Final Report

The Economic Impact of the National High Magnetic Field Laboratory (NHMFL or "MagLab")

Center for Economic Forecasting and Analysis,
Florida State University

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Executive Summary

The MagLab requested that an economic impact study be conducted in 2014, as it marks the twentieth year of the opening of the MagLab's scientific user program. The economic research project undertaken by FSU CEFA involved data compilation and economic impact analysis of the MagLab annually and projected over the next twenty years on the Tallahassee metropolitan statistical area (MSA), the state of Florida and the United States.

Economic impacts are effects on the levels of activity in a given area. They may be expressed in terms of 1) business output (or sales volume) 2) value added (or gross regional product) 3) wealth (including property values) 4) personal income (including wages), or 5) jobs. Any of these measures can be an indicator of improvement in the economic well-being of area residents. The net economic impact is viewed as the expansion (or contraction) of an area's economy, resulting from changes in a facility or project, or in assessing the economic impact of an already existing facility or project. Economic impacts are different from the valuation of individual user benefits and the broader social impacts (amenity value) of a facility or project. However, assuming they can be quantified, they may be included to the extent they affect an area's level of economic activity. Short-term economic impacts are the net changes in regional output, earnings, and employment that are due to new dollars entering into a region from a given enterprise or economic event. The following economic impact analysis report provides a summary of the local, state and national area economic impacts (in 2014 dollars) associated with the MagLab.

In order to obtain estimates of the different types of macroeconomic effects of the MagLab on the Florida economy annually and over the next twenty years, the project team applied a well-established analytical tool known as the IMPLAN model. The IMPLAN Model (2012 data), an input output model, was used to perform the economic modeling analyses. The historical (actual data from years 1990-2013) was provided by the MagLab finance and budget staff, and included capital outlay, equipment, salaries/wages, among other data. For example, over 700 MagLab researchers reside in the Tallahassee area, paying property taxes totally approximately $1.56 million in 2013. More than 1,100 research facility users and 15,700 visitors travel annually to the MagLab from around the world to perform research activities using its unique facilities and scientific capabilities.

This economic impact analysis study provides a short-term perspective, and its associated economic impacts on the Tallahassee, state and national area economies. The economic impact model, an input-output model, included cross linkages between every sector of the economy within these areas. The effects of expenditures external to the Tallahassee, state and nation (termed leakages) are not included in the economic impact estimates. However, as the regional level covers a larger economic area then the county level, a greater portion of direct expenditures are captured, resulting in less leakage at the regional level.

The following table(s) presents the total economic impacts, and the direct, indirect, and induced economic impact results, respectively, in nominal dollars. The impacts were measured with respect to output (or sales/revenues), employment (or jobs), and income (or wages). The output generated represents the value of final goods and services produced across the Tallahassee, state and national area economies, respectively, as a result of the expenditures generated by the MagLab activities. The direct impacts measure the immediate effects as a result of the MagLab-related expenditure generated activities in the Tallahassee area; e.g., in employment and income. Indirect impacts are those that include changes to production, employment, income, etc., that occur as a result of the direct effects. Induced impacts are those further impacts of spending derived from direct and indirect activities – i.e., MagLab-related household purchases of consumer goods and services.

Annual Benefits to the City of Tallahassee, State of Florida and the Nation

Regarding the economic impact analysis results, the project research team found that in the Tallahassee MSA area the MagLab annually generates:

- $90 million in economic output;
- $34 million in income;
- while generating more than 1,150 jobs.

In the Florida area, the MagLab annually generates:

- $121 million in economic output ;
- $51 million in income;
- more than 1,200 jobs.

Nationwide, the MagLab annually generates:

- $182 million in economic output;
- $73 million in income;
- more than 1,500 jobs.

The project research team found that the MagLab generates annually (based on annual average expenditures) for the Tallahassee MSA, State and Nation respectively:

Annual Impacts	Output	Employment	Income
Tallahassee MSA	$89.9 million	1,157 jobs	$34.2 million
State of Florida	$121.2 million	1,255 jobs	$50.6 million
National	$182.0 million	1,562 jobs	$73.4 million

In addition, the annual economic impacts of visitors to the MagLab facilities are:

Annual Visitor Impacts	Output	Employment	Income
Tallahassee MSA	$2,081,205	19 jobs	$582,452
State of Florida	$2,821,673	23 jobs	$977,450
National	$4,121,581	29 jobs	$1,358,407

The economic impact of visitors to the MagLab is sizeable. Nationally, the visitor impacts are $4.1 million and $1.4 million, in output (sales/revenues) and income (wages/salaries) respectively, while generating an additional 29 jobs.

Projected Economic Impact of the MagLab Over the Next Twenty Years

The total projected state investment in the MagLab (i.e., $377 million) over the next twenty years (2014-2033) is projected to generate across the Tallahassee MSA, state and nation, respectively:

- $1.8 billion in economic output;
- $680 million in income;
- while generating more than 23,000 jobs.

In the Florida area, the MagLab is projected to generate:

- $2.4 billion in economic output;
- $1.0 billion in income;
- more than 25,000 jobs.

Nationwide, the MagLab is projected to generate:

- $3.6 billion in economic output;
- $1.5 billion in income;
- more than 31,000 jobs.

Years 2014-2033	Output	Employment	Income
Tallahassee MSA	$1.8 billion	23,136 jobs	$683.2 million
State of Florida	$2.4 billion	25,109 jobs	$1.0 billion
National	$3.6 billion	31,240 jobs	$1.5 billion

The results of the economic analysis indicate that the MagLab performs a significant role in the local Tallahassee MSA, the state of Florida, and the national economies. The economic benefits include large additions to employment, economic output, personal income, and tax revenues.

Annual Return on Investment to State of Florida

The annual benefits within the Florida economy are defined as the economic impacts resulting from the annual state investment in the MagLab and the economic activity brought into Florida (via contracts and grants, government and private sponsors, auxiliary fees/services, and other external sources), resulting in the following return on investment (ROI) ratios:

Annual Benefits to the State of Florida	Annual Benefits from MagLab Economic Activity	Benefits from Visitors to MagLab	Total Annual Benefits	ROI from State Investment
Output	$121,178,367	$2,821,673	$124,000,040	6.57
Employment	1,255	23	1,278	5.60
Income	$50,622,759	$977,450	$51,600,209	5.55

The results of the economic analysis indicate that the MagLab provides a large rate of return on the investments made by the state of Florida. The economic benefits include large additions to employment, economic output, personal income, and tax revenues.

- Benefit to the state = $124 million
- Cost of the state investment = $18.86 million
- Thus, for every dollar of state money invested in the MagLab, $6.57 is generated by the MagLab in economic activity for the State of Florida.

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I - Introduction and Overview of the National High Magnetic Field Lab

In August 1990, the National Science Foundation awarded the National High Magnetic Field Laboratory (NHMFL; aka the "Magnet Lab" or "MagLab") to Florida State University, in Tallahassee. The MagLab also includes sites at the Los Alamos National Laboratory (LANL) in New Mexico and at the University of Florida (UF) in Gainesville. Each site conducts research on a series of unique and self-designed magnets which has resulted in wide-reaching technological and economic impacts. Tallahassee is the headquarter location and home to the largest of the three facilities (at 370,000 square-feet).[1] With strong MRI machines, scientists at the MagLab also use high magnetic fields to better understand living things from cells to disease proteins. High magnetic field research is also playing an increasing role on the way people store and deliver energy. This high degree of specialization attracts and employs some of the top scientists from around the globe, as well as spurs the growth of local related industries.

As of early 2014, the MagLab employs over 702 affiliated staff representing 52 countries, including over 38.7percent with PhD's. The lab's paid and affiliated staff in turn support outside user research, conduct in-house research, and contribute to the scientific community. Figure 1 shows the breakout of MagLab facility by the percentage of total staff. More than 1,100 MagLab research facility users[2] and 15,700 visitors[3], visit annually from around the world for research activities. The user community, in addition to in-house and affiliated staff, is composed of scientists, researchers, and technicians from locations around the world. They are broken into user groups based on the facility that suits their research needs; however, their research is not always limited to a single user facility. Alongside the user community, the MagLab receives grants for cooperative research

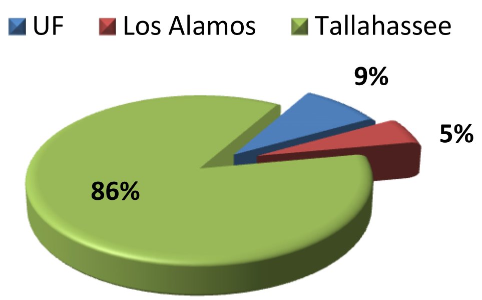

Figure 1: Employees by MagLab Location (Year 2013)

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[1] The Magnet Lab at Florida State University (Tallahassee), from http://www.magnet.fsu.edu/about/tallahassee.html

[2] From http://www.magnet.fsu.edu/usershub/

[3] Visitors for 2013 included: over 10,000 K-12 students, undergraduates, graduate students, and more than 200 teachers. The MagLab Open House attracted 5,500 visitors. On Family Day, there were 140 visitors to LANL. From: http://www.magnet.fsu.edu/mediacenter/publications/reports/annual_reports/2013/annualreport_2013.pdf

projects between staff and users. These grants are allocated based on scientific merit and impact. In addition to this, the MagLab's in-house research and development program, or User Collaboration Grant Proposals, aim to improve magnet related technology and to provide support to user projects. This includes the Applied Superconductivity Center, Cryogenics facility, and the Magnet Science and Technology department, among others.

The FSU MagLab's Center for Integrated Research and Learning (CIRL) provides science education programming to K-12, undergraduate, graduate and postdoctoral academic levels. Although CIRL is based in Tallahassee, it also places interns, teachers, and undergraduate students in research positions in the Tallahassee, Los Alamos, and UF locations.

Advanced Magnet Research

FSU faculty researchers and visiting scientists regularly conduct research at the MagLab and publish their findings in many prestigious journals – including: *Nature, Science, Physical Review B, IEEE Transactions on Applied Superconductivity, Applied Physics Letters, Journal of Magnetic Resonance,* and *Journal of Physics: Condensed Matter,* and *Journal of American Chemistry Society* – among many others. In the last few years, the MagLab made many new discoveries resulting from their research. The Applied Superconductivity Center – an integral part of the MagLab – has had two very recent breakthroughs that have sparked much interest in the scientific community.

One MagLab physicist, with assistance from various collaborators, recently published an exciting study in *Nature Physics* that has resulted in scientists reevaluating previous research findings.[4] Researchers made a startling discovery regarding the nature of superconductivity in the presence of magnetic fields. The main objects of research are superconductors, composite materials which conduct electricity without resistance at extremely low temperatures. Superconductors also lose conductive property at high temperatures – or with the presence of a magnetic field that's too strong. The study examined a superconductive compound ($La_{2-x}Sr_xCuO_4$ - a compound made from lanthanum, strontium, copper, and oxygen) as it transitioned from conducting electricity freely, to insulating it. Previously, it was thought that the process was immediate and direct: from conducting, to not conducting. However, the groundbreaking result shows it is actually a two-stage process, with an intermediate stage. In the field of superconductivity, this breakthrough has many experimental scientists rethinking their past positions as they begin to piece together this new discovery with previous theories of quantum physics.

[4] MagLab physicists publish trailblazing study on superconductivity, from http://news.fsu.edu/

Another recent result from the Applied Superconductivity Center is a new way to process superconductive "BSCCO" wires (formally known as Bi-2212).[5] This is a major improvement for the construction of many types of high-powered magnets including high-field nuclear magnetic resonance magnets, a Muon Accelerator such as the one at Fermilab, or even the Hadron Collider, at CERN. Previously, magnet research using BSCCO wires were limited to thin, flat ribbons. However, the new process developed at the MagLab gives the option for round BSCCO wires. This is much preferred for magnet construction due to higher possible electric currents and is more feasible in creating the complex, winding coil shapes required by large magnets. Scientists from the MagLab determined that a simple change in shape has attributed to a 10-fold increase in the critical current density for BSCCO wires.

Much research at the MagLab has a broader scope than the advancement of magnet related sciences. One recent breakthrough may have a substantive impact on the future treatment of cancer.[6] There are two user facilities in the MagLab that specialize in magnetic resonance imaging, or MRI technology[7]. Research at the MagLab has led to a new process for imaging sodium in the body. The levels of sodium in cancer cells have been proven to correspond with how resistant they are to chemotherapy – or as a measure of how well the current treatment is working. A special imaging technique called "diffusion MRI" tracks the movement of water, and, when combined with sodium imaging, has major implications. This means it is now possible for researchers to detect within hours if the treatment is working. Previously patients needed to wait weeks, or even months to determine the effectiveness of a particular cancer treatment. This constitutes a major potential improvement for the effective treatment of cancer, and has a huge possible impact on many patients' lives.

II - MagLab Funding Sources

The research contracts and grant awards generated by the MagLab's seven different user facilities stem from a variety of sources - many from locations across the nation and even the world. This funding is separated into three categories: funds from the state of Florida, funds through the NSF Core Grant (or Core Award), and funds that are non-state, non-NSF Core Grant which includes any private or non-NSF Core federal funding sources. The NSF Core Grant defines the central mission of the MagLab to maintain and operate world-class infrastructure for magnet researchers. For the purpose of this report, any funding that is

[5] MagLab Researchers Make Superconducting Breakthrough, from http://www.magnet.fsu.edu/

[6] Sodium Science: Sodium MRI techniques point to better cancer treatments, from http://www.magnet.fsu.edu/mediacenter/publications/flux/issue10/sodium_science.html

[7] One user facility is located in Tallahassee, the other facility is located at UF-ARMIS.

not from the state of Florida or from the NSF Core Award is labeled as "Other Grants". In total, non-state funds now comprise around 70 percent of total MagLab funding – a large portion of this coming from the National Science Foundation. There is also a large amount of other grant funding, which as stated previously, comes from numerous federal and private sources. Figure 2 depicts total MagLab funding by source over the years 1990 – 2013.

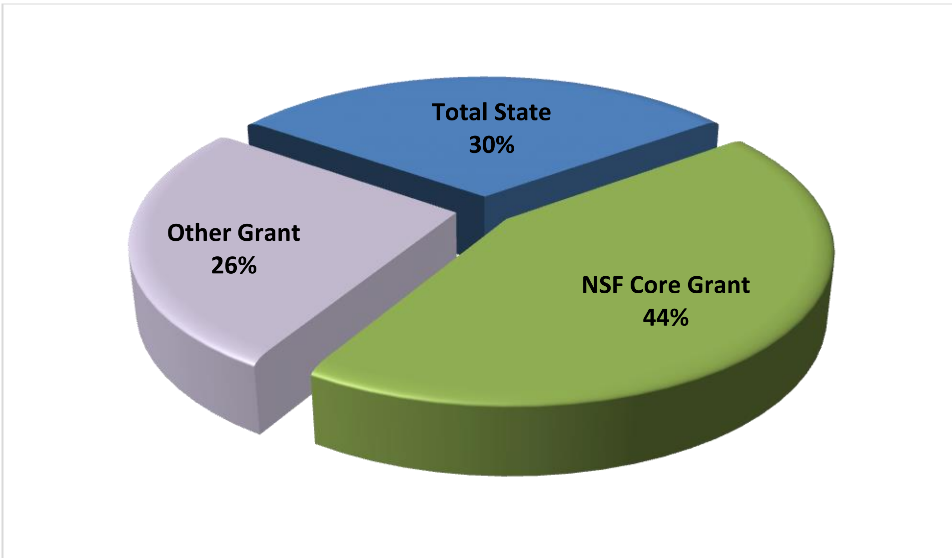

Figure 2: Sources of MagLab Funding (from Years 1990 -2013)

Research from high magnetic fields can be used to further develop, analyze, and improve materials and technologies. In this report, FSU CEFA researchers focus on the economic impacts, to employment, output, and income, generated by the MagLab over time.

Figure 3 depicts the total amounts of annual funding received from years 1990 until 2013, broken down by each source of funding. Conditional on the NSF awarding of the MagLab to Florida State University, the state agreed to pay for the initial building construction and the capital equipment necessary to get the facility up and running. The continued investment by the state has also helped to leverage the success of the MagLab. After the initial investment by the state, the NSF has provided the majority of MagLab funding in the form of five-year renewable awards. In addition to this NSF core award, the growing amount of funding from other grants has become a larger component of overall MagLab funding.

As the figure below shows, the contribution of state money significantly dropped after the completion of the MagLab facility construction; however state funds remain steady through FSU and UF State Operating funds and Board of Governors utility funding. In 2005, a large, single year infrastructure grant was received from the state, and in 2013, the level of state funding received an annual increase from the state. The figure also illustrates how other grant funding is contributing an increasing share of total MagLab funding when compared to the MagLab's earlier years.[8]

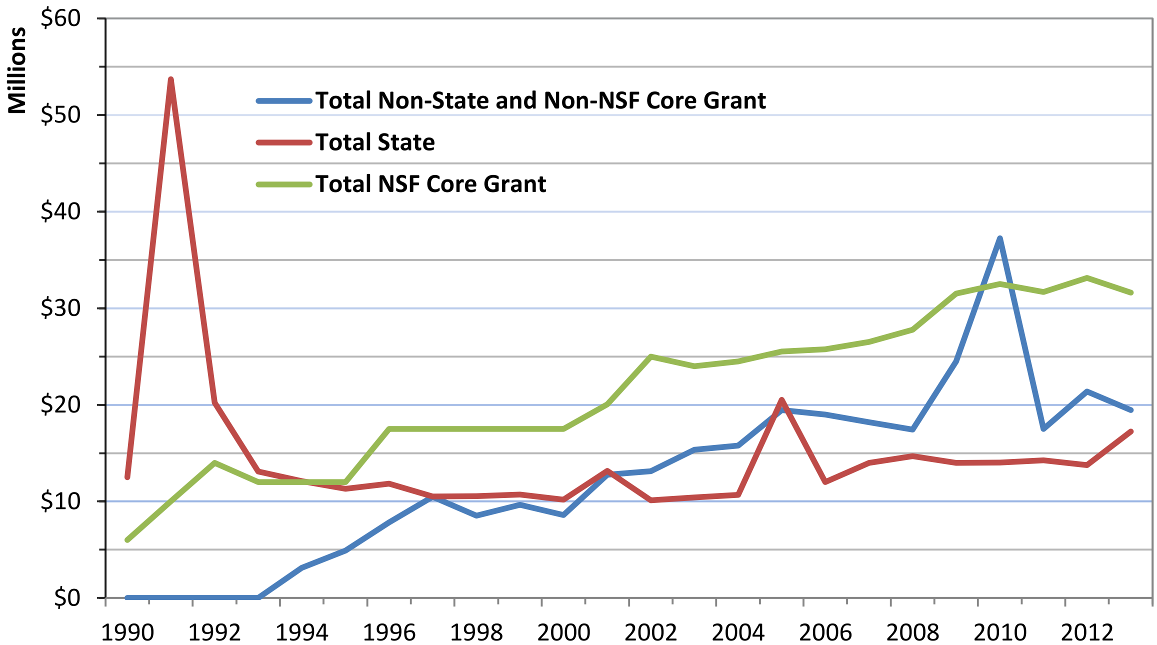

Figure 3: Comparison of Historic MagLab Funding by Source (Years 1990-2013) in Nominal Dollars

Figure 4 depicts a comparison among the different sources of funding for the MagLab. The shaded area represents CEFA's projected funding to Year 2033 by source, for the MagLab.

[8] It should be noted that although the share of private PI grant awards are increasing, these awards are not included as a share of the overall operations and maintenance funds. The spike in Other Grants around 2010 is due to major awards including the MagLab's Series Connected Hybrid grant, the 32T All-Superconducting Magnet, the Cross NIH grant, and the 21T Ion Cyclotron Resonance Magnet grant, as well as the contract for the Helmholtz Zentrum Berlin Series Connected Hybrid Magnet.

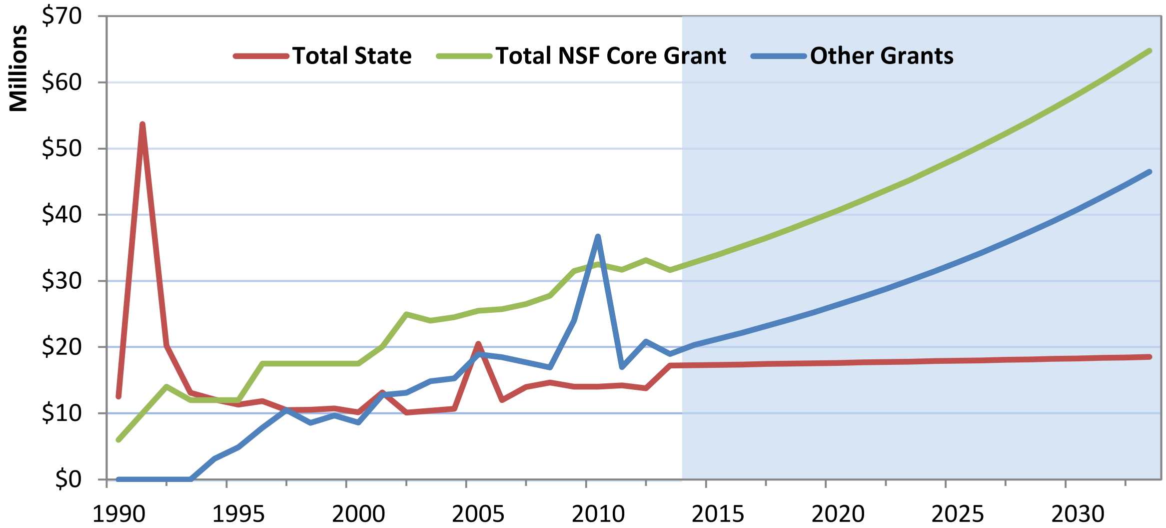

Figure 4: Comparison of Historic and Forecasted MagLab Funding by Source (Years 1990-2033) in Nominal Dollars

For purposes of our economic projections, we extrapolate from existing trends such that funding from other grants is projected to increase in the future with relatively little growth in state funding projected. On the other hand, the state comprises a significant portion of MagLab funding. Between the years 2009-2013, state funding totaled $82.9 million dollars, representing 23 percent of total MagLab funding over that timeframe.

Revenues

A specific breakout of the MagLab's funding (since construction in 1990) can be seen in Figure 5 and Table 1. The NSF Core grant is the largest component of MagLab funding at 44 percent of total revenue, while State Operating funds comprise 16 percent. The "Other Sources" category includes any non-state, non-NSF Core grants and PI awards. Other Sources contribute to 15 percent of the total; however, this source of funding in recent years has played a larger role in research funding at the MagLab. The UF category in the pie chart below is comprised of UF State Operating, NSF Core funding, and other Grant Support received by the UF site.

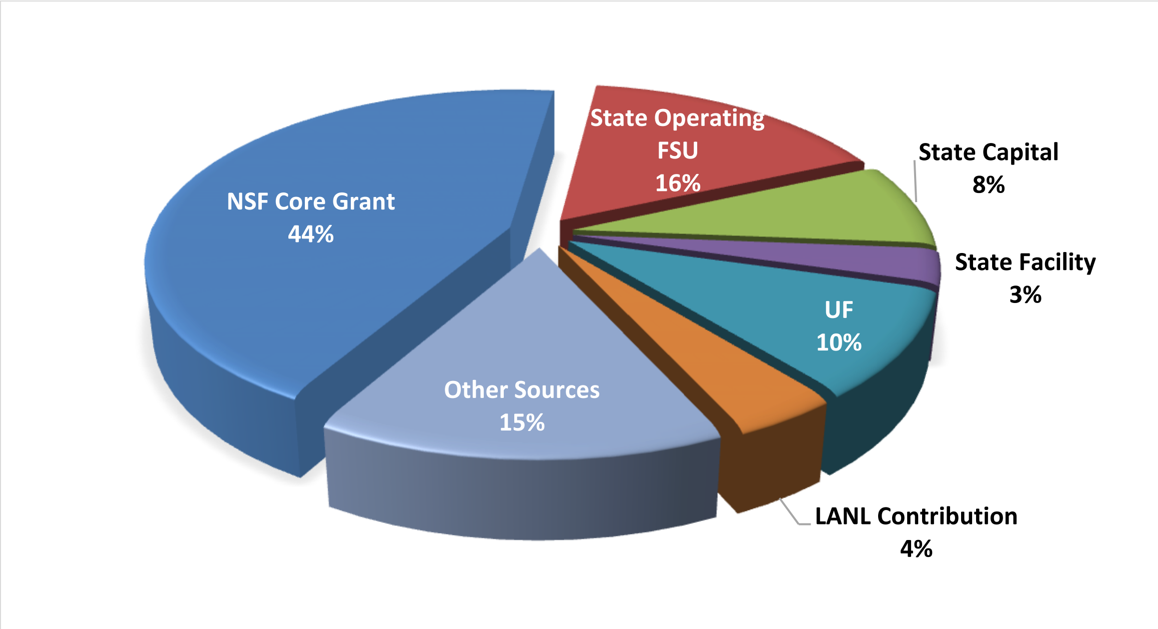

Figure 5: Percentage of MagLab Funding by Source (Years 1990-2013)

Table 1: Breakdown of MagLab Funding by Source (Year 2013 and Years 1990-2013) in Nominal Dollars

MagLab Funding Source	2013		1990 – 2013	
	Amount	% of Total	Amount	% of Total
NSF Core Grant	$ 31,622,000	46.30%	$ 512,923,547	43.74%
State Operating FSU	$ 12,710,428	18.61%	$ 190,738,736	16.26%
State Capital	$ -	0.00%	$ 92,850,000	7.92%
State Facility	$ 1,496,000	2.19%	$ 36,880,000	3.14%
UF	$ 8,581,822	12.56%	$ 114,421,930	9.76%
LANL Contribution	$ 3,305,400	4.84%	$ 46,594,105	3.97%
Other Sources	$ 10,584,737	15.50%	$ 178,322,310	15.21%
Total Funding	**$68,300,387**	**100%**	**$1,172,730,628**	**100%**

The following Figure 6 depicts MagLab funding items broken into five-year intervals to reflect relative changes in different types of funding over time. This gives a clearer picture of the trends with respect to the MagLab's various funding types. State Capital comprised almost 50 percent of total funding for the first five-year interval. The dotted lines show polynomial trends of the NSF Core Grant and Other Sources of funding. For the NSF Core Grant, this shows an upward trend in funding amounts after the initial construction period, then leveling out at an average of about 42 percent of the MagLab's total funding. As the MagLab matures, the trend line for other grant sources shows a steady increase in the other sources percentage of total funding.

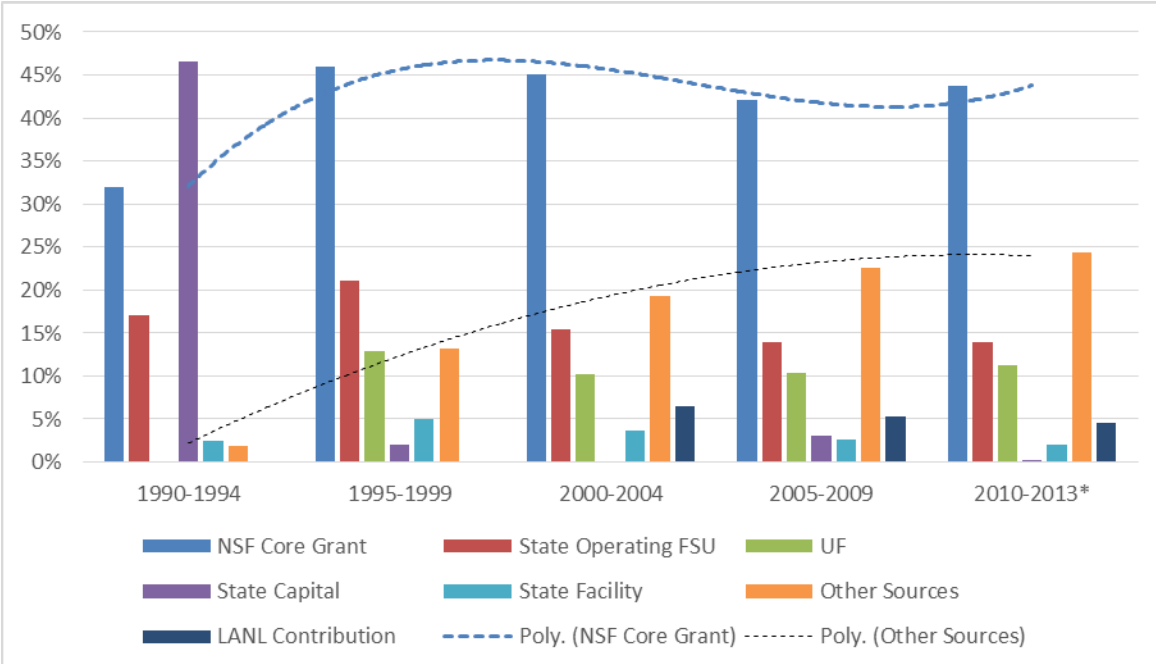

Figure 6: MagLab Funding by Source, Percent of Total Five Year Intervals (Years 1990-2013)

Similar to the previous Figure 6, the following Figure 7 shows the total MagLab funding stream over time by percentage of sources. The funding sources are further simplified into state funding, the NSF Core Grant and other grants funding. Shown are percentages of total MagLab funding, which are relative to the total amount of funding. This depicts the large initial investment by the state, as well as the NSF Core Grant, and increasing amounts of other sources of grant awards.

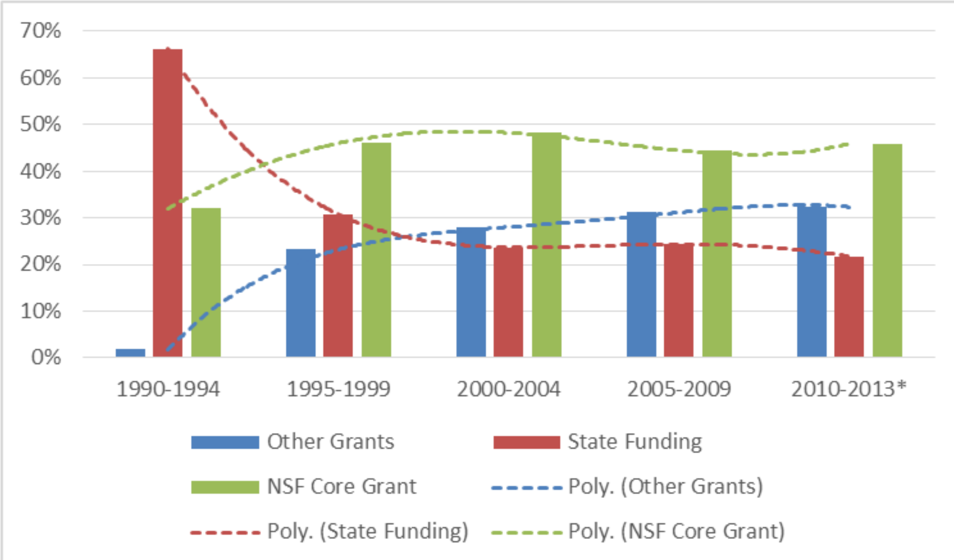

Figure 7: MagLab Funding by Source, Percent of Total Five Year Intervals (Years 1990-2013)[9]

State Funding

Historically speaking, for the years 1990-1993, the total amount of money the state provided for the MagLab facility construction was $76 million. Adjusting for inflation, this is equivalent to about $135.4 million (in nominal 2013 dollars). This initial investment by the state was for the startup construction of the Tallahassee facility, as well as initial equipment purchases necessary to get the facility operational. Although those initial years assumed a large component of the state's funding to the MagLab over time, the state of Florida continues to be an important source of ongoing funding for the MagLab. In 2005, there was an injection of $10 million dollars in State Capital funding allotted for needed infrastructure upgrades at the FSU and UF branches. At the conclusion of Florida's 2012 Legislative Session, $3.3 million annual recurring funds were signed into the State Operating budget.[10] This contributes to a 21 percent increase from the previous year of total state spending on the MagLab and a 35 percent increase in State Operating FSU. After this increase, state spending is projected to remain stable at around $20 million until 2033 except for an occasional small increase in wages and increases in money received from Sponsored Research and Development (SRAD) distribution. Table 2 provides the total

[9] Years 2010-2013 represents only a three year period, but is still meaningful as it reflects total percentages of funding over the given range.

[10] 2012-2013 Allocation Summary and Workpapers, Education and General, State University System of Florida Board of Governors.

amount of state of Florida funding the MagLab has received, by source, for year 2013, and for years 1990 - 2013.

Table 2: Breakdown of State Funding (2013, 1990-2013) in Nominal Dollars

State Funding Sources	2013		1990-2013	
	Amount	% of Total	Amount	% of Total
FSU State Operating[11]	$12,710,428	73.81%	$190,738,736	53.65%
State Capital and Equipment	$0	0.00%	$92,850,000	26.12%
State Facility [12]	$1,496,000	8.69%	$36,880,000	10.37%
UF State Operating	$3,013,347	17.50%	$35,055,809	9.86%
Total State Funding	**$17,219,775**		**$355,524,545**	

Non-State Funding

After the initial construction of the MagLab was completed in 1993, the NSF CORE funding leveraged additional sources of funding to support and sustain non-operations growth of the MagLab facility. Table 3 provides a breakdown of the total amount of funding received from non-state sources for year 2013, and over time.

Table 3: Breakdown of Non-State Funding (Years 2013, and 1990-2013) in Nominal Dollars

Non-State Funding Sources	2013		1990-2013	
	Amount	% of Total	Amount	% of Total
NSF Core Grant	$ 31,622,000	61.91%	$ 512,923,547	62.77%
FSU Other Sources/Grant Support and Contribution[13]	$ 10,584,737	20.72%	$ 178,322,310	21.82%
UF Grant Support and Contribution	$ 5,568,474	10.9%	$ 79,366,121	9.71%
LANL Contribution	$ 3,305,400	6.47%	$ 46,594,105	5.70%
Total Non-State	**$ 51,080,612**	**100%**	**$ 817,206,083**	**100%**

[11] FSU and UF State Operating expenditures pertain to: salaries/wages, and corresponding benefits.

[12] Personal Communication, Mr Clyde Rea, Finance Director of the MagLab. The state facility can be equated with "POM", or "Planned Operations Maintenance", and it represents the per square foot cost of FSU maintenance of the MagLab's physical plant and grounds.

[13] Other sources include any non-state, non-NSF Core grants and PI awards.

The amount of non-state funding has continued to grow. These funds have been an important economic stimulus over the years. Figure 8 shows the total cumulative funding forecast of both state and non-state funding through Years 2033, with non-state funding broken into the NSF Core Grant and other grant sources.

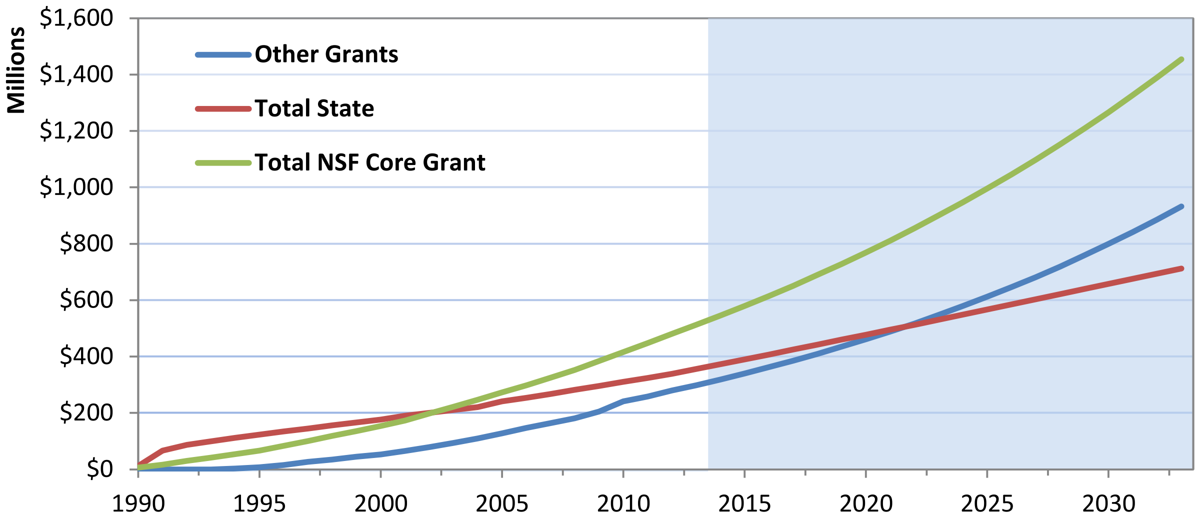

Figure 8: Comparison of Historic and Forecasted MagLab Cumulative Funding by Source (Years 1990-2033) in Nominal Dollars

As shown in the figure above, it took 13 years (2003) until cumulative spending by the state of Florida was surpassed by the cumulative NSF core grant amount. Using the forecasted amounts, state spending is estimated to comprise 23 percent of total funding by year 2033. Funding obtained from "other grant" sources is expected to surpass the cumulative funding amount from state sources by 2022.

National Science Foundation (NSF) Funding

The National Science Foundation has provided the MagLab with five-year awards since the initial establishment of the Tallahassee headquarters. These awards continue to support the partnership of FSU, UF, and LANL, and to maintain the lab's headquarters in Tallahassee. In the economic impact model, calculations are made under the assumption that the MagLab will continue to receive financial support through the NSF Core Award through 2033.

Other Sources of MagLab Funding

In recent years the MagLab has been acquiring an increasing amount of other non-NSF non NSF Core, non-state funding – which we include in the figures as "Other Grants". This includes any grant money brought to the MagLab by staff, royalties, magnet construction for other laboratories, and other large federal grants. The MagLab is becoming more specialized in the construction of unique magnets for others, utilizing the skills of MagLab's engineers and promoting magnet research on a global level. Since this contributes to revenues for the university and MagLab, it is included in the economic impact model and assumed that in the future the MagLab will continue to produce high quality magnets for patrons.

There are a large number of MagLab staff members who bring in projects from various departments to conduct magnet research. To examine the breadth of research associated with the MagLab, we compared grant awards obtained by MagLab faculty with the project departments associated with each grant award or contract. Table 4 shows the total percentage breakout by the project grant award's department. There are 21 project departments, with, for the sake of brevity, the lowest percentage shares (i.e., less than Chemical Engineering) grouped as "All Other Departments".

Table 4: Breakdown by Principal Investigator of Grant Funding by Project Department (Years 1996 – 2017)

Project Department	Amount	Percent of Total
National High Magnetic Field Lab	$76,434,136.83	50.20%
Chemistry & Biochemistry	$17,080,698.47	11.20%
Center for Advanced Power Systems	$12,489,190.99	8.20%
Applied Superconductivity Center	$11,610,154.57	7.60%
Physics Sponsored Projects	$4,676,949.44	3.10%
Electrical & Computer Engineering	$4,390,987.28	2.90%
Mechanical Engineering	$4,041,634.31	2.70%
Oceanography Sponsored Projects	$3,748,618.80	2.50%
Earth, Ocean & Atmospheric Science	$2,737,325.25	1.80%
IMB Sponsored Projects	$1,846,592.73	1.20%
Industrial & Manufacturing Engineering	$1,638,336.71	1.10%
Chemical Engineering	$1,420,761.64	0.90%
Other Departments[1]	$10,051,486.57	6.60%
Grand Total	$152,166,873.58	100.00%

[1] See Appendix for Complete List

The previous table indicates that the MagLab has a strong role in interdisciplinary and collaborative research with other academic departments. For the economic impact of the MagLab, however, the CEFA research team included grant awards specific to the National High Magnetic Field Laboratory and the Applied Superconductivity Center (ASC) as direct funding to the MagLab. While the previous table illustrates the interdisciplinary research activity among MagLab research staff, the CEFA research team also examined the grant award funding to other departments that were not tied to the home department of the MagLab or ASC. Over the past four years, the research team calculated the total to be: $28.57 million dollars of grant awards to other FSU departments. Around $3.02 million dollars (9.5% of total) were attributed to grant awards that did not involve the MagLab or ASC, in terms of their contribution as a Principal Investigator (PI). This can be considered a strong measure of MagLab researchers' collaborative activities. It should be noted that the examination and degree of collaborative activities is not typically measured in economic analysis studies. However, it's surmised that the substantive spillover effect of the MagLab's cross-disciplinary research is a key component of successful high magnetic field research. To put into perspective how large this surrounding academic environment is, a previous FSU CEFA study found that approximately 45,000 jobs[14], or about 31 percent of total employment, were attributed to FSU, in the Tallahassee area.

Another source of other grant funding comes from royalties obtained through the use of products and services provided by the MagLab. One particularly notable service that helps fund the MagLab come from Mike Davidson's microscopy lab. Using high-powered microscopes and imaging technology, Davidson emblazoned ties and other products with colorful images of molecules of every-day items, earning several million dollars for the MagLab. In addition to this, he has created various educational websites and included microscope testing which has resulted in $8 million dollars in revenues for the MagLab.[15]

III - MagLab Expenditures

The MagLab finance and budget staff provided financial data to the CEFA research team including: total expenditures on salaries, capital, direct and indirect expenses for the MagLab, for the years 1990 to 2013. Figures 9 and Table 5 provide a breakdown of the MagLab's historical total spending by category.

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[14] Direct, Indirect, and induced jobs. From: Key Facts about Florida State University's Economic Impact on Tallahassee Leon County – Latest Facts and Figures – 2013, CEFA

[15] See: http://www.tallahassee.com/story/opinion/columnists/ensley/2014/05/16/mag-labs-davidson-ailingbut-research-students-live/9180205/

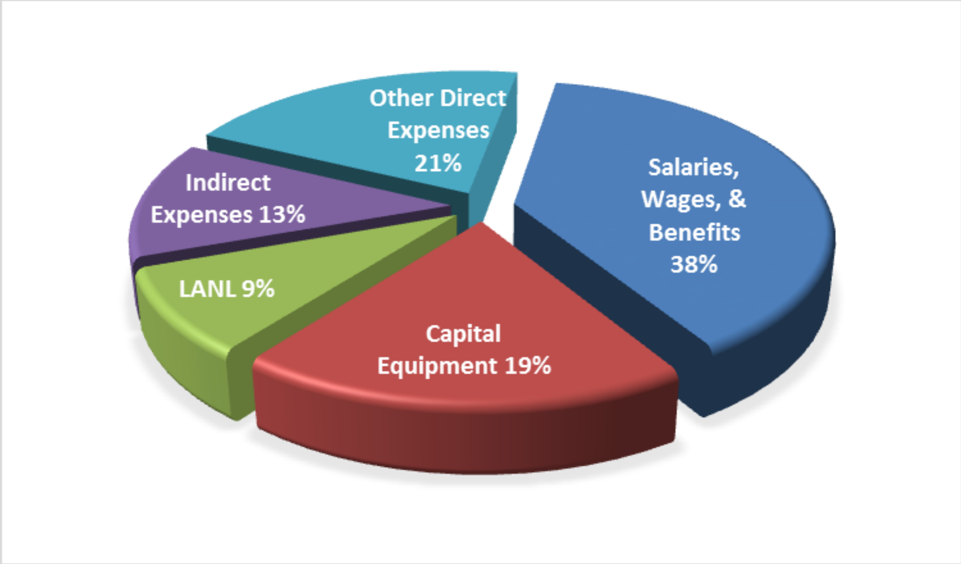

Figure 9: Historical Expenditures of MagLab for Years 1990-2013

Table 5: Allocation of MagLab Historic Spending (1990-2013) in Nominal Dollars

Expenditure Category	Amount	% of Total
Salaries, Wages, & Benefits	$ 450,618,842	38.42%
Capital Equipment	$ 226,340,536	19.30%
LANL	$ 105,811,386	9.02%
Indirect Expenses	$ 148,785,379	12.69%
Other Direct Expenses	$ 241,174,484	20.57%
Total	**$1,172,730,628**	

Individual line item expenditures were grouped into categories that represented the data inputs for the economic impact model. MagLab-generated expenditures result in additional spending activity throughout the economy. These "multiplier" effects are included in the economic impact model.

Table 6 is a brief overview of how each expenditure category is defined. For the economic impact of the MagLab, variables representing spending are chosen within the model that corresponds with each MagLab's expenditure within the area economy.

Table 6: Overview of the Maglab Expenditure Categories

Expenditure Category	Description
Salaries, Wages, & Benefits	Includes any money allocated towards staff that maintains MagLab operations: such as researchers, administration, office management, clerical workers, technicians, and other research staff.
Capital Equipment	Includes any purchases made to build up MagLab's physical infrastructure: such as any facility add-ons, building improvements, scientific instruments, or anything else that can be considered an owned property item.
Indirect Expenses[16]	Costs related to expenses incurred in conducting or supporting research or other externally-funded activities but not directly attributable to a specific project. General categories of indirect costs include general administration (accounting, payroll, purchasing, etc.), sponsored project administration, plant operation and maintenance, library expenses, departmental administration expenses, depreciation or use allowance for buildings and equipment, and student administration and services.
Other Direct Expenses	Includes any expendable materials and supplies, publication costs, sub-awards and consulting services (for rare situations), graduate student tuition remission, as well as any costs for computer or technical services (magnet and supercomputer usage costs, scientific information services, etc.) and sub awards.[17]

IV - Economic Impact Assumptions and Methodology

In order to forecast the economic impact of the MagLab to year 2033, CEFA researchers had to estimate the levels of funding the MagLab expects to receive in future years. The forecast for the MagLab funding was based on previous trends and current information concerning future MagLab funding. The forecast was presented earlier in the report, in Figure 4 and Figure 8. Using these revenue projections, CEFA staff then determined the dollar value that likely would be spent by the MagLab within each expenditure category. Expenditure

[16] It should be noted that for the purposes of this study, SRAD (as described on page 10) was considered solely as federal funding, and was excluded from the economic analysis. The state must authorize, not appropriate, the expenditure of these funds by the Office of Vice President of Research (OVPR). OVPR has total discretion over the allocation of these funds.

[17] The Indirect cost on sub awards is charged only on the first $25K for the term of the award.

category percentages over the most recent year 2009 to 2013 timeframe were used in order to reduce the variability associated with single year values.

The CEFA research team assumed that the MagLab will continue to receive annual support from NSF, and that it would continue to increase at an annual rate of approximately 3.65 percent.[18] After the level of NSF funding was determined, it was separated further into expenditure categories. Figure 10 shows the percentage breakdown of the NSF award, for the years 2009-2013, by various expenditure categories, including the LANL sub-award. CEFA staff assumed that the percentages from the NSF core grant would remain fairly consistent in the future.

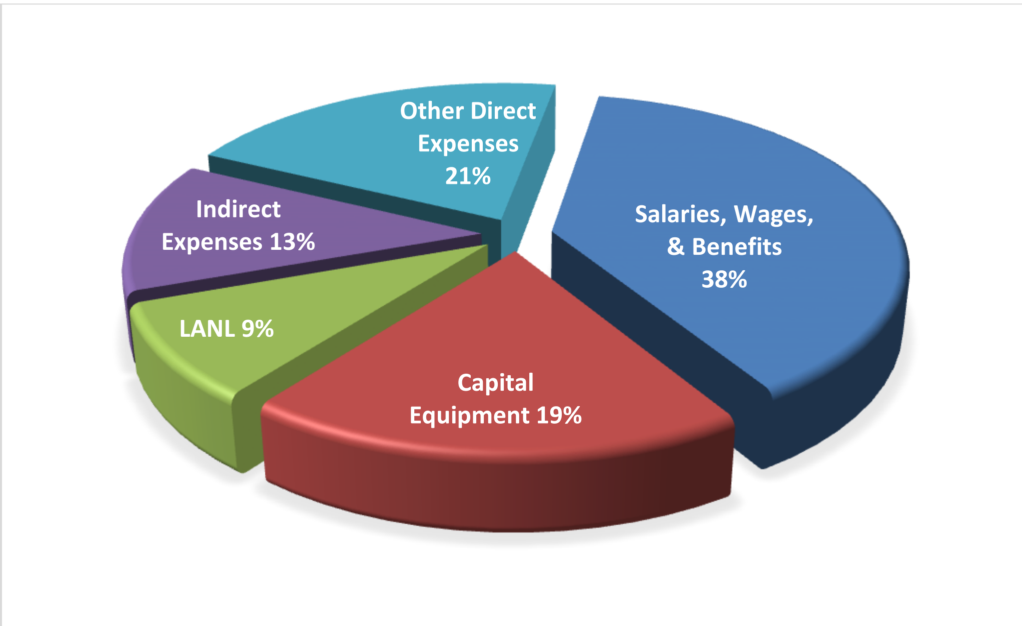

Figure 10: Allocation of NSF Award Funding (Years 2009-2013)

CEFA staff used a similar forecasting methodology pertaining to projected levels of state funding sources. FSU state operating expenses include faculty and professors salaries – which are estimated to remain fairly level and increase by about 2 percent, occurring once every three years[19]. UF state operating expenses are estimated to increase by about 1.8 percent annually, based on previous rates of growth for the facility. Both state operating funding sources are Education & General (E&G) funding provided by the state, and are

[18] Estimate of NSF funding growth provided by previous economic impact analysis study conducted by FSU CEFA, in 2009.

[19] In other words, an annual salary increase is expected to be 2/3 percent.

primarily spent under salaries, wages, & benefits for the MagLab. The remainder is for general expenses and travel, and little is spent on equipment. In addition to State Operating sources, SRAD and SRAD Infrastructure represent the dispersed money through the respective university department which returns back to the MagLab. The regular SRAD distribution is spent about 40 percent on salaries, wages and benefits, 20 percent on general expenses, 20 percent on travel, and 20 percent on equipment. Virtually the entire infrastructure SRAD is spent on equipment and infrastructure enhancements.[20] The growth of these SRAD amounts has followed the growth of indirect or overhead costs, as by definition they are the dollar amounts returned from the overhead costs paid to institutions. The state facility grant, through the Board of Governors, is based on the square footage of the facility and is assumed to remain constant. State capital funding was state money used in the past to fund the MagLab's infrastructure, with 2005 being the most recent infusion year. The state provided infrastructure grants for the years 2010-2011 as well, however, future funding under state capital grants is not assumed since these can't be anticipated. Figure 11 shows the percentage breakdown of state funding ranging from the years 2009-2013. These percentages are expected to change very slightly over time. However, since each funding item contributes directly to each expenditure category, those that are salary amounts, and those that are used for capital equipment purchases are included in the appropriate expenditure category.

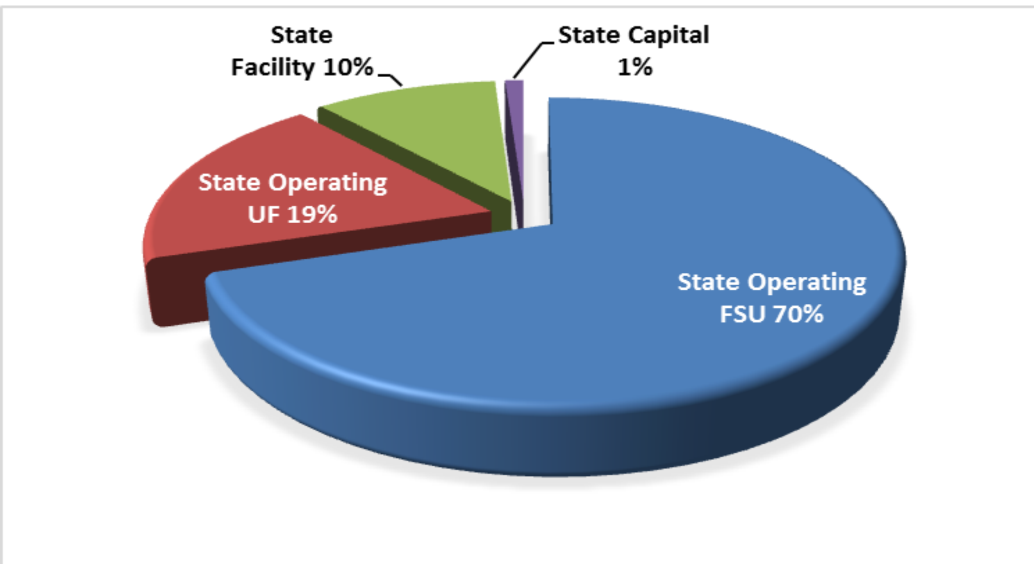

Figure 11: Percentage of State Funding by Funding Source (Years 2009-2013)

[20] Personal communication, Clyde Rea, October 2014. Email: rea@magnet.fsu.edu

"Other grants" funding has played an increasingly prominent role in MagLab funding, peaking at over 43 percent of total MagLab funding in year 2010. The CEFA research team predicts a 4.45 percent annual growth trend in other grants funding, which is based on the average growth of federally-funded research conducted at universities and colleges for the last five years, provided by the National Science Board's *Science and Engineering Indicators*. Figure 12 shows the breakdown of other grant sources for years 2009-2013. Regarding the projections of each input variable, it is assumed that the percentages for all funding from other grants will remain fairly consistent in the future.

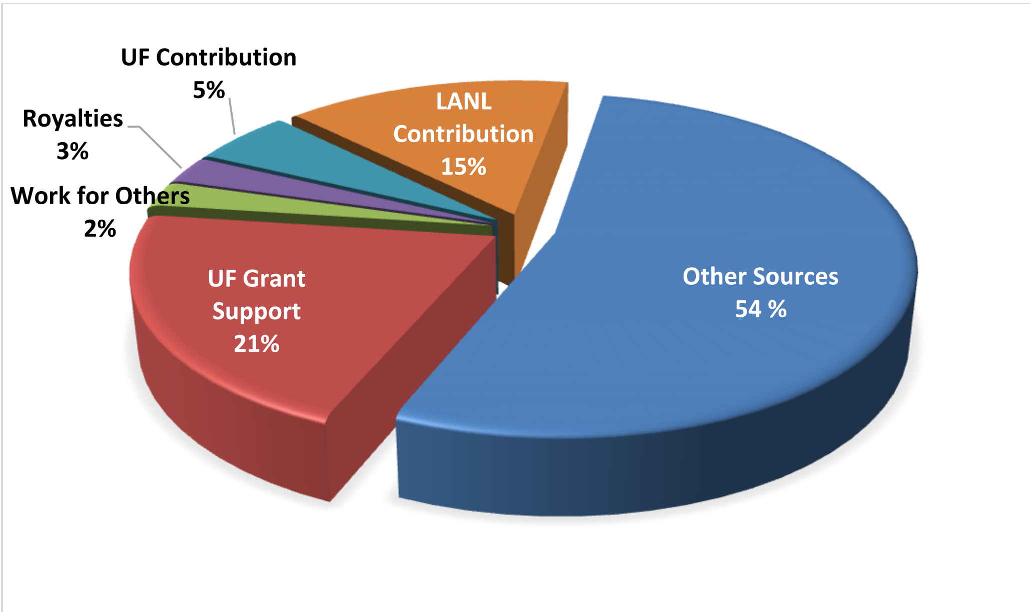

Figure 12: Percentage of Other Grants by Source (Years 2009 – 2013)

Figure 13 shows the average breakdown of total MagLab expenditures for years 2009-2013, excluding the LANL sub-award. In the forecasting of the expenditure categories, CEFA staff assumed all unspecified funding line items (such as any future other grants) would follow similar general expense, or spending, percentages.

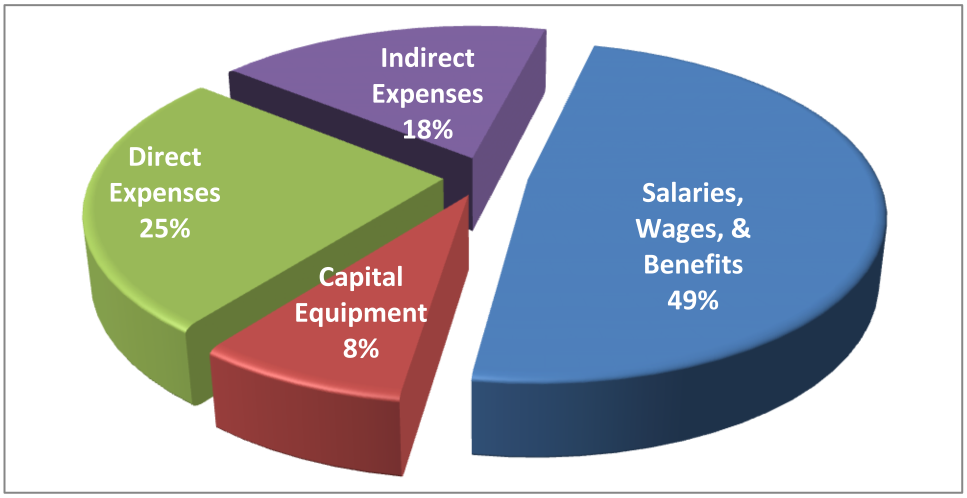

Figure 13: Allocation of Total MagLab Spending, Excluding LANL Sub-award (Years 2009 – 2013)

For the LANL sub-award, CEFA staff obtained projected funding amounts for the fiscal years 2013–2017 to give an approximation of how sub-award funding at the LANL is spent. The LANL facility has different spending patterns, so the funding was broken out by how it would be spent based on LANL budget amounts. Figure 14 shows the breakout of LANL facility spending of the sub-award (part of the NSF Core Grant). CEFA staff assumed this breakout for the sub-award remains relatively stable over time, for the LANL facility.

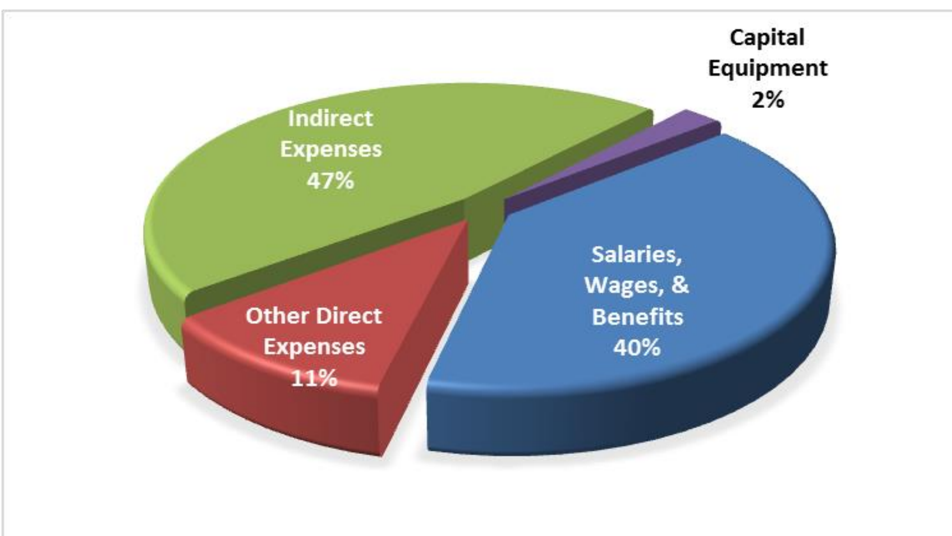

Figure 14: Allocation of the LANL Sub-award (Based on Projected FY 2013-2017)

V - The Economic Impacts of the MagLab

Economic Impacts on the Tallahassee MSA, or Local Economy

After CEFA research staff examined the MagLab's past expenditures based on historical data, the projected spending by category was estimated. The expenditure categories of each MagLab funding source that would occur within the Tallahassee Metropolitan Statistical Area (i.e., Leon, Gadsden, Wakulla, and Jefferson counties) were further estimated. Figure 15 shows a visual representation of expected MagLab spending over time. This forecast of the various expenditure categories represent items that would likely be spent in the Tallahassee MSA, excluding any funds allocated to UF or LANL facilities[21].

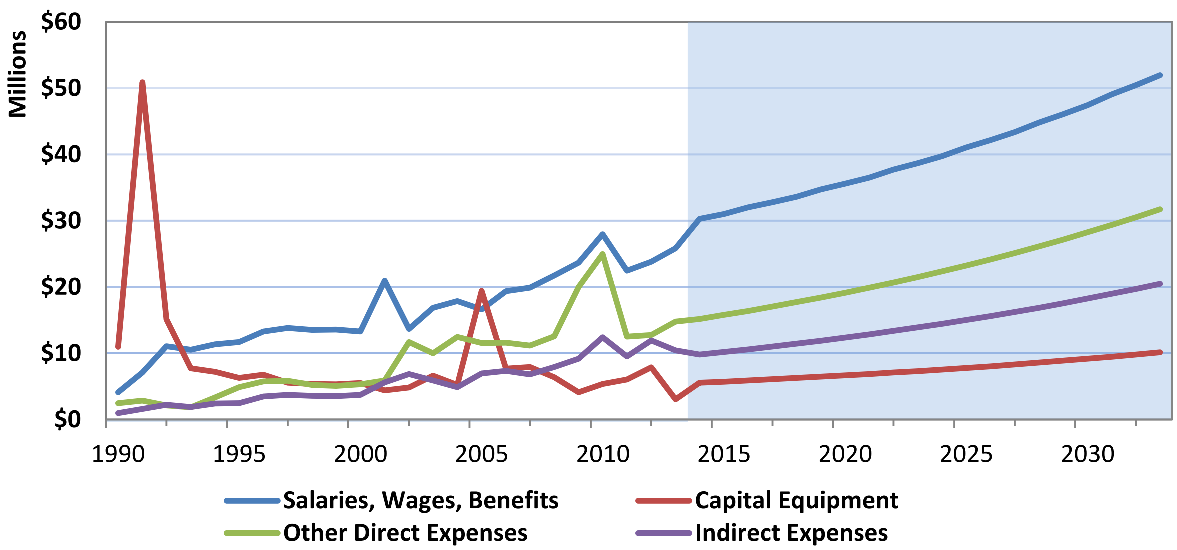

Figure 15: MagLab Spending in the Tallahassee MSA by Category (Years 1990 - 2033) in Nominal Dollars

These expenditure categories were used as inputs to the economic impact model for the local Tallahassee MSA[22] economy. The economic impact model variables were then matched with the MagLab input data/expenditure categories in order to perform the economic impact modeling analyses.

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[21] The Los Alamos facility is located in New Mexico, while UF is in Gainesville, Florida, so their expenditures will not have a direct impact on the Tallahassee MSA or local economy.

[22] The Tallahassee Metropolitan Statistical Area (MSA) includes: Leon, Gadsden, Jefferson and Wakulla Counties.

The following Table 7 corresponds only with the average annual amount of funding expected to be spent within the Tallahassee local economy during the 2014-2033 time period. This is compared with the Tallahassee MSA local economy in order to examine only the effect of the MagLab's expenditures in the local area. The economic impact analysis shows that the average annual state projected expenditures of $18.9 million in the local economy would generate about $90 million in output, 1,157 jobs, and $34.2 million in income across the Tallahassee MSA.

Table 7: Average Annual Economic Impact in the Tallahassee MSA (Years 2014 – 2033) in Nominal Dollars

Average Annual Economic Impact for Years 2014 – 2033 Economic Impact of MagLab Spending on Tallahassee MSA			
	Output	Employment	Income
MagLab Expenditures (Tallahassee)	$89,942,235	1,157	$34,160,657

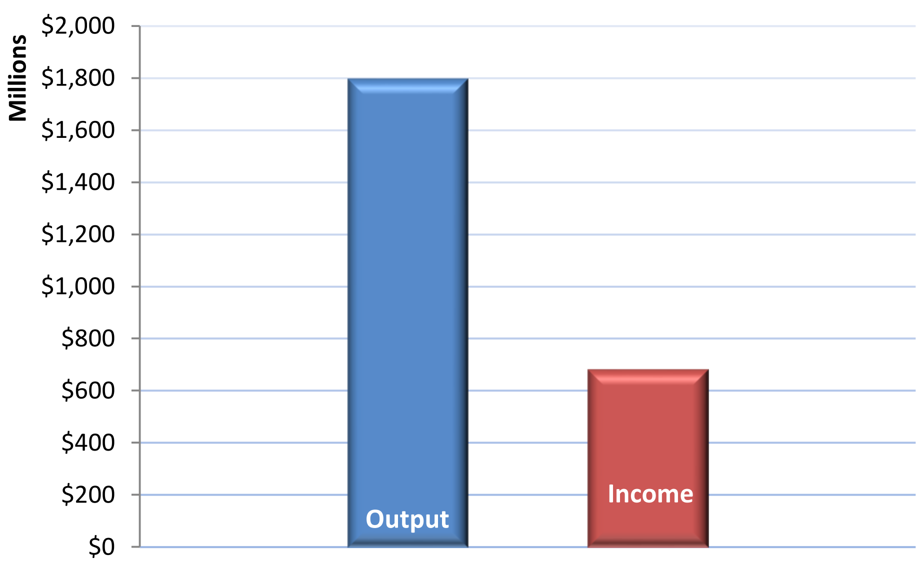

Figure 16: Cumulative Economic Impact of Total MagLab Funding in the Tallahassee MSA (Years 2014 – 2033) in Nominal Dollars

Figure 16 above shows the MagLab's projected total economic impact for years 2014-2033, within the Tallahassee MSA. The total investment across the Tallahassee area over the next 20 years will generate about $1.8 billion in local output and $683.2 million in income, while generating 23,136 jobs across the local economy.

Economic Impact on the State of Florida Economy

After computing the amount of funds spent within the local Tallahassee MSA, CEFA researchers also ran a statewide economic impact model using funds that would likely be spent within the state of Florida. As the UF facility is located in Gainesville, Florida, expenditure categories were recalculated as shown in Figure 17 to include all provided UF funding sources.

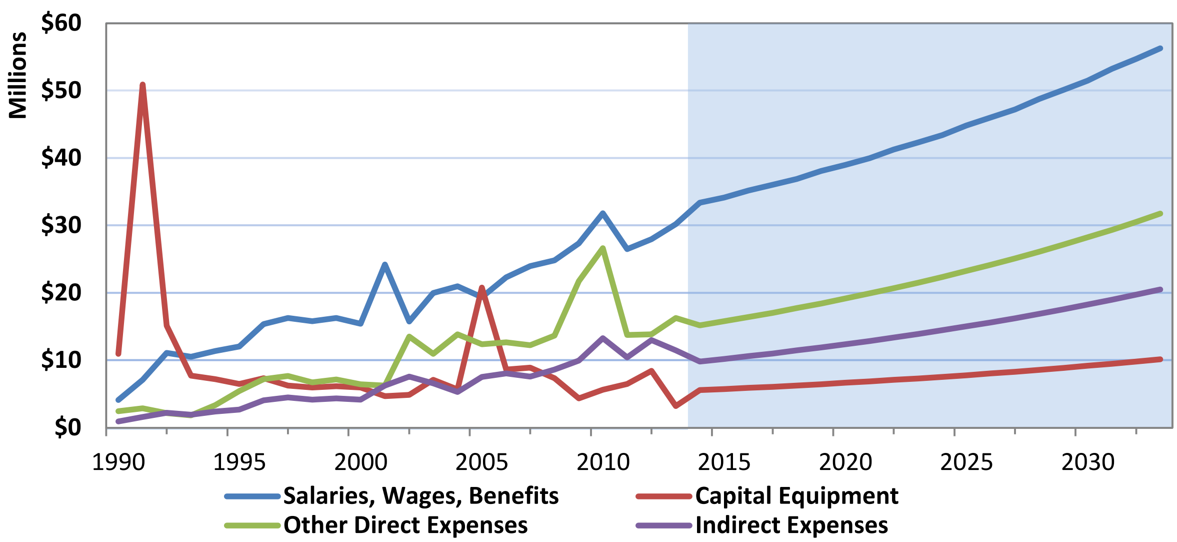

Figure 17: MagLab Lab Spending in the State of Florida by Category (Years 1990 - 2033) in Nominal Dollars

After these policy variables were selected and the data entered, the IMPLAN model was used to determine the economic impact of the MagLab on the statewide economy. The top row of Table 8 summarizes the average annual projected state investment for the MagLab, including projected annual income and employment.[23]

The second row of the table indicates that the state funding will attract an annual average economic stimulus to the Florida economy over six times as large as the state investment, based on the MagLab expenditures (or spending). This table shows the economic impacts on output, employment and labor income.

[23] The average value of expected state spending for years 2014-2033 is estimated to be $18.9 million per year (or $377.24 million over twenty years).

Table 8: Average Annual Economic Impact in the State of Florida (Years 2013 – 2033) in Nominal Dollars

Annual Average Economic Impact for Years 2013 – 2033[24]			
	Output	**Employment**	**Income**
State of Florida Investment	$18,861,908	228	$9,297,296
Economic Impact of MagLab Spending in Florida	**Output**	**Employment**	**Income**
MagLab Expenditures (including Tallahassee & UF)	$121,178,367	1,255	$50,622,759
Benefit to Cost Ratio	**6.42**	**5.50**	**5.44**

The MagLab's annual stimulus in terms of output will exceed $121 million dollars. This represents the value of final goods and services produced across the Florida economy as a result of state and non-state spending at the MagLab. The annual average value of income generated by MagLab spending over the year 2014 – 2033 timeframe is $50.6 million across the state. Finally, the MagLab on average generates 1,255 jobs across the Florida economy annually – jobs that are directly and indirectly created by the total spending projected over that period.

[24] It should be noted that these ROI estimates do not yet include the MagLab visitor impacts, which are described and included further in the report narrative.

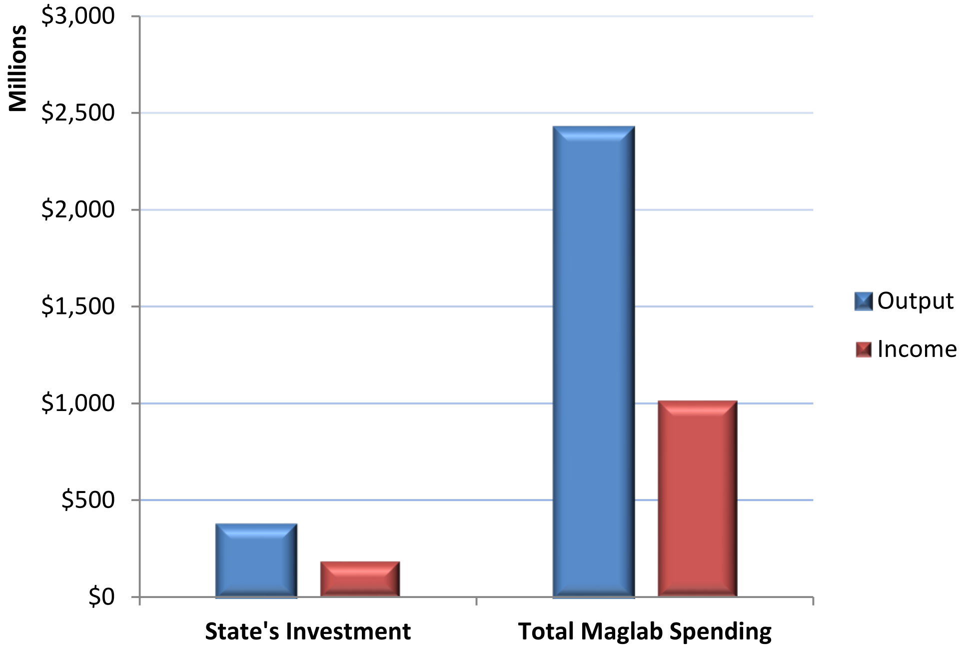

Figure 18: The Cumulative Economic Impact on the Florida Economy of the State's Investment and Total MagLab Spending (Years 2013 – 2033)

Figure 18 above shows the total economic impact for years 2014 – 2033 for both the projected MagLab spending and the state investment. The total investment across Florida over the next 20 years will generate about $2.4 billion in state of Florida output, $1 billion in wages for state of Florida workers and over 25,109 jobs across the state economy.

Economic Impact on the National Economy

For the total economic impact of the MagLab on the national economy, CEFA staff included expenditures for all three facilities that would be infused into the national economy. Figure 19 shows the historic and predicted expenditures for the entire MagLab including the LANL sub-award.

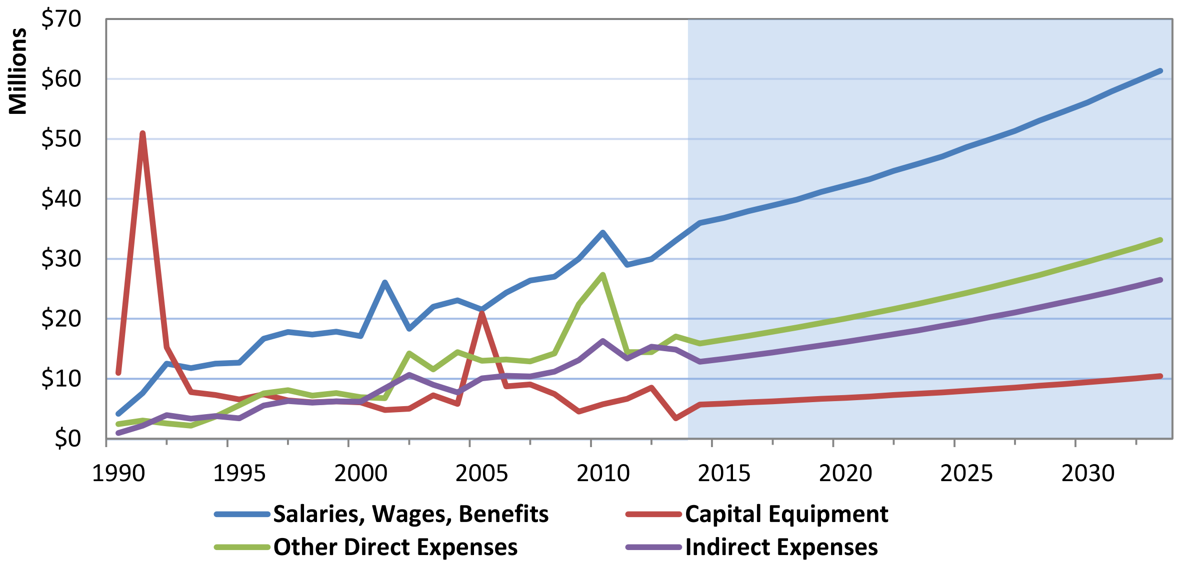

Figure 19: National MagLab Spending by Category (Years 1990 – 2033) in Nominal Dollars

These expenditure categories are used as inputs for the national economic impact model, and include all expenditures for the MagLab within the national economy. This contains expenditures for all three of the MagLab facilities. While the MagLab headquarters and UF facilities are located in Florida, the MagLab operates on a national level with an additional site at Los Alamos National Laboratory and with researchers travelling from around the country and world to use the facilities across all three sites. With data provided by the MagLab, CEFA staff assessed the total value of grants and other funding brought in by the MagLab that had an impact on a national level. CEFA staff assumed that the LANL sub-award would be spent similar to the previous breakout for the LANL projected budget (see: Figure 14) in order to calculate future spending on a national level. Table 9 shows the average annual economic impact of total MagLab funding compared to the baseline U.S. economic forecast. All expenditures by the MagLab generate jobs through operational spending, employment, and labor income.

Table 9: Average Annual Economic Impact of the MagLab on the National Economy (Years 2014 – 2033) in Nominal Dollars

Average Annual Economic Impacts for Years 2014 – 2033			
MagLab Total Spending National Economic Impacts	**Output**	**Employment**	**Income**
MagLab Expenditures (Tallahassee, UF, & LANL)	$182,016,487	1,562	$73,390,664

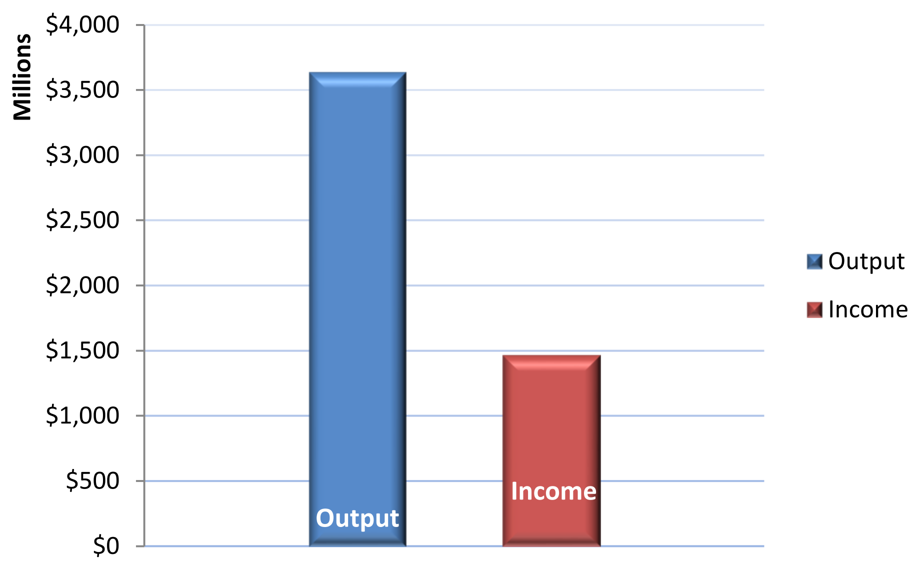

Figure 20. The Cumulative Economic Impact of the Total MagLab Funding on the National Economy (Years 2014 – 2033) in Nominal Dollars

Figure 20 above shows the cumulative economic impact of all projected MagLab funding on the national economy over the next 20 years. This includes all direct, indirect, and induced amounts for output, employment, and labor income. As a result of the projected 20-year investment of total MagLab funding, there is expected to be $3.64 billion in national output, 31,240 jobs generated across the nation, and $1.47 billion in income for those workers.

Economic Impact Model Input Data Based on Visitors

FSU CEFA performed an economic impact analysis of the visitors to the MagLab (including UF and LANL), using year 2013 visitor survey data from the MagLab.[25] FSU CEFA developed further economic assumptions in order to estimate any missing travel or visitor cost information. This section of the report provides a description of the financial, or input, data used for the visitor economic impact model developed by the FSU CEFA research team.

The 2013 visitor data was categorized by MagLab facility. MagLab staff estimated the average cost of each night stay to be $105. They also estimated that each guest spent an average of $50 per day on food, and $50 per day on car rental. The airfare averaged around $670. As presented in Table 10, the number of estimated visitor nights for the MagLab was 4,840. The estimated visitor nights for the UF High B/T were 360 nights, UF AMRIS were 72 nights, and LANL were 504 nights. Total visitor nights were estimated to be 5,776 across the three labs. The average and total number of visitors per site are presented in Table 11.

The CEFA research team further estimated "other" travel costs, or expenditures, associated with the visitor's time spent at the MagLab for 2013, based on relevant economic research[26,27,28,29] pertaining to education outreach travel costs,[30] and through discussion with the MagLab staff. It was estimated that visitors spent an average of about $43 per day on "other" expenditures such as retail shopping, recreation, entertainment, among others.

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[25] The MagLab visitors survey data was provided by Mr. Tom Cordi, Asst MagLab Director, Business Administration. The MagLab visitor survey data was collected as a component of a larger visitor survey conducted by Strategic Planning Group, Inc. (SPG) for an economic feasibility study for the Civic Center.

[26] University of Massachusetts, Center for Policy Analysis, Dartmouth, Mass. 2007. Program Evaluation and Economic Impact Analysis, 2007. They found that participants spent on average: event attendees per day: Admission: $45.82, Food/Drink: $54.23, Hotel/Lodging: $186.64, Miscellaneous retail: $29.53, Other: $38.00, Transportation: $48.37.

[27] Grado, C. Strauss, and B. Lord. 2008. The Economic Impacts of Conferences and Conventions. *Journal of Convention & Exhibition Management*. Pertaining to conference attendees "All visitors averaged $114.53 per activity day with non-residents spending 85% more than residents." Resident total expenditure percentages: On-site: 80.2%, Transportation: 4.1%, Lodging: 0.0%, Food: 5.4%, and Goods and Services: 10.3%.

[28] Boo, S., M. Kim, and D. Jones. 2009. Comparative Analysis of Travel-Related Characteristics Between Special event Attendees and Non-Attendees in a Metropolitan City. "Most spending expenditure patterns of special event attendees and non-attendees are quite similar with the exception of the "shopping" category. In terms of the average total spending expenditures, the non-attendee group's average total spending expenditure of ($275.30) was higher than that of the special event attendee group ($235.96). However, there was no statistically significant mean difference between the two groups."

[29] Randall, J., and B. Warf. 1996. Economic Impacts of AAG Conferences. University of Saskatchewan and Florida State University. Average expenditure per day at conference for all types of attendees was $130.66 See pg.282.

[30] The "other" travel costs, or expenditures, were adjusted to current dollars.

This "benefits transfer" method of estimation was conducted in order to best gauge an average visitor's travel costs and expenses.

Table 10: Estimated Annual Number of Visitors by Event to the MagLab, for Year 2013

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
User Program	350	350	350	350	350	350	350	350	350	350	350	350	4,200
Visiting Scientists	20	20	20	20	20	20	20	20	20	20	20	20	240
Physics School	240												240
External Advisory Meeting								60					60
User Committee										60			60
NSF Site Visit Committee											40		40
Total Visitors to MagLab													4,840

Table 11: Estimated Average and Total Number of Visitors by MagLab Site, for Year 2013

Site	Average Nights per Visitor	Total Nights	Estimated Visitors
MagLab	7	4,840	691
UF High BT	45	360	8
UF AMRIS	1	72	72
LANL	7	504	72
Total		5,776	843

As shown in Table 12, the estimated total travel costs were $918 per day (when including airfare per visitor).

Table 12: Estimated Total Visitor Travel Costs for Year 2013

Estimated Travel Cost per Item*	Average Daily Costs	FSU DC Field	UF High BT	UF AMRIS	LANL	Total
Visitors for 2013		691	8	72	72	**843**
Assumptions for Spending						
Hotel Night/Lodging	$105	$508,200	$37,800	$7,560	$52,920	**$606,480**
Food & Beverage	$50	$242,000	$18,000	$3,600	$25,200	**$288,800**
Transportation (car rental)	$50	$133,100	$9,900	$1,980	$13,860	**$158,840**
Airfare	$670	$463,257	$5,360	$48,240	$48,240	**$565,097**
Other Expenses (shopping, recreation, etc.)	$43	$208,120	$15,480	$3,096	$21,672	**$248,368**
Total	**$918**	**$1,554,677**	**$86,540**	**$64,476**	**$161,892**	**$1,867,585**

* Maglab Visitors Survey data for 2013

Table 13: Estimated Local, State and National Economic Impacts of Visitors to the MagLab for Year 2013

Average Annual Economic Impacts			
Economic Impacts of Visitors to the MagLab	**Output**	**Employment**	**Income**
Visitor Impact on Local Economy	$2,081,205	19	$582,452
Visitor Impact on State Economy	$2,821,673	23	$977,450
Visitor Impact on National Economy*	$4,121,581	29	$1,358,407

*Includes the three MagLab facilities in Tallahassee, UF, & LANL

The economic impact of visitors to the MagLab is sizeable. Nationally, the visitor impacts are $4.1 million and $1.4 million, in output (sales/revenues) and income (wages/salaries) respectively, while generating an additional 29 jobs.

Additional Value Added Associated with MagLab Operations

Since 1998, the MagLab has produced over 54 patents and other products from the on-site research. Various spin-off companies have begun to form in surrounding areas of the MagLab, bringing in resources and national interest to Tallahassee and Innovation Park. These newly-formed companies are frequent users of the facilities.

Several different facilities of Florida State University have been created in part due to the MagLab. The Future Fuels Institute of FSU is supported by sponsoring companies interested in the different compositions of oil. The research at the MagLab helps develop new techniques for conducting research and training for chemical analysis. One neighbor of the MagLab headquarters is the Center for Advanced Power Systems (CAPS), which was a spinoff of the MagLab. Their scope of research includes the development of future power systems for U.S. Navy ships, advanced materials and applications, and power systems management.

Several different entities have also formed within the MagLab. In 2006, the Applied Superconductivity Center was brought to the MagLab from the University of Wisconsin. It is now an integral part of the MagLab, specializing in superconductive materials research and their many applications. The Florida State University Magnet Research and Development, Inc. is a not-for-profit corporation and is a direct support organization for FSU. Using the MagLab's expertise, they build magnets for institutions around the world – the largest recent being an $11.6 million dollar project with the Helmholtz Centre Berlin.[31] Collaboration of this kind has been a goal of the MagLab since its inception.

CEFA staff has included grant revenues for the MagLab from Future Fuels, Magnet Research and Development, Inc., and the Applied Superconductivity Center within the economic impact for the MagLab. Although CAPS is not an integral component of the MagLab, they are frequent magnet users and contribute to its funding.

To sustain operations at the MagLab, large amounts of electricity (as described in greater depth in the next section) are only part of the MagLab's utility bill. The MagLab previously purchased around $1 million in helium per year, which their cryogenics lab converts into liquid helium in order to keep the magnets cold enough to operate. However, in 2012 the MagLab's helium recovery project now allows used helium to be captured instead of wasted. This is expected to reduce the expenditure of helium, a non-renewable resource, to only a quarter of its previous cost per year.[32]

[31] MagLab to Celebrate Significant Milestone in Large-Scale Magnet Project, from MagLab website.

[32] Helium Comeback: A recent helium recovery project means major savings, more focus on science, from MagLab website.

The Benefits of the Magnet Lab to the City of Tallahassee

Tallahassee - being the home of the MagLab headquarters - supplies the electricity for the lab through the city's power grid. With around 70 percent of the total electricity bill for the MagLab coming from the operation of magnets alone, the MagLab may consume 56 megawatts of electricity at the Tallahassee site at any one moment. While the local grid has a generating capacity of 817 megawatts, the MagLab is able to consume about 7 percent of that. It is also worth noting that the City of Tallahassee power grid is comprised almost entirely of natural gas.[33]

In the previous twelve-month period (April 2013-March 2014), the entire utility bill for the Tallahassee headquarters was $4.18 million.[34] This large amount of energy usage ranks the MagLab headquarters alone as the sixth largest consumer of energy in Tallahassee, just behind the entire Leon County School Board account.[35]

Since the MagLab's facility is state owned, it is not taxed. However, MagLab employees own property in Tallahassee and contribute city and county taxes. The amount of property taxes estimated in 2013 amounts to over $1.56 million. In addition to this, the city collects an estimated $1.29 million in residential utilities. This includes electricity, sewage, and water usage and associated fees based off of rates from the city of Tallahassee. Figure 21 shows an estimate of taxes and fees collected by the City of Tallahassee from total MagLab affiliated employees and utilities from the MagLab.

[33] Year 2010 data. See: http://www.magnet.fsu.edu/mediacenter/factsheets/numbers.html
[34]Data obtained by address lookup on utility website, www.talgov.com
[35] City of Tallahassee's Annual Report to Bondholders, February 2013

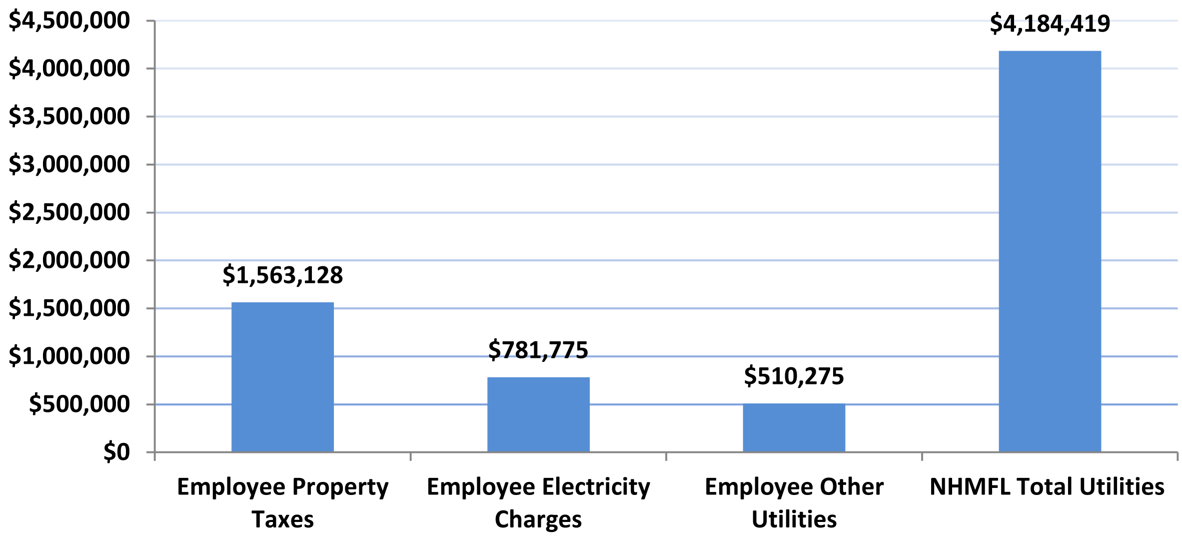

Figure 21: Taxes and Fees Collected by the City of Tallahassee from the MagLab[36] (Years 2013 – 2014)

VI – Conclusions

Economic impacts are effects on the levels of activity in a given area. They may be expressed in terms of 1) business output (or sales volume) 2) value added (or gross regional product) 3) wealth (including property values) 4) personal income (including wages), or 5) jobs. Any of these measures can be an indicator of improvement in the economic well-being of area residents. The net economic impact is viewed as the expansion (or contraction) of an area's economy, resulting from changes in a facility or project, or in assessing the economic impact of an already existing facility or project. Economic impacts are different from the valuation of individual user benefits and the broader social impacts (amenity value) of a facility or project. However, assuming they can be quantified, they may be included to the extent they affect an area's level of economic activity. Short-term economic impacts are the net changes in regional output, earnings, and employment that are due to new dollars entering into a region from a given enterprise or economic event. The following economic impact analysis report provides a summary of the local, state and national area economic impacts (in 2014 dollars) associated with the MagLab.

[36] Average property values obtained from www.zillow.com, residential utility rates obtained from www.talgov.com, all estimates made using total affiliated staff located in Tallahassee.

In order to obtain estimates of the different types of macroeconomic effects of the MagLab on the Florida economy, the project team applied a well-established analytical tool known as the IMPLAN model. The IMPLAN Model (2012 data), an input output model, was used to perform the economic modeling analyses. The historical (actual data from years 1990-2013) was provided by the MagLab Finance and Budget Staff, and included capital outlay, equipment, salaries/wages, among other data.

The following table(s) presents the total economic impacts, and the direct, indirect, and induced economic impact results, respectively, in nominal dollars. The impacts were measured with respect to output (or sales/revenues), employment (or jobs), and income (or wages). The output generated represents the value of final goods and services produced across the Tallahassee, state and national area economies, respectively, as a result of the expenditures generated by the MagLab activities. The direct impacts measure the immediate effects as a result of the MagLab-related expenditure generated activities in the Tallahassee area; e.g., in employment and income. Indirect impacts are those that include changes to production, employment, income, etc., that occur as a result of the direct effects. Induced impacts are those further impacts of spending derived from direct and indirect activities – i.e., MagLab-related household purchases of consumer goods and services. Regarding the economic impact analysis results, the project research team found that in the Tallahassee MSA area the MagLab annually generates:

- $90 million in economic output;
- $34.2 million in income;
- while generating a total of 1,157 jobs.

In the Florida area, the MagLab annually generates:

- $121.2 million in economic output ;
- $50.6 million in income;
- 1,255 jobs.

Nationwide, the MagLab annually generates:

- $182 million in economic output;
- $73.4 million in income;
- 1,562 jobs.

The project research team found that in the MagLab generates annually (based on annual average expenditures), for the Tallahassee MSA, State and Nation respectively:

Annual Impacts	Output	Employment	Income
Tallahassee MSA	$89.9 million	1,061 jobs	$34.2 million
State of Florida	$121.2 million	1,255 jobs	$50.6 million
National	$182 million	1,562 jobs	$73.4 million

The total investment across the Tallahassee MSA, State and Nation over the next 20 years (Years 2014-2033) is expected to generate respectively:

Years 2014-2033	Output	Employment	Income
Tallahassee MSA	$1.8 billion	23,136 jobs	$683.2 million
State of Florida	$2.4 billion	25,109 jobs	$1.0 billion
National	$3.6 billion	31,240 jobs	$1.5 billion

In addition, the annual economic impacts of visitors to the MagLab facilities are:

Annual Visitor Impacts	Output	Employment	Income
Tallahassee MSA	$2,081,205	19 jobs	$582,452
State of Florida	$2,821,673	23 jobs	$977,450
National	$4,121,581	29 jobs	$1,358,407

The results of the economic analysis indicate that the MagLab provides a large rate of return on the investments made by the state of Florida. The annual benefits within the Florida economy are defined as the economic impacts resulting from the annual state investment in the MagLab and the economic activity brought into Florida (via contracts and grants, government and private sponsors, auxiliary fees/services, and other external sources), resulting in the following return on investment (ROI) ratios:

Annual Benefits to the State of Florida	Annual Benefits from MagLab Economic Activity	Benefits from Visitors to MagLab	Total Annual Benefits	ROI from State Investment
Output	$121,178,367	$2,821,673	$124,000,040	6.57
Employment	1,255	23	1,278	5.60
Income	$50,622,759	$977,450	$51,600,209	5.55

The economic benefits include large additions to employment, economic output, personal income, and tax revenues.

- Benefit to the state = $124.0 million
- Cost of the state investment = $18.86 million
- Thus, for every dollar of state money invested in the MagLab, $6.57 is generated by the MagLab in economic activity for the State of Florida.

The results of the economic analysis indicate that the MagLab performs a significant role in the local Tallahassee MSA, the state of Florida, and the national economies. The economic benefits include large additions to employment, economic output, personal income, and tax revenues.

Appendix A - Review of the Literature

The Linkage of Scientific Innovation and the Economy

> *"The pioneer spirit is still vigorous within this nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to higher standard of living, and to our cultural progress."*
>
> *Vannevar Bush*
> *In a letter to President Franklin D. Roosevelt, 1945*

Over the past eighty years, scientific research has paved the way for what is now a much greater standard of living. Research conducted by industry, government, universities and colleges has developed the world around us. From the products we use daily, such as cell phones and computers, to advances in our general well-being through research in healthcare: there is no doubt of a benefit obtained from research. In spite of this knowledge, the real economic benefit of research is poorly understood by most.

On a local and statewide scale, there is an established impact that scientific research conducted at colleges and universities has on their surrounding economies**.** Research requires trained, high-tech workers, which are more often than not introduced directly from university and college systems. The experience and technological innovation generated by university research impacts every economic sector. Some of these benefits also go unrecorded, as any gains in socio-economic – or quality of life – areas of research that are directly accounted for. This includes any increases in health care, quality of environment, or human services that are the product of our university labs and research centers.

In an age where economies are becoming progressively linked on a global level, it is important to keep in mind not only what we can directly measure. A common result of basic research can increase in the stock of knowledge, which can then be built upon by others. It is a major boon, not only to those who receive direct economic benefits of building a facility, hiring highly trained workers, and inadvertently growing desirable sectors of their economy - but to the ones who conducted the original research as well: who receive an even greater return for their initial investment in research.

When it comes to the bigger picture, it is easy to lose track of these indirect benefits, as the effects are often not directly measurable. In the current decade especially, this has proved to be quite a barrier for research. In a global economy increasingly driven by profits, there has been less interest in funding investments when the benefits cannot be directly captured. This can be seen especially in recent years, where changing trends in the funding and performers of research may have long term impacts on our economic growth, quality of life, and overall economic efficiency.

Following is a brief review of outside literature prepared by the staff of the Center for Economic Forecasting and Analysis at Florida State University that looks at the current trends of research, as well as the linkage between basic research and economic and socio-economic gains.

Appendix B - Overview of the Economic Value of Basic Research

It's clear that federal, industrial, and university-funded research has not only improved the American standard of living, but has put us at the front of the innovation curve. The U.S. has contributed to major quality of life improvements such as: electronics, radio communications, biotech, to medicine and vaccines – among others. While many great products continue to be revolutionized by American researchers, many fields are facing increasing barriers to conduct research. Table 14 below shows the total U.S. expenditures on research and development (R&D) by source (in millions of 2005 nominal dollars). The growth of R&D expenditures has remained fairly steady over time, increasing by 60 percent over 1980-1990 and around 50 percent from years 1990-2000. During years 2000-2010 this rate of growth slowed to a meager 20 percent, however, this was largely due to the decrease in research expenditures as a result of the recent recession.

Table 14: U.S. Expenditures on R&D, Total by Source (Nominal 2005 M Dollars)

Years	1970	1980	1990	2000	2010	2011	2012 Prelim
Federal	17,068	16,385	21,687	21,693	28,804	31,559	32,563
Industry	72,292	90,453	148,632	225,378	251,348	259,436	274,467
Colleges and Universities	9,933	13,507	23,441	34,595	54,391	55,097	54,359
FFRDCs	5,874	8,478	10,867	10,447	16,203	15,630	15,119
Nonprofits	2,780	3,470	5,710	10,971	16,579	15,985	15,697
TOTAL	107,947	132,293	210,337	303,084	367,325	377,707	392,205

Sources: National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES)

Research and development can be broken down into three categories: development, basic research and applied research. Basic research is often considered the foundation for increasing the stock of knowledge and is also known as "pure research." Applied research, as described by the National Science Foundation is defined as "systematic study to gain knowledge or understanding to meet a specific, recognized need." Development, on the other hand is the refinement of research for the improvement, or generation of output. Industry conducts the majority of total R&D at almost 70 percent of the total 2012 preliminary amounts, according to the NSF's *National Patterns of R&D Resources.* However, industry conducts only 18 percent of basic research. Meanwhile, over 80 percent of all development and applied research is conducted by industry. Although basic and applied research seem largely different, there is frequent blurring between what is basic and what is applied research, as basic research is often the basis for an applied approach. It is largely important to understand how the different types of research and development are inexplicably intertwined, as is often the case in important discoveries that are based off of existing research. When assessing the value of basic research this must be taken into account.

As of 2012, universities and colleges conduct about 13.8 percent of total R&D, but conduct 54 percent of all basic research. Table 15 shows total U.S. expenditures on basic research by performer (in millions of nominal 2005 dollars).

Table 15: U.S. Expenditures on Basic Research, Total by Performer (Millions of Nominal 2005 Dollars)

	1970	1980	1990	2000	2010	2011	2012
Federal	2,309	2,537	3,209	4,243	4,604	4,332	4,408
Industry	**2,326**	**2,521**	**6,406**	**7,935**	**14,750**	**11,486**	**12,094**
Colleges and Universities	7,622	9,029	15,397	25,823	35,667	35,534	34,705
FFRDCs	**1,235**	**2,692**	**4,198**	**4,549**	**5,968**	**5,699**	**5,320**
Nonprofits	1,276	1,519	2,660	5,636	8,733	8,370	8,340
TOTAL	**14,768**	**18,298**	**31,870**	**48,186**	**69,722**	**65,421**	**64,867**

Sources: National Science Foundation, National Center for Science and Engineering Statistics (NSF/NCSES)

For basic research in the U.S., recent years marked a significant decline in real expenditures, largely due to the recent 2009 recession. The American Reinvestment and Recovery Act (ARRA) assisted R&D funding largely, however basic research remains underfunded. Industry conducted about 18 percent of preliminary basic research expenditures in 2012. This is a drop from conducting 21 percent of total basic research in 2010. Basic research conducted by federal sources has largely dropped as a share of total basic research expenditures from over 15 percent of total in 1970, to just below 7 percent of the 2012 preliminary total. While the federal government still funds about 60 percent of all basic research, in 2005 government support for academic R&D fell for the first time in twenty-five years.

Appendix C - Assessment of the Economic Impact of Basic Research

There are three methods that are used to evaluate the economic and social value of research. The majority of researchers use econometric modeling (rates of return), case study (quantifying results, or activity) or survey evaluations (views of researchers and managers). Although no one method fully encompasses the potential benefits from research, the next sections give an overview of different channels which basic research flow into the economy and society, which these methods attempt to measure.

Economic Impact And Benefit-Cost Assessment

The direct benefits to the U.S. economy are often measured through economic impact and cost assessment. This method is preferred for capturing the economic impact form the amount of research funding flowing from public, private, and internal sources. These funding sources are recorded and the economic impact of the funds are assessed in terms of the number of jobs created, the economic value added, as well as the generation of taxes which all stimulate local and regional economies. Researchers typically focused on the economic impact of expenditures for specific research parks, university research centers, or other institutions. These indirect benefits to the economy have become increasingly important for scientific policy discussions (Saha and Weinberg, 2010). Although using models allow us to measure the economic impact resulting from expenditures, it does not fully cover the indirect benefits of research results. The following are results of a variety of economic impact studies conducted from funding and operational expenditures of research centers.

Arizona

In 2009, a report was conducted on the economic impact of the University of Arizona Science and Technology Park in Pima County. Data was collected on operation-related activities, such as faculty wages and other operating expenses. The economic impacts were then calculated for the county and state. Table 16 below shows the results of the study.

Table 16: Economic Impact of the Univ. of Arizona Technology Park (CY 2009)

Economic Impacts	Employment (# Jobs)	Wages and Salaries ($ Millions)	Total Dollar ($ Millions)
Pima County			
Direct Impacts	6,494	$471.5	$1,805.8
Indirect & Induced Impacts	7,795	$282.4	$861.6
Total	14,289	$753.9	$2,667.4
Arizona			
Direct Impacts	6,494	$471.4	$1,805.8
Indirect & Induced Impacts	9,624	$433.2	$908.1
Total	16,118	$904.7	$2,713.9

The indirect and induced effects are the additional impact that is generated from the initial shocks to the economy. Total dollar impact is measured by the sum of output sales including wages and tax revenue. By measuring the ratios of results, multiplier effects for each category can be calculated.

The following are the multiplier effects of the UA Technology Park for the state of Arizona:

- For every job directly created from operating expenditures, there are 2.48 jobs created in the state.
- For every $100 of direct expenditures on wages to Tech Park employees, there is $92 of additional wages generated in the state.
- For every $100 in total dollar impact, an additional $50 total dollar impact ripples through the state economy.

Florida

In 2007, an economic impact study was conducted by FSU CEFA of Innovation Park (including 1,733 employees), in Tallahassee Florida[37]. The study found that there was about $400 million generated in sales/revenues, supporting 3,000 jobs, with about $186 million in wages, in 2007 dollars.

[37] The study was conducted at the request of the former Innovation Park Director, Ms. Linda Nicholson, in September, 2007.

Canada

The Association of University Research Parks Canada (AURP Canada) represents 28 existing and proposed research parks across Canada. In a report released May 2013, the economic impact of these centers was evaluated for the national economy. By collecting data on expenditures, operating costs and capital equipment purchases, the impact on output, employment, and tax revenues was assessed. Table 17 below shows the results of the study.

Table 17: Economic Impact of University Research and Technology Parks in Canada

Economic Impacts	Spending ($ M)	GDP ($ M)	Wages and Salaries ($ M)	Employment (# Jobs)	Government Tax Revenues ($ M)
Total economic impacts (direct, indirect, and induced)					
Current Year	$6,059	$4,305	$3,209	65,187	$596
Future (upon completion)	$9,122	$6,443	$4,828	99,599	$903
Current Year	$1,515	$1,062	$793	16,560	$148
Future (upon completion)	$2,378	$1,663	$1,248	26,821	$235

This study concludes that the current research and technology parks in Canada alone facilitate approximately $6.1 billion in annual spending across the Canadian economy. From this, over 65,000 jobs are created with over $3.2 billion in wages and salaries. The Canadian government receives over $596 million in tax revenues annually. Once fully operational and completely built, the economic impact facilitated by research and technology parks increases roughly 50 percent. Approximately 25 percent of these impacts are directly generated by the operating expenditures for research and technology parks.

It is worth noting that the economic gains from these do not capture the results of research conducted – this is an issue when assessing returns on research. Even so, operating cost expenditures by research centers have shown to benefit an economy's employment and output.

Research Centers as a Stimulus to Innovation

Not all economic benefits of basic research are caused by the physical act of building a research facility and hiring workers, but by what researchers refer to as a "technological incubator" effect. This is often caused by technology transfer resulting from research centers onto the surrounding economy. Research centers are seen as enablers for infrastructure build-up and provide the opportunity for large-scale innovation hubs for the surrounding economy (Saha and Weinberg 2010). Cooperative relationships between academic basic research centers and industry, as well as U.S. federal labs and industry have long been documented to further technologic development (Mansfield, 1980, 1990; Georghiou and Roessner 2000). Qualitative survey and case study methods are used to track technological innovation through graduates from university programs or programs of other research centers.

Many methods measure the transfer of technology from research programs. They may choose to follow one program, project, or researcher, while evaluating the economic and socio-economic impact generated. These are largely produced by the generation of bold ideas that grow within any research environment. This approach is often considered the core mission of basic research: to improve the standing knowledge in the field. This is the basis of new ideas, products, or designs across every field imaginable. Improvements and the creation of new scientific instrumentation and methodology have been gains obtained from basic research in particular (McMillan and Hamilton, 2003). These improvements are considered capital goods of scientific industry and can generate large economic returns.

Publically funded and basic research has long been seen as a base for additional research and development. Tijssen (2002) examined the "science dependence" of new generated inventions in science dependence of technologies: evidence from inventions and their inventors. The study concludes that some 20 percent of private sector innovations are completely or partially based off of public sector research. Another paper published in 2003 by McMillan and Hamilton examined the patenting and publication patterns of 119 U.S. companies in the biotechnology industry. Over 7000 scientific papers were cited, with over 64 percent of those being directly from basic (versus applied) research journals. In addition to this, 72 percent of the 7000 papers cited were funded by public sources.

While there is still no exact measure that can fully encompass the total output enabled by research labs, the Association of University Technology Managers (AUTM) publishes its *Licensing Survey* annually. This survey is collected from over 299 major academic research institutions from the U.S. The FY 2012 *Licensing Survey* at AUTM estimated $63.7 billion total spending in U.S. economic activity due to sponsored research activity.

AUTM licensing survey for FY 2012 (AUTM 2012) 21,353 invention disclosures reported

- 13,066 new U.S. patent applications filed
- 4,627 U.S. patents issued
- 482 new commercial products launched, bringing the total number of new products over the last ten years to be 5,245 (2002-2012)
- 655 new companies established as a result of academic research, with 78 percent of them being within the home state
- University generated over $1.305 billion in royalties on licenses
- 5,567 new licenses and options executed, a 3.1 percent increase from FY 2011

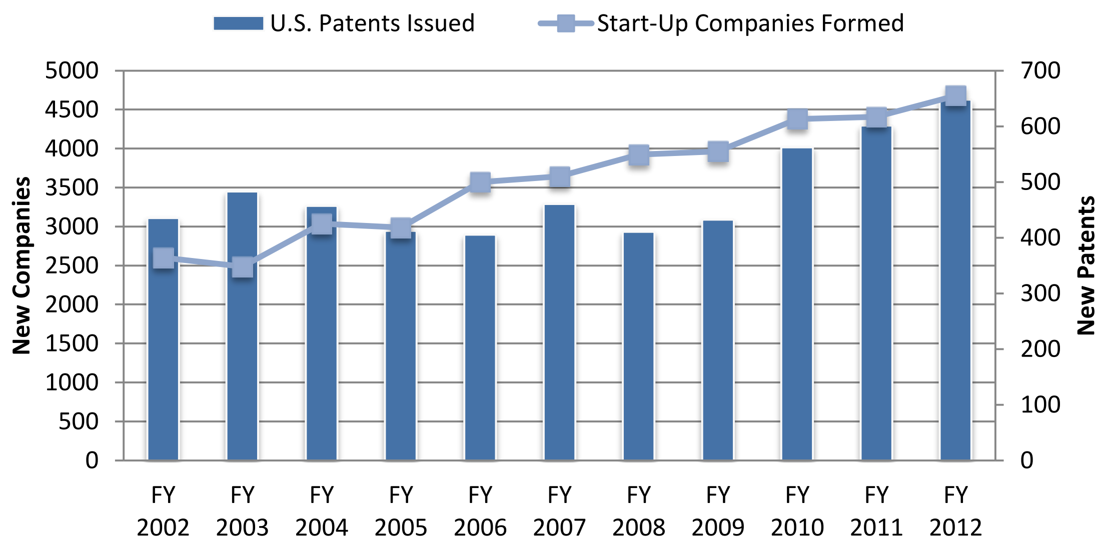

Figure 22: New University Patents and Start-Up Companies Formed, 2002-2012

Externality Effects of Basic Research

There are also methods that attempt to measure the socio-economic benefits of research, such as improvements in quality of life, health and human services. Although many of the non-economic benefits resulting from research are not directly measurable in dollars, the benefit is indeed felt as if it was so. Attempts to add these to exact figures to assess a return on the investment for research are likely inadequate due to oversimplification of the channels in which it impacts us – economic or otherwise. For example: basic research attributed to a genetic marker test for Alzheimer's (JEC, 2010) has undoubtedly benefited many people. The value of this marker test to society is difficult to assess. Out of this value, it is even harder to attribute the benefit the basic research experiment provided. Even so, typically for assessing improvements such as these, a case study is used for a particular project or program in order to quantify the benefits through improvements made.

Basic research has largely been seen as the starting point for many innovations in healthcare. In a recent article by Francis S. Collins, the director of the National Institute of Health, stated the much needed importance of basic biomedical research: "When everybody gets to one side of the boat, it usually tips over." Researchers have reached conclusions on the socio-economic value of healthcare increases resulting from research, especially biomedical research (Buxton et all, 2004).

There are four main indirect benefits from biomedical research:

1. The economic value of workforce health (reduced loss of output).
2. The intrinsic value of health, estimated by placing a value of the quality of life improvements.
3. The direct benefit from cost-savings from the reduction of, or cheaper medical treatments.
4. The evaluation of benefits resulting from commercial development.

According to *Effect of a US National Institutes of Health programme of clinical trials on public health and costs* (Johnston et all 2006), a collection of 28 clinical trials that resulted from NIH research were analyzed. From a publicly funded $3.6 billion dollars over ten years, there is an expected increase of over 470,000 quality adjusted life years for the U.S. Adjusting results to gross dollar amounts, this is a projected net benefit of over $15.2 billion resulting from decreased costs and measurable improvements in health. These results indicate a benefit of over four times the initial public investment.

Another societal benefit obtained from basic research is the public need for information, for which the value is largely immeasurable (Martin and Salter, 2000; McMillan and

Hamilton, 2003; Martin and Tang, 2006). The supply of knowledge to the public is a product in its own right. Environmental quality has been an increasing global issue in the most recent decades. Research has led to many improvements in keeping our atmosphere, oceans, and land cleaner. Environmental economics is a process of quantifying changes in quality of environment.

Beyond the Linear Model - Scientific Collaboration and Long Term Investment

Collaboration among scientists has been largely increasing in recent decades. Along with the development of the Internet and the decreased costs of distant communication, scientists have developed communities within their field that are not just local. In previous decades, collaboration has been done within a university, or just between related institutions. There are growing international networks of researchers within the same field, all who read the same journals and attend the same conferences. Although it's difficult to measure the benefit from increased collaboration, survey methods determine that interaction between researchers is effective in learning about the latest research and instrumentation techniques. The density of researcher networks has been considered to be a measure of robustness for a local or national innovation system (Cooke and Morgan 1993).

Furthermore, according to a 2013 article *Quantifying the benefits of international scientific collaboration,* when more countries are involved, the impact of the research being conducted tends to be greater. Using the number of other citations accrued as the "impact" of a paper, they found that many countries with weaker scientific impact benefit greatly from collaboration with high impact neighbors. Meanwhile, there was little to no negatives for the high impact country. Due to the vast area of the United States, collaboration between the multitudes of prestigious home institutions largely outweighed other measurements. Nevertheless, international collaboration systematically increased the impact of scientific research across all fields.

The study *The Benefits from Publicly Funded Research* (Martin and Tang 2006) gives an outline of different cases in which countries retain socio-economic benefits from the flow of research. The subscripts in the diagram labels all indicate the country (A, B, or C) in which the step occurs. Research that occurs across various countries can be refined and then built upon – from which every country then reaps the benefits resulting from increases in the stock of knowledge.

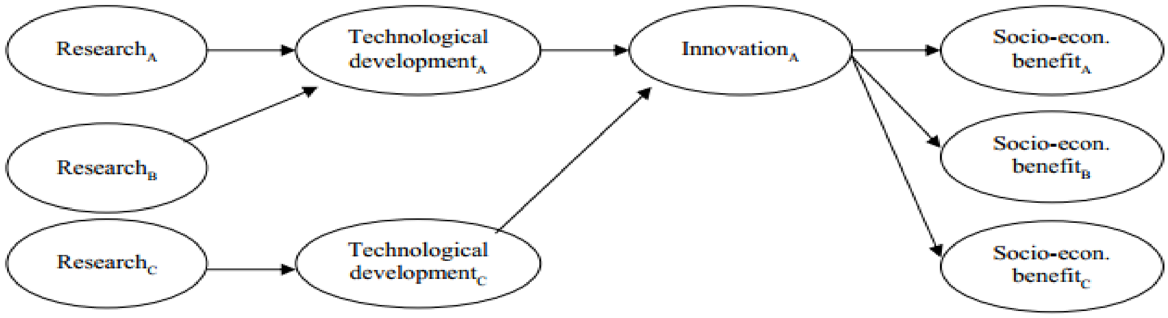

Figure 23: Cross Country Effects of Research (Where Letters Indicate the Country)[38]

It is well known that the very core of basic research is to increase the stock of human knowledge. Many believe this is a large portion of economic growth, as innovations in the product market often come from the formation of new knowledge (Salter and Martin 2000, McMIllan and Hamilton 2003, Saha and Weinberg 2010). Since economist Robert Solow in 1957, economic output has largely been seen as a function of workers and machines, with growth largely determined by how they interact; increasing the stock of knowledge often improves technology and productivity. Productivity through technology is the key for economic growth, so although job creation through research funding obtains a lot of attention, indirect benefit may be best measured in terms of the value added to the economy through increases in productivity and newly formed industry.

For the year 2013, the gross domestic product for the entire U.S. was $16.8 trillion dollars. If research were to account for a 1 percent increase in productivity, then it would add $168 billion dollars. This would not even take into account the number employed, the wages paid, or any socio-economic improvements from the conducting of research – this is only the result of improving U.S. productivity. However, basic research is a long-term investment, taking years, or decades for efforts to provide substantial rewards of pure output. One NBER paper uses econometric models to estimate basic research increasing the efficiency of other research and development expenditures: the lag of this effect is about 6-8 years (Toole 1999).

One example of a long-term, multinational research collaboration that increased the stock of knowledge is the Human Genome Project. With the goal to map the entire human genome, the Human Genome Project was a 15-year international research effort starting in 1990, which was in total a $3.8 billion dollar investment by the U.S. government. However, the project involved funding from research institutions in the United States, United

[38] Source: Martin and Tang, 2006

Kingdom, China, Japan, Germany and France. All the countries contributed to work towards mapping the human genome. In a report issued by Battelle, *The Economic Impact of the Human Genome Project* assessed the impact resulting from the generated economic activity of the project. In a single year (2010), the newly formed genomics industry generated over $3.7 billion in federal tax revenues from economic activity. This almost completely covers the total 15-year investment cost for the U.S. in one year. There is currently no estimate on the complete benefit for all participants of the study.

V. Training of skilled engineers and scientists

As previously mentioned, more than half of all basic research has been conducted by academic sources. Many of these basic research centers employ scientists and engineers straight from their associated university. The role of a student is often not just to be the recipient of education but also to assist in conducting research for professors and university research centers. Those who receive training in conducting basic research obtain a desirable set of skills for when they enter the industry and continue their path as a researcher. Many believe this is the most important mechanism for basic research programs to derive economic benefit, as well as give a competitive edge in a global market (Dasgupta and David, 1994; McMillan and Hamilton, 2003; Martin and Salter, 2000).

A brief look into the sought-after skillset of a scientific researcher includes:

1. Knowledge of recent studies and journals in the field.
2. Skillful implementation of newly created instrumentation techniques.
3. Access to a network of related scientists and engineers in the field.
4. Elevated Problem solving and analytical abilities.

Among economic researchers, this accumulation of education and highly desirable skills is often referred to as "human capital." Much research has been done linking human capital with increased long run growth and economic stability. One NBER paper investigated the linkages between research and human capital accumulation within multiple metropolitan areas (Abel and Deitz, 2009). Their findings concluded that there was a small positive relationship between an area's economic production and its stock of human capital due to the high levels of migration, or movement, of trained individuals. The highly mobile college graduate is often an important part of policy discussion when referring to human capital. The main findings of the paper concluded that academic R&D activities not only increase the localization of human capital, but also the region's share of high skill level occupations. It should come to no surprise that in order to keep a concentration of high skill level workers, it would require not only academic institutions to produce, but research centers to employ said workers.

No Basic Assumptions

A 2010 report by the Joint Economic Committee (JEC), titled *The Pivotal Role of Government Investment in Basic Research,* calls for additional investment in basic research as current levels may be far below optimal amounts. As of 2012, basic research only compromises 16.5 percent of total R&D expenditures, the vast majority being publicly funded. If basic research were funded by the private sector alone, the majority of beneficial discoveries would never have been made. Cited in this report is an academic paper titled *Sources of U.S. Economic Growth in a World of Ideas*. Using econometric models, author Charles Jones from University of California – Berkeley, estimates up to 80 percent of U.S. GDP growth between 1950 and 1993 can be attributed to growth in research intensity (research levels relative to GDP) coupled with higher levels of educational attainment. Not including increasing education levels, increases in research intensity alone account for 50 percent of total U.S. GDP growth.

An academic paper released in 2014 by the National Bureau of Economic Research (NBER) and University of Pennsylvania, *Back to Basics: Basic Research Spillovers, Innovation Policy and Growth,* introduces a model for technological change through basic and applied research. The paper gives an overview of the complex relationship between basic and applied research from an industrial policy standpoint. They identified two facts that are key for their model:

Fact 1: *A firm's basic research investment is increasing in its multi-industry presence.*

Fact 2: *Basic and applied research investments are complementary. In particular, higher public basic research investment encourages firms to invest more in applied research.*

The findings included that 89 percent of spillover benefit resulting from basic research was cross-industry (between fields) and that basic research improves the productivity of applied research by 60 percent. Only the firms involved in a variety of industries are ones likely to invest in basic research, as they are more likely to capture the potential spillover benefit to other industries. On the other hand, applied research has a much smaller spillover effect on other industries and any benefit is typically contained within the performing industry. They concluded their study with a key take-away message on the importance of proper allocation of R&D subsidies. Standard policies that impose a uniform subsidy for both applied and basic research do not generate the expected impact due to the relationship of the two. This is due to a relative over investment in applied research in relation to basic research.

When the question is asked: what is the return on investment basic research? For an investment standpoint, it largely depends. Some experiments produce results to be cataloged in a research journal and kept in mind for the future, while other research has led to breakthroughs in modern day science, spawning entire new industries in its wake. From economist estimates of private rates of return on investment for research and development, this is as low as 9 percent, and as high as 43 percent. Meanwhile, the rate of return on investment for the entire economy is estimated anywhere from 10 percent to 160 percent (Martin and Salter 2000). There is, by and large, no agreement or middle ground on the issue, and many caution the reliability of their own numerical estimates.

After reviewing the variety of different ways in which potential benefits of basic research can be assessed, one should have a greater understanding of the standing of basic research. There is a reason why it is mainly publicly funding and why academic sources are the main conductors of basic research. It should come as no surprise that basic or "pure research," has a greater scope of potential impact than its privately funded counterpart. And with its main goal of greater human understanding, the many prestigious U.S. academic institutions are in a prime position to perform it. From this, we find the balance of research and development to be increasingly crucial to, not only local and state economies, but to our overall quality of life, and international competitiveness.

APPENDIX D - IMPLAN Model

For state and local economic impact portion of this study, the FSU Center for Economic Forecasting and Analysis (CEFA) staff used the state of Florida Impact Analysis for Planning, or IMPLAN, model. The IMPLAN model is used extensively by 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 these models:

- They are calibrated to local conditions using a relatively large amount of local county level and state of Florida specific data;
- They are based on a strong theoretical foundation; and
- They use 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 and counties of Florida. 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 MagLab spending.

The Maglab's Collaborations with Other Departments

As described earlier in the report, the MagLab collaborates with many other university research departments. The top collaborative research departments were listed earlier in Table 4 of the narrative, however, the "other department" (i.e., less than one percent of total research activity) included the following: Future Fuels Institute, Biology Department, Geology Department, EOAS/Oceanography Department, Physics, EOAS/Geological Sciences, Florida Center for Advanced Aero-propulsion, Scientific Computing, Martech, Center for Intelligent Systems, Control and Robotics, Psychology Department, FSU Coastal & Marine Lab, Geography, Aero-Mechatronics Energy Center, Medicine Biomedical Sciences, Chemical & Biomedical Engineering, Department of Scientific Computing (CSIT), Institute for Energy Systems, Economics and Sustainability (IESES), Civil & Environmental Engineering, Nutrition Food & Exercise Science, EOAS/Geological Sciences, and the FSU Graduate School.

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