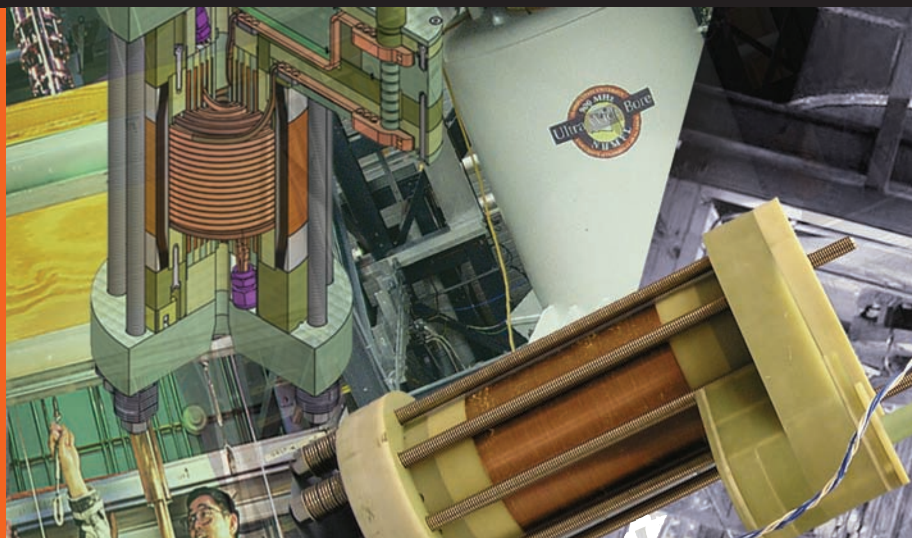

The National High Magnetic Field Laboratory and Its Forecasted Impact on the Florida Economy

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Executive Summary

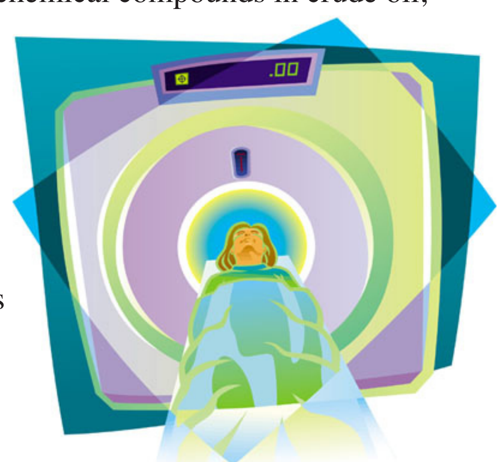
> "In a global environment in which prospects for economic growth now depend importantly on a country's capacity to develop and apply new technologies, our universities are envied around the world. If we are to remain preeminent in transforming knowledge into economic value, the U.S. system of higher education must remain the world's leader in generating scientific and technological breakthroughs and in preparing workers to meet the evolving demand for skilled labor."
>
> *– Alan Greenspan, Chairman, U.S. Federal Reserve, 2004*

Sound, university-driven research is inextricably linked to virtually all economic growth and quality of life enhancements in this information age. Basic scientific research underpins these new technologies, whether they are faster and better computers or medical devices and pharmaceuticals.

In a world where information is so readily available, it's easy to forget how much we still don't know about the natural world. Basic science is fundamental to creating knowledge and understanding, and that knowledge spurs innovations that enhance and lengthen life, and give us new tools and experiences.

Basic research is the National High Magnetic Field Laboratory's stock-in-trade. Investments in high-magnetic-field research have sown the seeds of nearly every modern technology and material, including electric lights, plastics, computers, motors, semiconductors and magnetic resonance imaging (MRI).

High-field magnets are essential tools for probing the mysteries of nature that lead to new materials and technology. Current research activity at the lab includes study of superconductors that have the potential to revolutionize the electric power industry; mapping the chemical composition of the ocean floor; development of a new generation of drugs to treat tuberculosis; detailed analysis of all the chemical compounds in crude oil; the study of comet dust that is believed to be older than the sun; the basic science behind electron "spins" that could one day lead to advanced quantum computers; and collaboration with Scripps-Florida that gives scientists a powerful new tool for drug discovery.



Investment in basic research reaps big dividends in our lives and in our economy. While the tangible applications often take decades to materialize (see page 3), the immediate economic impact of that research is very real.

Key findings

- The state of Florida investment over the next 10 years will generate $1.5 billion in output (value of goods and services produced) and $670 million in income while generating 15,669 jobs across the state economy.

- For each dollar the state invests in the Magnet Lab between 2005 and 2015, the state will realize a return of $5.50.

- From 2005 to 2015, the Magnet Lab is expected to attract $4.50 in federal and other sources of money. Over the 11-year time frame, the state's total projected investment of $125.6 million will net $564 million in non-state spending.

- State funding in the Magnet Lab will leverage an annual average economic stimulus to the Florida economy more than five times as large as if that investment had been spent elsewhere in Florida.

This report was commissioned by the National High Magnetic Field Laboratory (Magnet Lab) to forecast the lab's economic impact on the state and local economy over the next 10 years.

The Magnet Lab is funded by both the National Science Foundation and the state of Florida to pursue basic science and to advance high-magnetic-field research. This model partnership is a primary reason the lab was awarded to Florida State University in 1990, and it continues to help the lab leverage resources. This report examines how that partnership impacts Florida's economy by measuring the increase in employment and economic output generated by Magnet Lab activities across the state economy.

About the National High Magnetic Field Laboratory

The National High Magnetic Field Laboratory at Florida State University develops and operates magnet systems for research in physics, biology, bioengineering, chemistry, geochemistry, biochemistry, materials science, and engineering. Covering more than 300,000 square feet, the Magnet Lab is the world's largest – and highest powered – magnet facility. It's the only facility of its kind in the United States, and one of only nine in the world.

Dedicated to "users"

In addition to the main lab in Tallahassee, the lab has two additional branches, one in Gainesville and another in Los Alamos, New Mexico. All three facilities are open to the "user community," which means qualified scientists from across the globe have free access to the magnets as long as the researchers agree to share the results of their work.

Users also have access to the lab's world-class, research-support scientists, who have their own active research interests that complement and enhance user research. This user-facility designation attracts national and international attention to Florida and helps bring in more than 1000 outside researchers each year; 20 percent of those visitors come from overseas.

Advancing magnet research and technology

FSU faculty and visiting scientists regularly publish in the country's most prestigious academic journals, including *Nature, Science, Physical Review Letters, Journal of Magnetic Resonance, and Journal of American Chemical Society.*

The Magnet Lab's research track record and high-field arsenal are two of the primary reasons the Applied Superconductivity Center agreed to relocate from the University of Wisconsin to FSU. The center's relocation is considered a major step forward in FSU's drive to be recognized as one of the top research universities in the nation.

The lab's magnet engineers continuously strive to improve the performance of the lab's magnets by pushing the magnetic fields higher and increasing the quality of the fields. As a result, the lab boasts several world records.

MRI: 40 years in the making

Basic science isn't applied science in the traditional sense. People who study basic science usually don't enter into an experiment with the goal of creating a product. They want to learn more about materials, the body and the earth. But the discoveries they make eventually lead to applications … often in ways the scientists could never imagine.

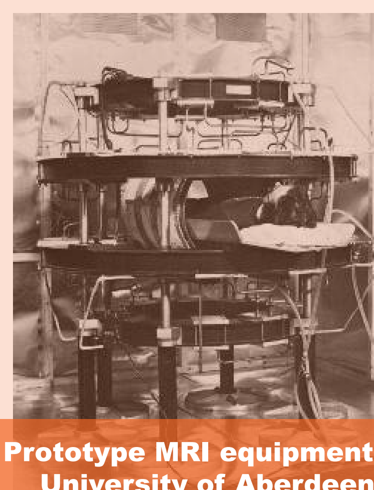
Here is just one example of how basic science led to discoveries that changed the world.

Forty years passed between the first documented observance of the phenomenon of magnetic resonance and the first whole-body scan in a magnetic resonance imaging (MRI) machine. And it would be a few more years before that technology was commercially available.

The phenomenon of magnetic resonance was first observed in 1937. Nearly 10 years later, in 1946, two American physicists independently determined that certain nuclei, when placed in a magnetic field, could absorb and then emit energy. When measured, that energy could be used to determine the composition of chemical compounds. This discovery launched the nuclear magnetic resonance discipline, or "NMR."

For 20 years (1950s-1970s), NMR was further developed and used to study and analyze chemical compounds. It wasn't until the early 1970s that researchers begin adapting NMR into magnetic resonance imaging, a non-invasive method to examine internal bodily structures. The first whole body MRI scan was demonstrated in 1977, and the technology became commercially available in the early 1980s.

More than 70 years after the basic research began, today MRI is an indispensable diagnostic tool that is widely available, with hundreds of thousands of machines around the world.



Prototype MRI equipment at University of Aberdeen

Integrating Research and Learning

The Magnet Lab offers a compelling environment and opportunity to educate and train students in science and engineering. Undergraduate, graduate and K-12 students frequent the Magnet Lab annually for hands-on experiences that complement classroom education and contribute to the nation's future supply of skilled scientists and technicians.

Each year, the Magnet Lab sponsors post-doctoral and other research fellowships for top-ranked graduate students, and many Magnet Lab personnel hold joint appointments at the university. The lab's education programs also sponsor and train teachers from across the country in the best techniques for presenting science and technology in the classroom.

The educational programs of the Magnet Lab are designed to excite and educate students, teachers, and the general public about science, technology and the world around them. All of the educational programs at the Magnet Lab are developed through close collaboration between research scientists and educators.

Since 1999, there have been 117 undergraduates in the 8-week residential Research Experiences for Undergraduates, or REU, program; and 112 middle school students and 30 high school students have had internships, externships, or participated in Regional Institute for Science and Math (RIMS) partnerships with FAMU. Annually, roughly 7,000 students are reached through classroom outreach. In addition, the number of students, teachers, and general public (including the Open House) who have toured the Magnet Lab annually totals approximately 10,000.

Hands-on experiences help train teachers from across the country in the best techniques for presenting science and technology in the classroom.

History and Evaluation of the Economic Impact of the Magnet Lab

The National High Magnetic Field Laboratory was awarded to a consortium headed by Florida State University in August 1990 by The National Science Foundation (NSF). The Magnet Lab is a national user laboratory that provides magnet systems for research in all areas of science, including biology, medicine, chemistry, geochemistry, engineering, materials science and physics. The Magnet Lab attracts and employs some of the top scientists in the world, including a Nobel Laureate, a member of the National Academy of Sciences, and a member of the National Academy of Engineering.

High magnetic fields are critical to understanding matter and living structures and to developing modern technologies and new and improved materials. While the Magnet Lab has greatly advanced scientific knowledge in these fields, this report focuses on the Magnet Lab's economic impact on Florida by measuring the increase in employment and economic output generated by Magnet Lab activities across the broader statewide economy.

Since 1990, the Magnet Lab has focused on establishing and improving the essential infrastructure required to conduct world-class research by building the largest and highest powered magnetic field research facility in the world, and recruiting a distinguished faculty to conduct that research. The Magnet Lab has achieved this goal primarily through funding by the National Science Foundation, the state of Florida, and through a combination of individual investigator grants, work for others and royalties.

Figure 1 shows the amount of funding the Magnet Lab received between 1990 and 2005. State funding includes all funds the Magnet Lab received from any state of Florida source, whereas non-state funds indicate private and/or out-of-state funding (e.g., NSF funding). The bulk of state funding was spent on construction and equipment to get the facility up and running. This commitment by the state to pay for the building and contribute capital equipment was required in the original solicitation to the NSF.

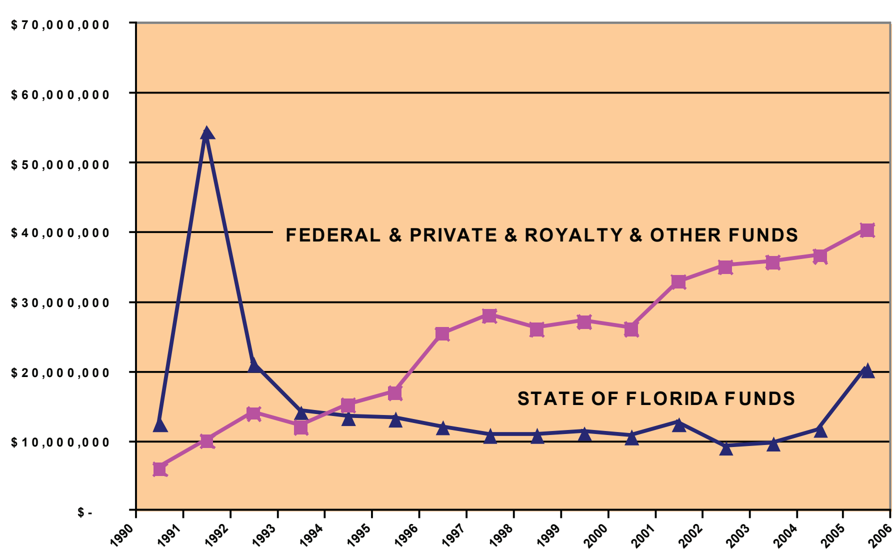


Figure 1.

Comparison of Annual State and Non-State Magnet Lab Nominal Expenditures (1990-2005)

While state of Florida funds continue to be critical for ongoing operation and maintenance of the Magnet Lab, the growing source of revenue comes from Federal and other sources outside the state. This level of external funding has been an important economic stimulus within Florida over the years, as this study will examine.

As the graph shows, the Magnet Lab received a large amount of funding in its early years. This infusion was needed to build the facility and acquire the equipment and machinery required to transform what was once an insurance building into a national laboratory. One can see from the graph that after 1994, the year the Magnet Lab's main complex was dedicated, non-state funding levels begin to exceed the level of state funding. State funding levels have hovered around $11 million over the last several years with the exception of 2005, where funding increased to almost $20 million because of a one-time appropriation for infrastructure improvements, a timely investment that many believe contributed to the National Science Board's decision not to compete the grant for 2008-2012. Non-state funding steadily increased over this period from two to almost four times state funding and, in 2005, concluded with a record $40 million.

Figures 2 and 3 project the cumulative funding forecast through 2015. State funding is expected to continue at around $11 million annually. Federal and other awards are projected to grow by 58% annually from 2005 to 2015, from $40 to almost $63 million. This constitutes an annual average increase of $2.1 million per year. The leveraging of state of Florida funding alone is quite high over the projected 2005 to 2015 time frame. This forecast suggests that for every dollar the state of Florida invests in the Magnet Lab (a projected investment of $125.6 million), Federal and other sources will leverage an additional $438.4 million dollars for a total of $564 million in non-state spending at the Magnet Lab over the 11 years.

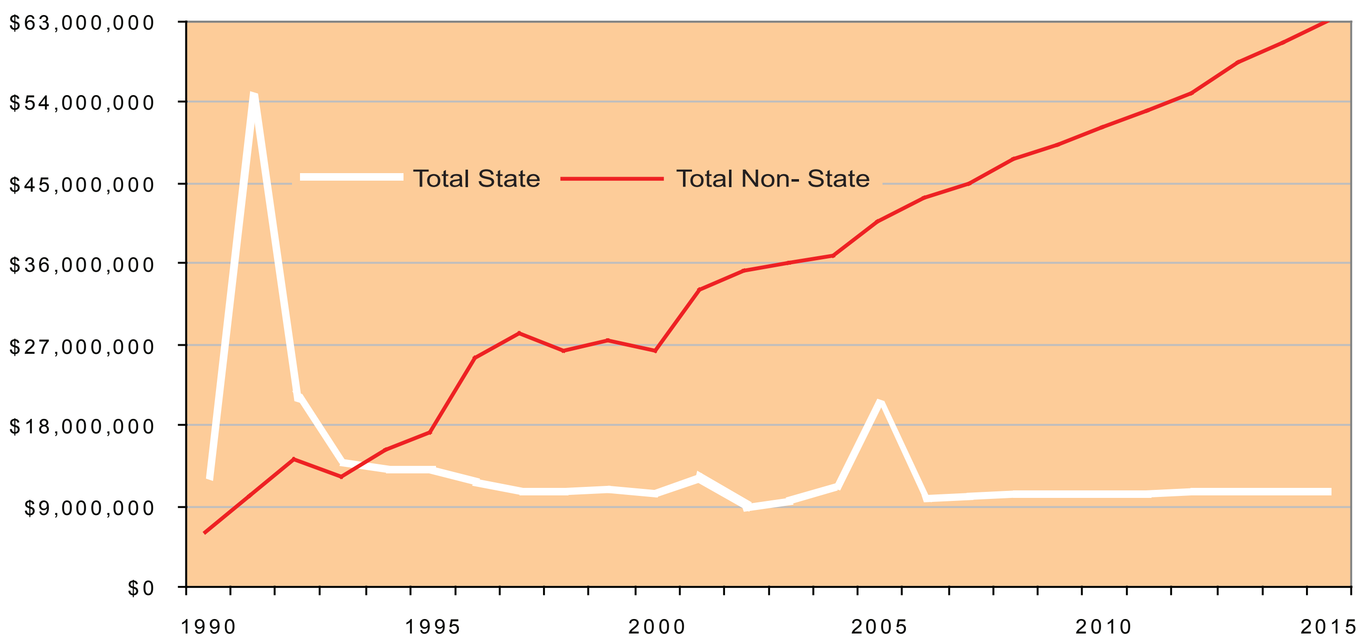


Figure 2.
Comparison of Historic and Forecasted Annual State and Non-State NHMFL Nominal Expenditures (1990-2015)

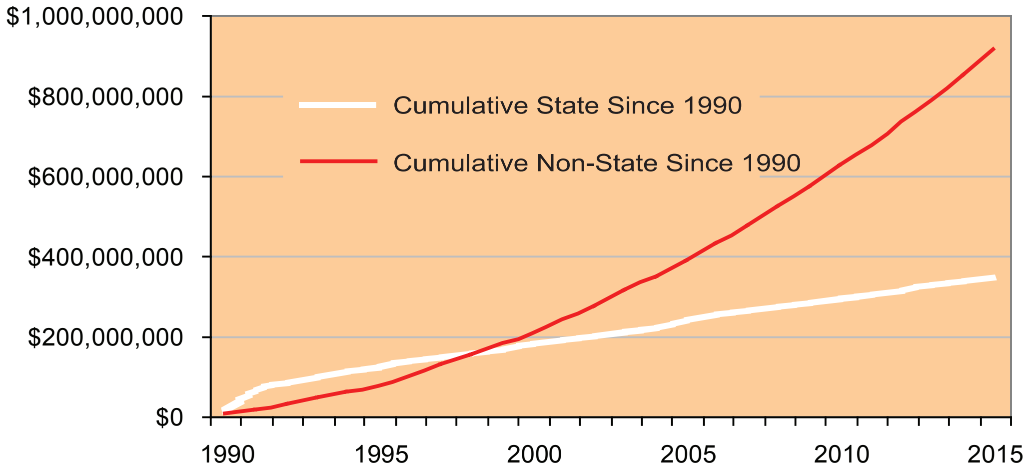
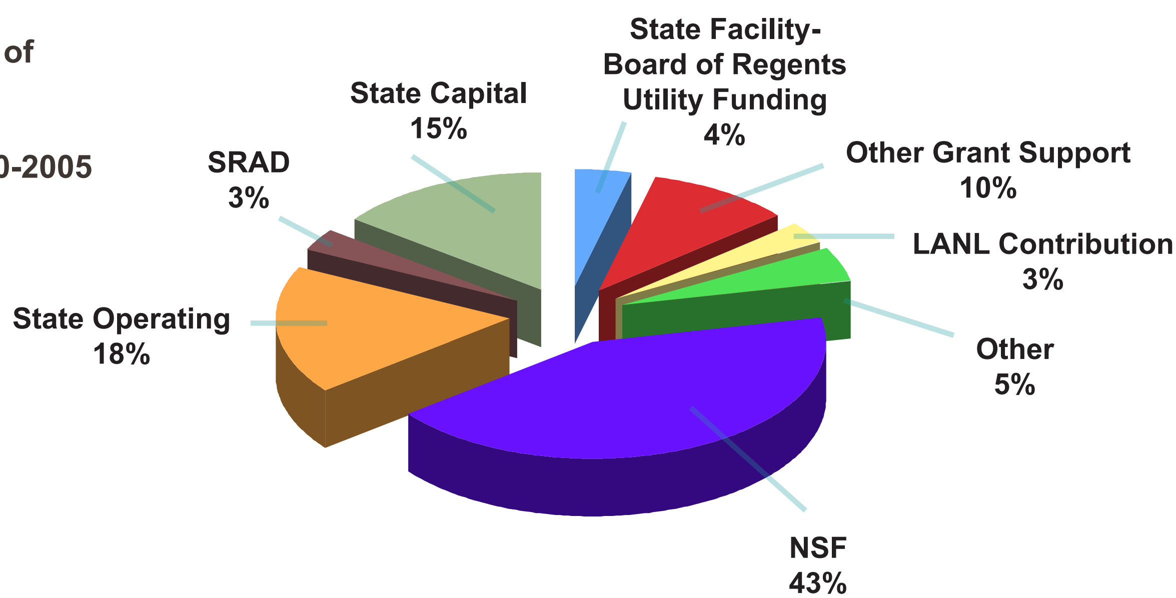


Figure 3.
Comparison of Cumulative Historic and Forecasted Annual State and Non-State NHMFL Nominal Expenditures (1990-2015)

To measure the impact of the Magnet Lab, expenditures on salaries, capital, and direct and indirect expenses were determined. These funds were then put into a Florida regional input-output model, which includes cross linkages between every sector of the full Florida economy. This study did not quantify the intangible benefits generated by the presence of the Magnet Lab to the local economy, such as quality of life enhancements, intellectual stimulation (through publications, presentations, public service), and creation of spin-off companies, among others.

The specific breakdown of Magnet Lab funding over the 1990 to 2005 period can be observed in Figure 4. The NSF was the biggest single financial supporter of the Magnet Lab over these years providing 43% of total revenues. State of Florida operation funds follow next, at 18%, and state capital at 15%. Other grant support rounds out the top four sources, at 10% of total Magnet Lab funding.

Figure 4.
Percentage of Magnet Lab Funding by Source 1990-2005



The IMPLAN Input-Output Model

For this study, CEFA staff used the state of Florida Impact Analysis for Planning, or IMPLAN, model, a widely accepted and used integrated input-output model. IMPLAN is used extensively by state and local government agencies to measure proposed legislative and other program and policy economic impacts across the private and public sectors. In addition, it is the tool of choice to measure these impacts by a number of universities and private research groups that evaluate economic impacts across the state and nation. There are several advantages to using IMPLAN:

- It is calibrated to local conditions using a relatively large amount of local county level and state of Florida specific data;
- It is based on a strong theoretical foundation; and
- It uses a well-researched and accepted applied economics impact assessment methodology supported by many years of use across all regions of the U.S.

The IMPLAN model used for this analysis was specifically developed for the state of Florida, and includes 509 sectors. IMPLAN's principal advantage is that it may be used to forecast direct, indirect and induced economic effects for an initial economic stimulus, in this case Magnet Lab spending. (For more detail on the IMPLAN model, see appendix.)

Methodology and Assumptions

Expenditures on salaries, capital, direct and indirect expenses for the Magnet Lab, for the years 2005 to 2015, were provided by Magnet Lab financial staff. An assumption was made that there would be fairly consistent percentage levels spent on each category (salaries, capital, etc.) and that it would not vary much over the time frame. We think this is a safe assumption as spending on broad categories such as these within institutions don't vary widely over such a short time frame. Figures 5 and 6 provide a breakdown of the Magnet Lab's allocation of spending for 2005, and from 1990 to 2015.

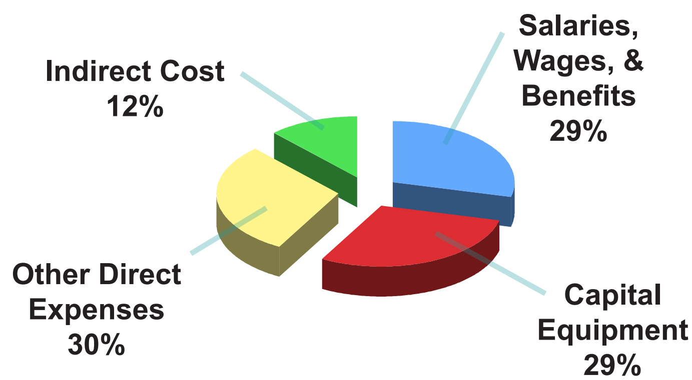


Figure 5.
Allocation of Magnet Lab Spending, for 2005

With this assumption and knowledge of past funding levels, we determined the dollar value that likely would be spent on each category by the Magnet Lab (Table 1). Expenditures on salaries, capital, and direct and indirect expenses by the Magnet Lab were then used as inputs in the IMPLAN model to calculate the lab's economic impact on the Florida economy.

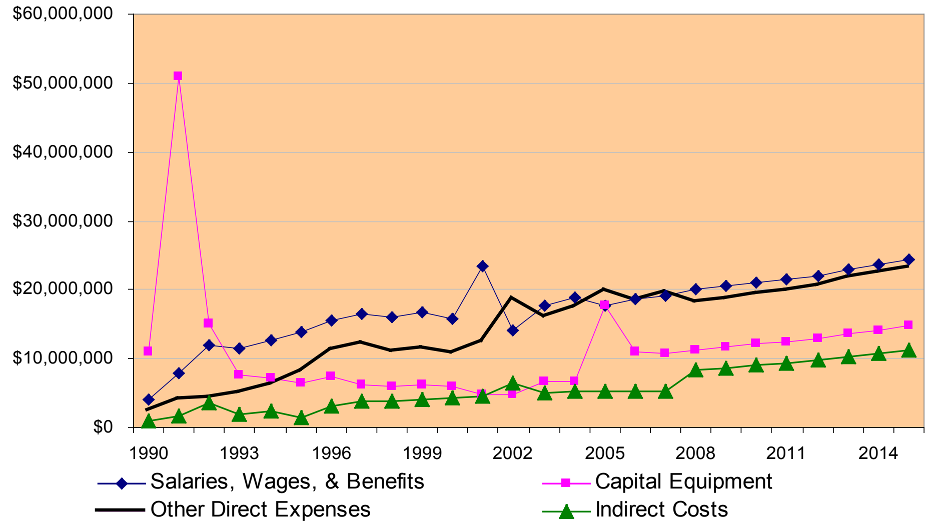


Figure 6. **Magnet Lab Spending 1990 - 2015**

Results of the IMPLAN Analysis

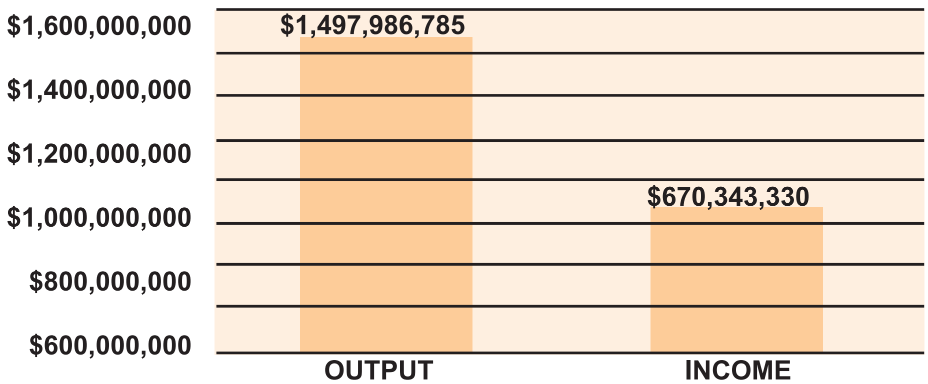
After these policy variables were selected and the data entered, the IMPLAN model was used to determine the economic impact of the Magnet Lab on the statewide economy. The top part of Table 1, below, summarizes the average annual economic impact of state of Florida funds supporting the Magnet Lab if those funds were spent elsewhere. This is referred to as the "alternatives analysis." The average annual expenditure of $11 million input into IMPLAN would generate $24.7 million in state economic output and $9.7 million in income while generating 273 jobs annually.

The second part of the table examines how much additional economic stimulus the actual state funding of the Magnet Lab generates by attracting non-state, Federal, and other funds that otherwise would be attracted elsewhere. This part of the table indicates that the state funding will leverage an annual average economic stimulus to the Florida economy more than five times as large as the alternative investment. This table shows the economic impacts on output, employment and labor income. The Magnet Lab's annual stimulus in terms of output will exceed $136 million dollars. This represents the value of final goods and services

Table 1. **Economic Impact of Magnet Lab State and Non-State Funding (2005-2015)**

Mag Lab 2005-2015 State of Florida Annual Average Alternative Economic Impacts Only			
	Output	**Employment**	**Income**
Annual Average Economic Impact of State of Florida Mag Lab Spending on Alternative Investments	**$24,727,957**	**273**	**$9,704,501**
Mag Lab 2005-2015 Annual Average All Spending Economic Impacts			
	Output	**Employment**	**Income**
Annual Average Economic Impact of Total State & Non-State Mag Lab Spending	**$138,180,617**	**1424**	**$60,940,303**
Benefit to Cost Ratio	**5.51**	**5.22**	**6.28**

Figure 7. **Cumulative Economic Impact of Total State and Non-State Magnet Lab Funding (2005-2015)**



produced across the Florida economy as a result of state and non-state spending at the Magnet Lab. The annual average value of income generated by Magnet Lab spending over the 2005-2015 period is almost $61 million across the state. Finally, the Magnet Lab generates 1,424 jobs across the Florida economy that are directly and indirectly stimulated by the spending projected over that period.

Figure 7 shows the 11-year 2005 to 2015 estimated total economic stimulation of Magnet Lab state and non-state spending (cumulative) across the Florida economy. If the Magnet Lab were not located in Florida, the Federal and other grants, royalties and other non-state funding would benefit another state. The state and non-state investment across Florida over the next 10 years will generate about $1.5 billion in state of Florida output and $670 million in income while generating 15,669 jobs across the state economy.

Benefit Cost Analysis

The benefits to the state of Florida were defined as the economic impact resulting from the initial state investment and the amount leveraged by the state investment (contracts and grants, government and private sponsors, auxiliary fees/services and other external sources). The costs to the state of Florida were defined as the opportunity cost of the initial state investment redistributed to higher education spending. As described above, the IMPLAN model estimated the following:

- Benefit to the state = $136 million
- Cost to the state (opportunity cost of average annual input of $11.4 million) = $24.7 million
- Final benefit to cost ratio: 5.5

This B/C ratio implies that for each dollar that the state invests in the Magnet Lab from 2005 to 2015, the state will realize a return of $5.50.

The Benefits of the Magnet Lab to the City of Tallahassee

The city of Tallahassee, which owns and operates a municipal power company, enjoys substantial benefits from the Magnet Lab. The lab consumes a large amount of electricity for which the city collects revenue. For the year 2005, the city collected $3.6 million in electricity revenues from the Magnet Lab. This ranks the lab as one of the five largest customers for the city in terms of electricity revenue collected.

Since the physical infrastructure of the Magnet Lab is government owned, it is not taxed. However, the employees who work at the Magnet Lab own houses and other property for which the city and county receive property taxes. The amount of city and county property taxes Magnet Lab employees paid for the year 2005 is estimated to be $1.2 million. Additionally, the city collects an estimated $582,923 in residential utility revenue from Magnet Lab employees.

Appendix A

Review of the Literature: Linkage Between Scientific Research and the New Science-Based High-Tech Economy

In the past six decades, collaboration among business and industry, government, universities and national laboratories has transformed the world around us. It is now widely recognized that scientific research at universities plays an important role in local, regional and state economies. Extensive literature documents the impact of university-business-government partnerships. But, in spite of all of the interest, university scientific research and its role in the Florida and U.S. economies is poorly understood. Current research indicates that university scientific research is among the least examined, but is the most important contributor to economic growth, efficiency, productivity and quality of life in our economy.

Technological innovation, in addition to well-trained high-tech workers, flows from our universities across the entire spectrum of industrial, scientific and commercial activities in our economy. Additionally, considerable gains in socio-economic – quality of life – areas of research (health care, environmental quality enhancements, human services advances, and so forth) also stem from our university labs and research centers. These gains in socio-economic areas often go unexamined, unreported, and therefore unrealized by policy-makers and the public itself.

Following is a brief review of the literature prepared by the economics staff of the Center for Economic Forecasting and Analysis at Florida State University that looks at the important linkage between university research and economic and socio-economic gains.

Overview of the Economic Value of National University Research

Since the end of World War II, federal, industrial and university-funded scientific research has improved the quality of life for every American through invention and innovation of many products, including the computer and the Internet; and vaccines, drugs, and medical technology such as magnetic resonance imaging (MRI); among others. University research is one of the main driving forces behind the United States' rise to become the world's only superpower.

Total university-based and funded research and development (R&D) as presented in Table 2, has increased by a factor of 1.5 over the 1990 to 2003 time frame from $21.6 to $39.3 billion. Meanwhile, federal-funded university-based R&D increased over the 1990 to 2003 time period from $20 billion to $24.3 billion. Private sector industrial R&D increased by a factor of almost 1.5 from $137 billion to $200 billion over that time. Meanwhile, total national R&D increased by 45% over the same period from $194.5 to $281 billion (NSF, 2005).

Table 2. **National Funds for R&D by Performers (2002 Million Dollars)**

	FY 1970 Actual	FY 1980 Actual	FY 1990 Actual	FY 2002 Actual	FY 2003 Prelim
Federal	15,816	15,190	20,042	21,860	24,273
Industry	66,986	83,849	137,362	193,868	200,200
Colleges and Universities	9,206	12,521	21,660	36,370	39,330
FFRDCs[1]	5,444	7,988	10,121	11,536	11,901
Nonprofits	2,578	3,183	5,277	5,739	6,150
TOTAL	100,021	122,730	194,462	269,374	281,854

Sources: NSC, Division of Science Resources and Statistics.
Increase in U.S., Industrial R&D Expenditures Reported for 2003 Makes Up For Earlier Decline, NSF, December 2005.
Academic Research and Development Expenditures: Fiscal Year 2003, NSF

Assessment of the Economic Impact of University Related Research

There are several alternative and complementary methods of evaluating the economic and social value of university-related research to the U.S. economy and citizens' quality of life. Most researchers use either cost effectiveness analysis, economic impact assessment, benefit cost analysis and case study, or survey evaluations. Each method addresses a specific interest of researchers such that no single method is sufficiently comprehensive to capture all potential effects. The following sections summarize the most significant findings on the value of university research to the U.S. economy and quality of life emerging from leading national researchers. This evaluation will summarize the university research studies in four groups. They are:

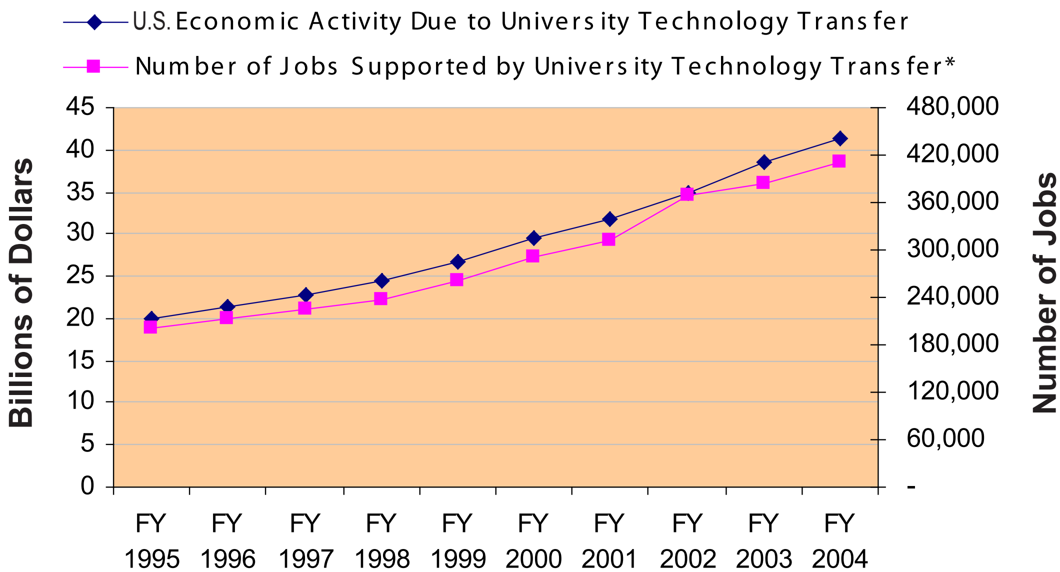
I) Economic impact and benefit cost assessment of university research;
II) Universities as technological and innovative-incubator and industrial partner;
III) Economic externalities of university research; and
IV) University research development of student human capital.

I. Direct Expenditure, Indirect and Induced Economic Impact Assessments

The direct expenditure method captures the amount of research funding flowing into the university from public, private and internal sources. The economic impacts measure the amount of economic stimulus activity flowing from these funds in terms of numbers of jobs created, numbers of students employed, dollars of economic sales and generation of taxes that stimulate the local and regional economies.

No comprehensive estimate is available from University research labs on how many jobs or how much economic activity is generated every year from academic research investments in the U.S. However, the Association of University Technology Managers (AUTM) publishes its annual *Licensing Survey* and collects data from 222 of the major research university organizations across the U.S. and Canada. (Current AUTM President John Fraser is the director of IP Development and Commercialization at Florida State University.) Figure 8 provides a profile of that analysis and extends it to impacts to FY 2003 and 2004.

The FY 2004 *Licensing Survey* at AUTM estimated an increase of $2.72 billion in U.S economic activity due to sponsored research expenditures. In 2004, a total of 192 institutions reported $41.24 billion in expenditures and in 2003, 188 institutions reported $38.52 billion in sponsored research expenditures.



Source: AUTM Surveys: 1995-2004. *Note: 2003-2004 jobs estimated using the historical average ratio Economic Activity vs Jobs: 1995-2002, CEFA.

Figure 8. **Total U.S. Economic Activity and Employment Related to Major University Research**

Technology Transfer

Other researchers have typically focused on the direct, indirect and induced economic impact from specific research university activities or state university systems.

Florida

Researchers at CEFA conducted a study to measure the contribution Florida university research centers and institutes (C&Is) make to Florida's economy. The study measured job creation, generation of Gross Regional Product, and personal income and state taxes using $88.8 million in state of Florida general revenue expenditures made by C&Is across the Florida university system (CEFA, 2001). Table 3 shows the primary economic impacts of state-funded C&I expenditures for 2001.

Table 3. **Florida Centers and Institute Expenditure Economic Impact 2001**

Florida Centers and Institutes Expenditures Economic Impact Assessment					
State of Florida 2000 Research Investment	Gross Regional Product (2001 $M)	Wages & Salaries (2001 $M)	Jobs Numbers	Tax Revenues (2001 $M)	Benefit/Cost Ratio
$88.8	$274	$245	6,955	$18	2.17

State of Florida 2001 investments in University Research Centers generated:

- 6,955 jobs
- Increases in Gross Regional Product of $2.17 for every dollar of state support
- Disposable income increases of $1.96 for every dollar of state support
- $18 million in tax revenues
- A final benefit cost ratio of 2.17

The study concluded that funding of the Florida university C&Is annually yields substantially higher benefits than the state of Florida investment costs.

California

Table 4 presents the dynamic economic impact of University of California (UC) research expenditures on the local economy. This study evaluates the economic impact of spin-off companies of research innovation and new products, as well as research revenues not examined in the Florida study. It is not a B/C analysis but an economic impact assessment.

Table 4. **Dynamic Impact of UC Research on Gross State Product Growth, 2002-2011**

California State University Research Economic Impacts				
UC Research Productivity Gains 2002-2011 ($B)	UC Research Related Job Creation 2002-2011	Number of UC Inventions 1999-2001	Value of Industry UC Contracts 2001	Percent of All R&D in California at UC
$5.2	104,000	2,600	$216	7%

Source: *California's Future It Starts Here UC's Contributions to Economic Growth, Health, and Culture*, March 2003, prepared by ICF Consulting.

This study concludes that 7% of all California R&D takes place on UC campuses resulting in a 10-year gain of:

- $5.2 billion in economic productivity
- 1.3% of all California GNP growth attributable to UC research activity gains
- 104,000 jobs created

Other gains include:

- $216 million in Industry-University contracts for 2001
- 2,600 UC inventions over 1999-200.
- Formation of 160 new companies founded on the basis of UC new technology licensing agreements

- 7% of all R&D completed in California is on a UC campus
- UC researchers brought in a total of $3.89 ($2.63 of federal and $1.26 of private funding) for each dollar of state-funded R&D in 2000-2001

New York

Aries and Sclar (1998) performed a case study of biomedical research in the New York metropolitan region. They found that $1.15 billion spending on biomedical research in 1991 resulted in $2.3 billion direct and indirect ripple effects on the regional economy. This spending directly generated 19,816 jobs per year in the research institutions and indirectly created 12,773 additional jobs.

Canada

Martin (1998) found that the dynamic impact of academic research is well beyond its estimated static impacts. The study estimated that university research in Canada generated $5 billion of GDP and created 81,000 jobs, which was almost 1 percent of Canada's 1994-1995 GDP, and more than 0.5 percent of total annual job creation. However, the dynamic impact of university research was well beyond the static impact, which was estimated as $15.5 billion each year.

In summary, the economic impact studies range from a short time frame using research development expenditures to determine economic impact, to more extensive analyses including socioeconomic benefits of the academic research on state and local economies. All related studies confirm the significant direct and indirect impacts of academic research on local economies in terms of increases in production, employment, invention, innovation and human capital.

II. University Research as an Economic and Technological Innovation-Incubator and Industrial Partner

This section reviews survey and other evaluation case study and quantitative methods that track both technological innovation and graduates from university programs that are spinoffs from existing university research. The critical role that university research plays in both technological development and economic growth has received increased attention in the past few decades and has been well documented by numerous researchers (Brooks & Randazzese, 1998; Florida & Cohen, 1999; Kennedy & Davis, 2003; Mowery, Nelson, Sampat & Ziedonis, 1999).

Research has tracked the development of a particular product line or individual researcher graduating from specific universities, and evaluated the economic and social value of the product or individual that germinated in the research environment. This method of evaluating university research serves as the core of what is often considered the primary applied mission of university research: to partner with industry and create products across all fields of human endeavors.

One study (BankBoston, 1997) evaluated the value on the economy and employment from industries generated through the Massachusetts Institute of Technology (MIT). They estimated that "if the companies founded by MIT graduates and faculty formed an independent nation, the revenues produced by the companies would make the nation the 24th largest economy in the world. The 4,000 MIT-related companies employed 1.1 million people and had annual world sales of $232 billion."

Another study conducted in the early 1990s by the Stanford University licensing office compiled information about technology-based companies founded by members of the Stanford community. Aggregate estimates of roughly $31 billion in revenues are attributed to firms in the San Francisco Bay area.

Stackpoole (2003) used a multivariate model to study the effects of university technology-transfer activity on the vibrancy of U.S. metropolitan economic activity. The results of his study indicate that university research activities have a significant positive effect on U.S. metropolitan economic activity. He further concludes that the development and maintenance of leading-edge research centers and educational institutions is a critical long-term, economic growth strategy for states and metropolitan areas.

Berman (1990) examined the economic impact of industry-funded university R&D based on data for the years 1953-1986. He found that industry-funded university R&D resulted in increased technological innovation in industry.

In literature, a new concept, "entrepreneurial university," is used to emphasize the importance of academic research as a driving force behind economic growth (Huggins & Cooke, 1997). Figure 9 presents academic research as an incubator in the economy.

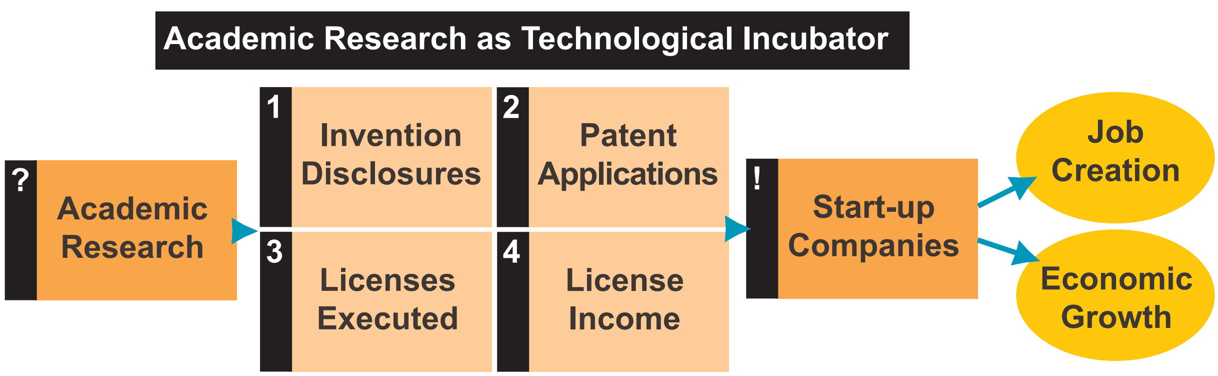


Figure 9. **Academic Research and Start-up Companies**

The AUTM *Licensing Survey* collected found the following for the FY 2004 (AUTM 2004):

- 16,871 invention disclosures reported
- 10,517 new U.S patent applications filed
- 3,680 U.S patents issued
- 567 new commercial products launched, bringing the total number of new products close to 2,000 in the last four years (1996 total)
- 462 new companies established as a result of academic research in addition to 4081 since 1980
- Universities generated more than $1.1 billion in royalties on product sales ($1.122 billion)
- 4,783 new licenses and options executed, bringing a 6.1% increase in new licenses and options executed

Figure 10 summarizes the number of new company startups formed between 1994 and 2004 as well as the number of new U.S patents applied for by the universities in the survey over that period. The number of new companies spinning out from this research increased by 118% over this period while the number of patents applied for climbed by a significant 102%.

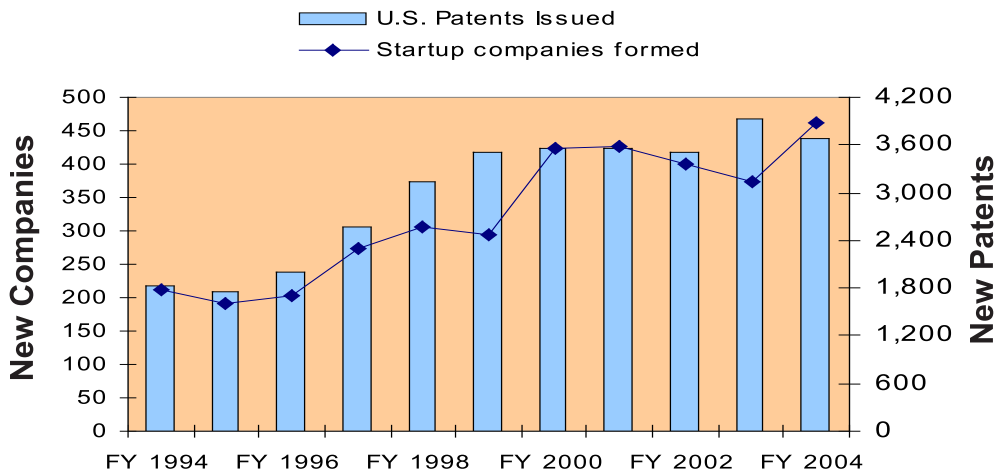


Figure 10. **New University Patents and Start-Up Companies Formed, 1994 – 2004**

III. University Research in Non-Quantitative Economic Externalities (socioeconomic – health care, social services, environmental quality and services, quality of life, etc.) Terms

Beyond these primary economic research areas, a wide range of important non-monetized quality-of-life evaluations document and highlight the important societal benefits of university research. University researchers are noticeably improving the quality of life in ways that economic models cannot capture. For example, improved knowledge of the past from archaeological or anthropological evaluations, as well as the development of social science disciplines, has improved the quality of life. University research funding supports “quality” assessment projects ranging from environmental damages mitigation to social services research (e.g., medical care across all areas of service for all ages, enhancements in elder care, child care, care for people with disabilities).

In FY 2001, the NIH received $20.3 billion to support its mission to expand our knowledge of living beings; to lead development and improvement of new strategies for the diagnosis, treatment, and prevention of disease; to reduce the burdens of disease and disability; and to assure a continuing cadre of outstanding scientists for future advances.

In May 2000, the U.S. Congressional Joint Economic Committee (JEC) issued The Benefits of Medical Research and the Role of NIH, which states that the benefit of increased life expectancy in the U.S. as a result of advances in health care creates annual net gains of about $2.4 trillion (in 1992 dollars). The committee concludes that, “if only 10 percent of these increases in value ($240 billion) are the result of NIH-funded medical research, it indicates a payoff of about

15 times the taxpayers' annual NIH investment of $16 billion." (JEC)

The JEC report estimates the rate of return from NIH-funded research to be between 25% and 40% a year. JEC estimated the economic costs of illness at $3 trillion annually. The NIH medical research discoveries result in spillover benefits by reducing 1) lost wages due to mortality and illness, 2) expenditures on health care and treatment of disease, and 3) intangible costs of pain and suffering caused by disease.

Additional researchers (Davis, T., 2003) have documented university research related gains for all citizens in the areas of:

- Environmental quality
- Arts and culture
- Library and information technologies access
- Community outreach and volunteerism
- Athletics, recreation and youth summer recreation

IV. University Research Impact On Student Human Capital Development Growth

Excellent classroom instruction, sufficient training opportunities, and adequate prospects for engaging in public service define student success in a university and ultimate success thereafter as productive workers in the knowledge economy. As social institutions, universities play an important role in sustaining present society by providing competent workers, new technology and various knowledge bases.

Historically, American colleges and universities have been developed as teaching institutions, especially for undergraduate instruction (Geiger, 1990; Whiston & Geiger, 1992). According to Gross's research about the goals of the university (Gross, 1968), research goals such as basic research and applied research ranked 7th and 12th out of 47 important goals of universities, respectively. Furthermore, as the 6th rank goal, training students in the methods of scholarship and scientific research was ranked even higher as a research-related university goal.

According to the findings by the Florida Council for Education Policy, Research and Improvement (CEPRI, 2003), 81.8% of student activities in research centers in Florida public universities concentrate on research and training. Student success in higher education is a result of excellent instruction and training.

According to a study conducted by Kent Hill at the Center for Business Research at Arizona State University, private industry in the United States performs more than 90 percent of development and about 70 percent of applied research; therefore, industry accounts for almost three-quarters of total U.S. R&D. However the impact of industry research clearly depends on University research. Typically, students assist with research and help transfer research findings to industry. As Hill mentions, one of the advantages of teaching and research is that students are involved in the research process. As mentioned by Feller (1999), students who are involved in research can serve as a conduit to transfer new research findings to industry.

According to “The Center” at University of Florida in July 2001, the definition of a Research University involves two primary characteristics:

- Universities compete successfully for federal research funds. Major research institutions spend at least $20 million a year from these sources, while other research institutions spend less.
- Research universities are regionally accredited institutions whose academic programs award accredited academic degrees.

In addition, “The Center” determined the following nine measures that provide reference points for identifying the top research universities in the United States: Total research expenditures; federal research expenditures; endowment assets; annual giving; faculty members in the National Academies; faculty awards; doctoral degrees; postdoctoral appointees; and entering freshmen SAT scores. Clearly, The Magnet Lab contributes greatly to Florida State University with respect to these measures.

Notes:

Appendix B

IMPLAN model background

IMPLAN was founded in 1993 as an extension of two researchers' work at the University of Minnesota and involving collaborative work with the U.S. Forest Service Land Use Planning Unit in Colorado. It is non-survey based, and its structure typifies that of input output models found in the regional science literature. IMPLAN assumes a uniform national production technology and uses the regional purchase coefficient approach to regionalize the technical coefficients. IMPLAN 2002 Florida state-level (current version) was used for the economic analysis for this research. This newer version now has 509 sectors (instead of 528) and includes the conversion from standard industrial classification (SIC) to North American Industrial Classification System (NAICS) codes. The model generates a number of types of multipliers: Type I, Type II, and the Type SAM (Social Accounting Matrix) multipliers. The difference between IMPLAN's Type I and Type II and SAM multipliers is an induced consumption effect. Type I multipliers yield the direct and indirect effects only. Type II multipliers present the direct, indirect and induced effects, based on income. SAM multipliers are also based on direct, indirect and induced effects, however, they're based on information from the social accounting matrix. They include Social Security and income tax leakage, institution savings, and commuting. Multipliers are generated for employment, output, value added, personal income, and total income.

IMPLAN builds its data from top to bottom. National data serve as control totals for state data. In turn, state data serve as control totals for county data. The primary sources of employment and earnings data are County Business Patterns data and Bureau of Economic Analysis (BEA) data. IMPLAN estimates output at the state level by using value added reported by BEA as proxies to allocate U.S. total gross output. Also, IMPLAN allocates state total gross output to counties based on county employment earnings.

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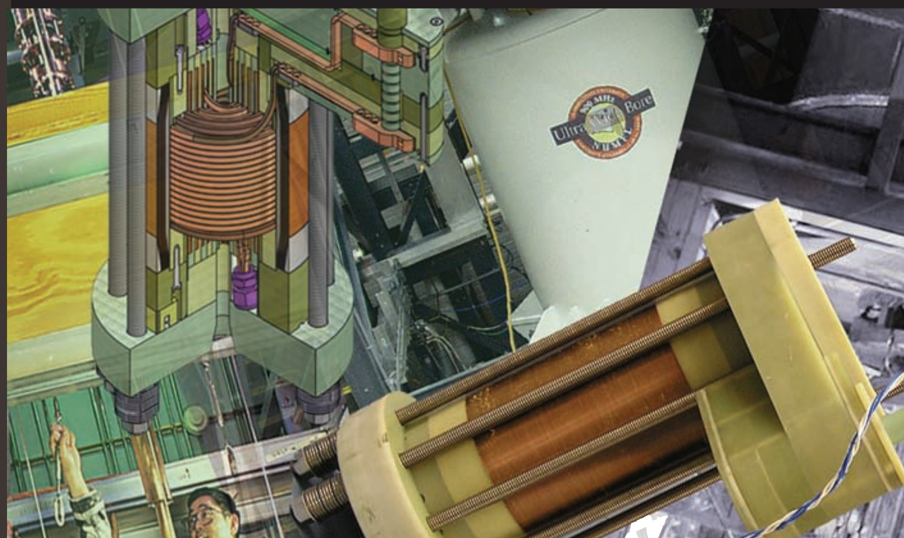

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