobacco. The negative health effects of smoking are well documented in the literature, which identifies smoking as one of the most serious health issues in the United States.

Figure 1 reports the prevalence of cigarette smoking among adults aged 25 years and over, based on data provided by the National Health Interview Survey. As indicated, the percent of persons who smoke cigarettes begins to decline beyond the level of high school education.

Figure 1: Prevalence of smoking by education level



The CDC reports the percent of adults who are current smokers by state.[29] We use this information to create an index value by which we adjust the national prevalence data on smoking to each state. For example, 18.1% of North Dakota's adults were smokers in 2008, relative to 18.3% for the nation. We thus apply a scalar of .99 to the national probabilities of smoking in order to adjust them to the state of North Dakota.

Alcohol

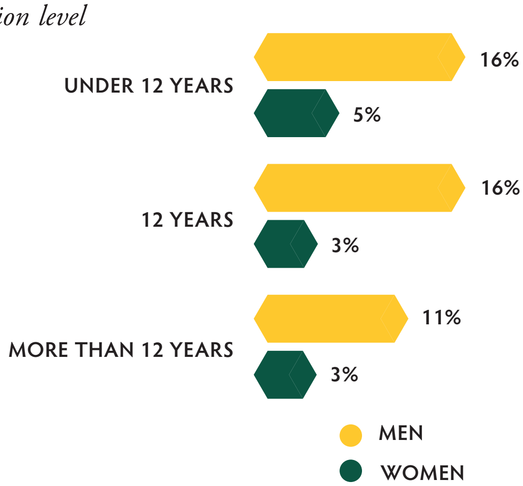
Alcoholism is difficult to measure and define. There are

29 Center for Disease Control and Prevention (CDC), Prevalence and Trends Data, Tobacco Use—2008, Adults who are current smokers (accessed June 2009).

many patterns of drinking, ranging from abstinence to heavy drinking. Alcohol abuse is riddled with social costs, including health care expenditures for treatment, prevention and support; workplace losses due to reduced worker productivity and premature mortality; and other costs related to vehicle crashes, fire destruction, and social welfare administration.

Figure 2 presents the percent of the adult population that are heavy drinkers, by gender and education level.[30] These statistics give an indication of the correlation between education and the reduced probability of alcohol abuse. As indicated, heavy drinking among males falls from a 16% prevalence rate among individuals with fewer than 12 years of education, to an 11% prevalence rate among individuals with more than 12 years of education. The probability of being a heavy drinker also falls on a sliding scale for women, from 5% to 3%. Note that women are less likely to be heavy drinkers than men.

Figure 2: Prevalence of heavy drinking by gender and education level



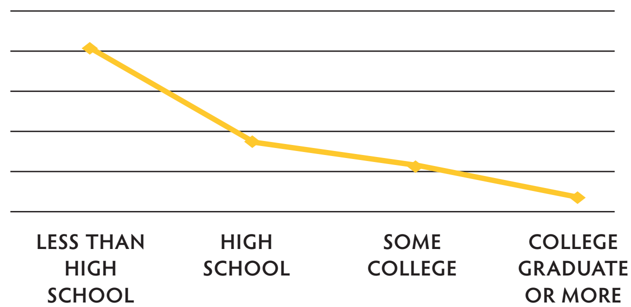
CRIME

As people achieve higher education levels, they are statistically less likely to commit crimes. The analysis identifies the following three types of crime-related expenses: 1) incarceration, including prosecution, imprisonment, and reform, 2) victim costs, and 3) productivity lost as a result of time spent in jail or prison rather than working.

Figure 3 displays the probability that an individual will be incarcerated by education level. Data are derived from the breakdown of the inmate population by education level in state, federal, and local prisons (as provided by the Bureau of Justice Statistics), divided by the total population. As indicated, incarceration drops on a sliding scale as education levels rise.

30 Data are supplied by the National Institute of Alcohol Abuse and Alcoholism.

Figure 3: Incarceration rates by education level



Victim costs comprise material, medical, physical, and emotional losses suffered by crime victims. Some of these costs are hidden, while others are available in various databases. Estimates of victim costs vary widely, attributable to differences in how the costs are measured. The lower end of the scale includes only tangible out-of-pocket costs, while the higher end includes intangible costs such as future loss of productivity resulting from traumas, crimes not handled or prosecuted through the judicial system, and money spent on personal security that would otherwise have been spent on other, more productive endeavors.[31]

Yet another measurable benefit is the added economic productivity of people who are now gainfully employed, all else being equal, and not incarcerated. The measurable productivity benefit here is simply the number of additional people employed multiplied by the average income in their corresponding education levels.

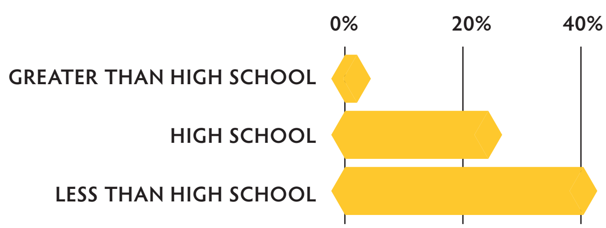
31 The model makes use of tangible, lower end costs that can be directly measured without controversy. Thus, 2.0 million inmates (in 1999) divided into $105 billion costs an average of roughly $52,000 per inmate. From this we derive an estimate of $85,000, assuming that the 1999 study was based on at least two- to three-year-old data.

WELFARE AND UNEMPLOYMENT

Statistics show that as education levels increase, the number of welfare and unemployment applicants declines. Welfare recipients can receive assistance from a variety of different sources, including TANF (Temporary Assistance for Needy Families), food stamps, Medicaid, Supplemental Security Income (SSI), housing subsidies, child care services, weatherization programs, and various educational programs.

Figure 4 relates the probabilities that an individual will apply for welfare by education level, derived from data supplied by the Department of Health and Human Services. As shown, the probability of claiming welfare drops significantly as individuals move to higher levels of education. Note that these data are based on TANF recipients only, as these constitute the most needy welfare recipients and are the point of departure for the allocation between the other ethnic groups in the model.

Figure 4: Probability of claiming welfare, by education level

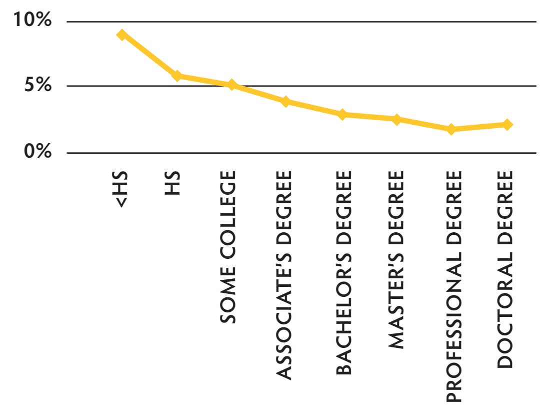


Unemployment rates also decline with increasing levels of education, as illustrated in Figure 5. These data are supplied by the Bureau of Labor Statistics. As shown, unemployment rates range from 9% for those with less than a high school diploma to 2% for those at the doctoral degree level.

CONCLUSION

The statistical databases bear out the simple correlation between education and improved health, lower incarceration rates, and reduced welfare and unemployment. These by no means comprise the full range of benefits one possibly can link to education. Other social benefits certainly may be identified in the future as reliable statistical sources are published and data are incorporated into the analytical framework. However, the fact that these incidental benefits occur and can be measured is a bonus that enhances the economic attractiveness of university operations.

Figure 5: Unemployment rates by education level



Appendix 6

INVESTMENT ANALYSIS—A PRIMER

The purpose of this appendix is to provide some context and meaning to the investment analysis results in general, using the simple hypothetical example summarized in Table 1 below. The table shows the projected (assumed) benefits and costs over time for one student and associated investment analysis results.[32]

Assumptions are as follows:

- The time horizon is 10 years—i.e., benefits and costs are projected out 10 years into the future (Column 1). Once education has been earned, benefits of higher earnings remain with the student into the future. The objective is to measure these future benefits and compare them to the costs of education.
- The student attends college for one year, for which he or she pays total fees of $1,500 (Column 2).
- The opportunity cost of time (earnings forgone while attending college for one year) for this student is estimated at $20,000 (Column 3).
- Together, these two cost elements ($21,500 total) represent the out-of-pocket investment made by the student (Column 4).
- In return, it is assumed that the student, having completed the one year of study, will earn $5,000 more per year than he/she would have without the education (Column 5).
- Finally, the net cash flow column (NCF) in Column 6 shows higher earnings (Column 5) less the total cost (Column 4).

The assumed "going rate" of interest is 4%, the rate of

32 Note that this is a hypothetical example. The numbers used are not based on data collected from an existing college or university.

Table 1. Costs and benefits

YEAR	TUITION	OPPORTUNITY COST	TOTAL COST	HIGHER EARNINGS	NET CASH FLOW
1	2	3	4	5	6
1	$1,500	$20,000	$21,500	$0	-$21,500
2	$0	$0	$0	$5,000	$5,000
3	$0	$0	$0	$5,000	$5,000
4	$0	$0	$0	$5,000	$5,000
5	$0	$0	$0	$5,000	$5,000
6	$0	$0	$0	$5,000	$5,000
7	$0	$0	$0	$5,000	$5,000
8	$0	$0	$0	$5,000	$5,000
9	$0	$0	$0	$5,000	$5,000
10	$0	$0	$0	$5,000	$5,000
Net present value			$21,500	$35,753	$14,253
Internal rate of return					18%
Benefit/cost ratio					1.7
Payback period					4.2 years

return from alternative investment schemes, for the use of the $21,500.

Results are expressed in standard investment analysis terms, which are as follows: the net present value (NPV), the internal rate of return (IRR, or simply RR), the benefit/cost ratio (B/C), and the payback period. Each of these is briefly explained below in the context of the cash flow numbers in Table 1.

NET PRESENT VALUE (NPV)

"A bird in hand is worth two in the bush." This simple folk wisdom lies at the heart of any economic analysis of investments lasting more than one year. The student in Table 1 can choose either to attend college or to forgo post-secondary education and maintain present employment. If he or she decides to enroll, certain economic implications unfold: student tuition and fees must be paid, and earnings will cease for one year. In exchange, the student calculates that with post-secondary education, his or her income will increase by at least the $5,000 per year as indicated in the table.

The question is simple—will the prospective student be economically better off by choosing to enroll? If he/she adds up higher earnings of $5,000 per year for the remaining nine years in Table 1, the total will be $45,000. Compared to a total investment of $21,500, this appears to be a very solid investment. The reality, however, is different—benefits are far lower than $45,000 because future money is worth less than present money. Costs (student tuition and fees plus forgone earnings) are felt immediately because they are incurred today—in the present. Benefits (higher earnings), on the other hand, occur in the future. They are not yet available. All future benefits must be discounted by the going rate of interest (referred to as the discount rate) to be able to express them in present value terms.[33] Let us take a brief example—at 4%, the present value of $5,000 to be received one year from today is $4,807. If the $5,000 were to be received in year ten, the present value would reduce to $3,377. Put another way, $4,807 deposited in the bank today earning 4% interest will grow to $5,000 in one year; and $3,377 deposited today would grow to $5,000 in ten years. An "economically rational" person would, therefore, be equally satisfied receiving $3,377 today or $5,000 ten years from today given the going rate of interest of 4%. The process of discounting—finding the present value of future higher earnings—allows the model to express values on an equal basis in future or present value terms.

The goal is to express all future higher earnings in present value terms so that they can be compared to investments incurred today—student tuition and fees and forgone earnings. As indicated in Table 1, the cumulative present value of $5,000 worth of higher earnings between years 2 and 10 is $35,753 given the 4% interest rate, far lower than the undiscounted $45,000 discussed above.

The net present value of the investment is $14,253. This is simply the present value of the benefits less the present value of the costs, or $35,753 – $21,500 = $14,253. In other words, the present value of benefits exceeds the present value of costs by as much as $14,253. The criterion for an economically worthwhile investment is that the net present value is equal to or greater than zero. Given this result, it can be concluded that, in this case, and given these assumptions, this particular investment in education is very strong.

INTERNAL RATE OF RETURN (IRR)

The internal rate of return is another way of measuring the worth of investing in education using the same cash flows shown in Table 1. In technical terms—the internal rate of return is a measure of the average earning power of money used over the life of the investment. It is simply the interest rate that makes the net present value equal to zero. In the NPV example above, the model applies the "going rate" of interest of 4% and computes a positive net present value of $14,253. The question now is what the interest rate would have to be in order to reduce the net present value to zero. Obviously it would have to be higher—18% in fact, as indicated in Table 1. Or, if a discount rate of 18% were applied to the NPV calculations instead of the 4%, then the net present value would reduce to zero.

33 Technically, the interest rate is applied to compounding—the process of looking at deposits today and determining how much they will be worth in the future. The same interest rate is called a discount rate when the process is reversed—determining the present value of future earnings.

What does this mean? The internal rate of return of 18% defines a breakeven solution—the point where the present value of benefits just equals the present value of costs, or where the net present value equals zero. Or, at 18%, higher incomes of $5,000 per year for the next nine years will earn back all investments of $21,500 made plus pay 18% for the use of that money ($21,500) in the meantime. Is this a good return? Indeed it is. If it is compared to the 4% "going rate" of interest applied to the net present value calculations, 18% is far higher than 4%. It may be concluded, therefore, that the investment in this case is solid. Alternatively, comparing the 18% rate of return to the long-term 7% rate or so obtained from investments in stocks and bonds also indicates that the investment in education is strong relative to the stock market returns (on average).

A word of caution—the IRR approach can sometimes generate "wild" or "unbelievable" results—percentages that defy the imagination. Technically, the approach requires at least one negative cash flow (student tuition and fees plus opportunity cost of time) to offset all subsequent positive flows. For example, if the student works full-time while attending college, the opportunity cost of time would be much lower; the only out-of-pocket cost would be the $1,500 paid for student tuition and fees. In this case, it is still possible to compute the internal rate of return, but it would be a staggering 333% because only a negative $1,500 cash flow will be offsetting nine subsequent years of $5,000 worth of higher earnings. The 333% return is technically correct, but not consistent with conventional understanding of returns expressed as percentages. For purposes of this report, therefore, all results exceeding 100% are expressed simply as: "n/a" or ">100%."

BENEFIT/COST RATIO (B/C)

The benefit/cost ratio is simply the present value of benefits divided by present value of costs, or $35,753 ÷ $21,500 = 1.7 (based on the 4% discount rate). Of course, any change in the discount rate will also change the benefit/cost ratio. Applying the 18% internal rate of return discussed above would reduce the benefit/cost ratio to 1.0—or the breakeven solution where benefits just equal costs. Applying a discount rate higher than the 18% would reduce the ratio to lower than 1.0, and the investment would not be feasible. The 1.7 ratio means that a dollar invested today will return a cumulative $1.70 over the ten-year time period.

PAYBACK PERIOD

This is the length of time from the beginning of the investment (consisting of student tuition and fees plus earnings forgone) until higher future earnings give a return on the investments made. For the student in Table 1, it will take roughly 4.2 years of $5,000 worth of higher earnings to recapture his or her investment of $1,500 in student tuition and fees and the $20,000 earnings he or she forgoes while attending college. Higher earnings occurring beyond 4.2 years are the returns that make the investment in education in this example economically worthwhile. The payback period is a fairly rough, albeit common, means of choosing between investments. The shorter the payback period, the stronger the investment.

Appendix 7

ALTERNATIVE EDUCATION VARIABLE

INTRODUCTION

The alternative education variable is the percent of students who would still be able to avail themselves of education absent the publicly funded colleges and universities in the state. This variable is estimated in the model through a regression analysis based on data supplied by 117 colleges previously analyzed by EMSI. The purpose of this appendix is to lay out the theoretical framework for determining the alternative education opportunity variable and the data used to make this determination.

ALTERNATIVE EDUCATION VARIABLE IN FUNCTION FORM

The alternative education variable is the dependent variable, expressed in functional form as follows:

1) $Y = b_1X_1 + b_2X_2 + b_3X_3 + e$

Where:
Y = Dependent variable
b_i = partial regression coefficients
e = standard error

INDEPENDENT VARIABLES

The three independent variables reflect the explanatory parameters that form the theoretical backdrop to the internal estimation of the dependent variable based on 117 observations. The three independent variables include the following:

X_1 = Population per square mile in the service region

This variable defines the population density of the service region. A positive coefficient (b) is expected, *i.e.*, the more densely populated the area, the more numerous the alternative education opportunities will be.[34]

X_2 = Number of private school employees per 1,000 population per square mile in the service region

This variable is a proxy for the availability of private educational institutions providing alternative education opportunities in the region. A positive coefficient (b) is expected, i.e., the more private school employees, the more alternative education opportunities there are in the area.[35]

X_3 = Personal income

The average personal income of residents in the region serves as a measure of the relative economic well-being of the area. A positive coefficient (b) is expected, i.e., the higher the average earnings in the area, the more the students will be able to avail themselves of the alternative education opportunities. This number is expressed in thousands.[36]

EXAMPLE OF ANALYSIS AND RESULTS

The procedure used to estimate the parameters was the ordinary least squares procedure (OLS). Fitting the equation by OLS yielded the following results:

2) $Y = 3.43E^{-05}X_1 + 0.023565X_2 + 0.005748X_3 + 0.064722$

34 Available from U.S. Census Bureau, Current Population Survey.
35 Available from U.S. Department of Commerce, County Business Patterns.
36 Available from U.S. Department of Commerce, Bureau of Economic Analysis.

$R_2 = .458$ (coefficient of determination)
$F = 31.84$ (Fischer test statistic)

The R_2 measures the degree to which the independent variables explain the variation in the dependent variable. The maximum R_2 attainable (1.00) is the case in which all observations fall on the regression line and all variability is explained. The .458 R_2 obtained in equation (2) indicates that nearly 46% of the variation in the alternative education opportunity is explained by the variables. The F-ratio indicates that the equation can be considered a good predictor of the alternative education opportunity.

The positive signs of the regression coefficients agree with expected relationships. As population density, the number of private school employees, and personal income increase, so does the provision of alternative education opportunities.

For example, suppose the institution has a service region of five counties. The total population of the five counties is 188,341, while the size of the region is 3,754 square miles; the average population per square mile is therefore a little over 50. Within this region, there is one higher education private school employee for every 3,000 residents. Finally, the average income per person within the region is $21,869 per year. Using these data, the following results are produced:

3) $Y = (3.43E^{-05} \times 50.2) + (0.023565 \times .3318) + (0.005748 \times 21.869)$

4) $Y = 13.5\%$

Thus, according to these calculations, an estimated 13.5% of the student population would have been able to receive an education elsewhere if there were no publicly funded colleges and universities in the state.