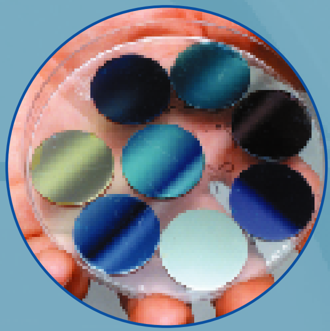

The Economic Impact and Benefit to Cost Ratio of Public and Private Higher Education Research in Florida

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Introduction

In 2001, the Leadership Board for Applied Research and Public Service (the Board) conducted a study of the statewide economic impact of the State University System (SUS) on the Florida economy (Lynch, Smallwood, and Barnes, 2001). The study examined the lifetime earnings of university graduates and the contribution that they made to the economy. In 2003, the Board collaborated with the Council for Education Policy, Research and Improvement (CEPRI) on another legislatively mandated study of the economic impact of state-supported university research centers and institutes (C&Is) (Harrington, 2003). The CEPRI/Board study concluded that "... in Fiscal Year (FY) 2000–01, C&Is spending accounted for 24 percent of total SUS external research spending and 27 percent of total SUS appropriated research expenditures." However, almost three-quarters of SUS research expenditures were excluded from the economic analysis (i.e., research conducted by individual faculty who were not affiliated with C&I). Nor have they been addressed in other studies. This study was undertaken to evaluate the statewide economic impact made by the entire public and private university research enterprise on Florida's economy.

In 2004, the Board staff completed a review of the literature (see Attachment) on the socioeconomic impact of university research and evaluated techniques that have been used to quantify these impacts (Lynch, Harrington, and Aydin, 2004). The review found four accepted types of methods that can be used to evaluate the economic and socioeconomic value of university-related research to the national and/or state economy:

1. Assessing the economic impact and benefit-cost analysis.
2. Focusing on universities as technological and innovation incubators and industrial partners.

3. Examining the socioeconomic externalities associated with university research.
4. Focusing on the student capital development aspects of university research.

The Board decided to begin the evaluation of the impact of university research with a comprehensive economic impact and benefit-cost analysis. During this 2004–05 FY, the Board staff initiated and completed a comprehensive economic impact assessment and benefit-cost analysis of research in all of the 11 public universities and 5 private colleges[1] and universities in Florida. The staff also compared levels of scientific and engineering research funding received in Florida with that received in other states.

Scope of Study

The study used data on university research funding from all sources (public, private, and other) and modeled the economic impact of the expenditures completed by these research institutions on the Florida economy for FY 2003–04 (July 1, 2003, through June 30, 2004). Measuring the economic impact of research expenditures in these colleges and universities captured the direct, indirect, and induced effects of total research funding that flowed into and out from these institutions from all sources. The economic impact assessment measured the amount of economic stimulus flowing from these funds in terms of numbers of jobs created, statewide wages, gross state output generated, and generation of taxes from those expenditures that ultimately stimulated the local and state economies. The Regional Economic Models, Inc. (REMI) impact assessment tool was used to complete the final phase of this analysis. The analysis included the direct and secondary economic impact from the public and private university research as well as a final benefit-cost ratio analysis resulting from these impacts.

[1]Private colleges include the University of Miami, Florida Institute of Technology, Nova Southeastern, Embry-Riddle Aeronautical, and Bethune Cookman.

This FY 2003–04 economic analysis was completed by

I. Gathering existing research funding data from the public and private higher education research programs, including the following sources:

   A. External funding sources

      1. Federal, state, and local
      2. Private industry
      3. International
      4. Foundation
      5. Other external sources

   B. Internal university research funding sources

      1. Royalty fees or patent based
      2. Student (and other) fees
      3. Benefactor or other charitable sources
      4. Other internal sources

II. Gathering existing data on research outcomes and direct impacts as a result of research completed in Florida universities.

III. Comparing results of a survey of each university's vice president for research on funding levels.

IV. Completing an economic impact assessment of the 16 Florida universities and colleges using the REMI modeling tool. Using these results, a cost/benefit analysis of the SUS research annual impacts was completed.

The estimated economic impacts include the final level of 2003–04 gross state product, wages, and employment generated by university research expenditure activity across Florida.

The final benefit-cost analysis where state and local public funds provided for higher education research that could have alternatively been invested in other state of Florida public-sector activities were viewed as the "opportunity cost." The direct and secondary economic impact of all higher education research fund expenditures were viewed as the benefits flowing from these state investment costs. The conclusions of the economic impact and the benefit-cost ratio analysis of Florida's higher education research will be valuable to university administrators, policy makers, and the legislature for future strategic planning and other purposes.

Methodology

The impact of Florida public and private higher education (FHE) research investments on Florida's economy was measured in terms of employment and economic output generated across the broader statewide economy. The net economic stimulus from FHE was estimated by summing FHE external and internal expenditures for FY 2003. External expenditures include those associated with contracts and grants (government and private sponsors), auxiliary fees/services, and other external sources. Internal expenditures include all state (SUS and other appropriated) expenditures. The sum of these expenditures represents all FHE expenditures that were used for salaries, materials and equipment, travel and services, and all other expenditures during this time period.

Board researchers examined several primary sources of data to complete this study. Each source varied from the other by very small amounts, thus confirming the veracity of the various reporting systems all drawing from the same basic source, the Florida higher education systems. Different sources, however, are developed with slightly differing time frames and purposes, and include differing combinations of higher education facilities across the state (for example, total public versus total public and private). These differences are described later in the report.

The REMI Model

The REMI model, as Bolton (1985) states in his review of econometric models, ". . . is a world apart in complexity, reliance on inter-industry linkages, and modeling philosophy." REMI, a widely accepted and used dynamic integrated input-output (I/O) and econometric model, generates year-by-year estimates of the total regional effects of any specific policy initiative. A wide range of policy variables allows the user to represent the policy to be evaluated, while the explicit structure in the model helps the user interpret the predicted economic and demographic effects. In addition, it is the chosen tool to measure these impacts by a number of universities and private research groups, government agencies (including most U.S. state governments), consulting firms, nonprofit institutions, and public utilities. REMI model simulations estimate comprehensive economic and demographic effects in wide-ranging initiatives such as economic impact analysis, policies and programs for economic development, transportation, infrastructure, environment, energy and natural resources, and state and local tax changes.

Articles about the model equations and research findings have been published in the *American Economic Review*, *The Review of Economic Statistics*, *Journal of Regional Science*, and *International Regional Science Review* (REMI, 2000). In Florida, REMI is used extensively to measure proposed legislative and other program and policy economic impacts across the private and public sectors of the state by the Florida Joint Legislative Management Committee, Division of Economic and Demographic Research, Florida Department of Labor, and other state and local government agencies.

The REMI model used for this analysis was specifically developed for the state of Florida. REMI's principal advantage is that it can be used to forecast both direct and indirect economic effects over multiple-year time frames. Other I/O models primarily are used for a single-year analysis. I/O models are basically accounting tables that trace the linkages among industry purchases and sales within a given county, region, state, or country. The I/O model produces multipliers that are used to calculate the direct, indirect, and induced effects on jobs, income, and gross regional product (GRP) generated per dollar of spending on various types of goods and services in Florida. REMI combines these capabilities plus the ability to forecast effects of future changes in business costs, prices, wages, taxes, etc.

REMI was first developed in 1980, and continues to be enhanced. The entire regional economy (i.e., Florida) is modeled as interactions between seven linked groups of economic variables: output, labor and capital demand, population and labor supply, wages, price, profits, and market shares of national and local firms operating in the region.

The output block contains the I/O component of the model. Final demand drives the output block. Production uses factor inputs (e.g., labor, capital, and fuel) and intermediate inputs. Coefficients of the production functions are based on national I/O tables produced by the Bureau of Labor Statistics. Intermediate inputs are used in fixed proportions. Factor input use is governed by Cobb-Douglas production functions in Block 2. The relative factor intensities respond to changes in relative factor costs (i.e., wage rate changes, cost-of-capital changes, and changes in fuel prices).

Labor supply in Block 3 responds positively to increased wage rates because of migration. Also, the ratio of residence-adjusted employment to the potential labor force influences migration. Place-of-work income also is adjusted for place of residence to obtain disposable income. The interaction of labor demand calculated in Block 2 and of labor supply calculated in Block 3 determines wage rates in Block 4. Migration induces government spending through additional taxes paid and consumer spending through increased wage and nonwage income. The increase in real disposable income derived from migration also stimulates residential investment. Nonresidential investment is stimulated by increased capital demand by businesses.

Wage rates affect the competitiveness of local firms relative to firms in other regions in Block 5. Regional competitiveness affects the shares of local and exports markets (market shares) that local firms capture. The proportion of the local market captured is known as the regional purchase coefficient (RPC), and the proportion of the export market is known as the interregional and international coefficient. Also, the RPC, which is a measure of self-sufficiency, increases as a region grows because of agglomeration effects.

Endogenous consumption, investment, and government expenditures plus exports are the final demands that drive the output block. The endogenous RPC gives the proportions of local expenditures satisfied by imports or local production. Solution values for the endogenous variables in the REMI model must satisfy the equations in all five blocks simultaneously.

By suppressing certain endogenous responses in the REMI model, multipliers comparable to those computed from an I/O model can be obtained. If the responses of labor intensities, labor supply, wage rates, industry RPCs, and endogenous final demands are suppressed, Type I I/O multipliers are obtained. By allowing consumption to be endogenously determined, Type II multipliers are obtained. Complete endogeneity in the REMI model produces what is referred to as Type III multipliers. This Type III multiplier differs from standard Type III I/O multipliers because of the endogeneity of export and propensity to import responses in the REMI model.

The detailed structure of the REMI model requires an extensive amount of data. The I/O component is nonsurvey based, using national technical coefficients. Of particular importance are data on employment, income, and output. Also, because complete regional accounts consistent with the National Income and Product Accounts are not routinely available, they must be constructed.

REMI uses three sources of employment wage and salary data: the Bureau of Economic Analysis (BEA) employment, wage, and personal income series; Bureau of Labor Statistics (BLS) establishment employment and wage and salary data; and County Business Patterns (CBP) data published by the Bureau of the Census. The BEA data are annual averages and are reported at the two-digit level for states and at the one-digit level for counties. The BLS data, the foundation for the BEA data, are collected monthly in conjunction with the unemployment insurance program at the two-digit level for counties and states. CBP data are collected in conjunction with the Social Security program in March of each year.

Confidentiality requirements often produce suppressions in the data. Where suppressions occur, the number of establishments and the ranges of the number of employees for each establishment are supplied by CBP. REMI fills in the suppressions based on the hierarchical structure of the BEA data within regions and within industries. First, all North American Industry Classification System (NAICS) codes are made consistent within corresponding one-digit industries for each state simultaneous with all two-digit industries summed to the major region two-digit totals. Second, for the counties, REMI uses the BLS data, if available, and CBP data if BLS data are not available. Whichever data set is selected, it is made consistent with BEA one-digit county totals and two-digit state totals.

Output measures are based on regional employment data, the BEA Gross State Product series, and national output-to-employment ratios. REMI begins by applying the national output-to-employee ratio to employment by industry. This application is adjusted by regional differences in labor intensity and total factor productivity. Regional differences in labor intensity are given by the industry production function and the unit factor costs. Total factor productivity calculations depend on industry value added in production reported in real U.S. dollars by BEA and on adjustments by REMI to the BEA numbers to reflect differences in regional production costs. The ratio of real regional value added per unit of input relative to U.S. value added per unit of input is the REMI relative total factor productivity.

Data Sources

The first and most timely data available for FY 2004 were provided to researchers from each of the 11 publicly supported universities.[2] The data collected from each public university by the Florida Department of Education (DOE) (http://www.fldcu.org/factbook/) was a second source of data that was evaluated for completeness and accuracy. The differences between the individually reported data provided in the first data set (which is updated data from those provided at the DOE Web site posted earlier in the year) only varied by .01%. This close collaboration confirms the accuracy of both sets of data.

The third and most comprehensive data set on higher education research funding is from the National Academy of Science (NAS) at http://www.nsf.gov/sbe/srs/nsf04330/htmstart.htm.

[2]Data was provided by John Fraser, Technology Transfer Director, Office of the Vice President for Research, Florida State University, August 2004.

There are many advantages associated with this data set. First, it provides a comprehensive estimate of higher education research revenues and expenditures from both public and private universities across, not only Florida, but for each of the 50 states. Another advantage is that these data are aggregated into standardized multiple categories (state and local, federal, industrial, and so forth) as well as standardized major categories of spending (scientific, engineering, social sciences, and so forth) as far back as 1995.

This data set provides researchers with the ability to complete both time-series and cross-sectional comparisons of sources of funds as well as expenditures. These data allow researchers to develop historical comparisons of Florida funding levels with other states and the national averages. The aggregate and comparative per capita spending levels of total statewide research budgets can be compared to other states both historically and for the most recent year of record.

There are two minor drawbacks to the NAS data sets. The first is that the reporting time period lags the other two in-state data sets for Florida's public universities by one year. While the in-state public university data sets are available for FY 2003, the NAS most current data are for FY 2002. The second minor drawback is the technique used to assemble and standardize the data sets includes an estimate of full federal overhead cost accounting measures. Often, institutions of higher education negotiate with each federal agency on the amount of overhead charged with each grant. While this amount varies on a case-by-case basis (typically between 20% and 45%), the NAS requests the standardization that all appropriate federal funding be reported using the full 45% overhead typically desired by federal agencies. Hence, the estimates provided by each reporting institution of higher education to the NAS (at its request) are slightly higher (approximately 1.3%) than those reported internally to FDOE (data described earlier).

Given these data set differences, Leadership Board staff chose to use the NAS historic and FY 2002 data sets for all interstate comparative, time-series, and cross-sectional analyses. In addition, the FDOE in-state public university FY 2003 research revenues and expenditures data (adjusted for the percent increase for private in-state higher education institution research funding levels) were used to conduct the economic impact assessment and benefit-cost ratio analyses.

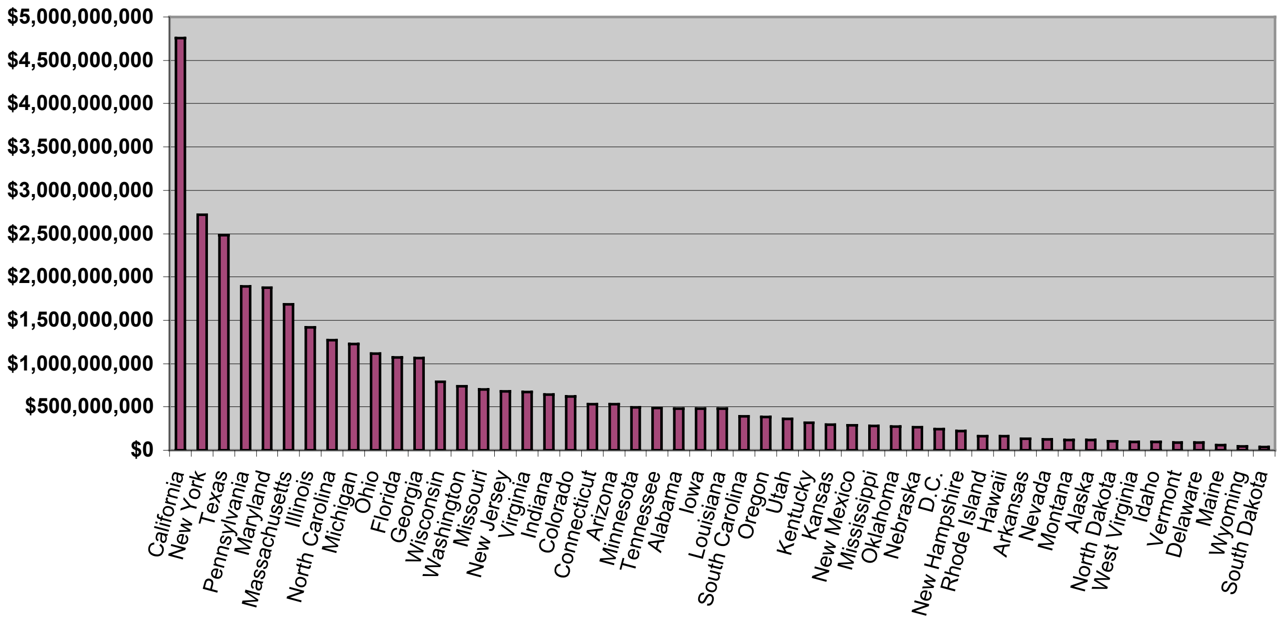
A summary of the data sets used in this research are provided in the technical appendix to this report.

State Rankings of Academic Research and Development

Academic research and development (R&D) is extremely important as contributors to a state's economy. Through funding for R&D, universities can undertake research they deem important to help drive advances in science, technology, medicine, the arts, and ultimately the economy itself. This research often generates a side benefit of improving the lives of citizens in the state as well. These benefits can be referred to as externalities and are not the focus of this analysis. Full accounting of these additional economic impacts on Floridians would potentially increase the magnitude of both the economic impact and the benefit-cost ratio considerably. Moreover, often R&D in the university spawns commercial innovations and applications that can create new industries in a state and increase employment and the overall level of the state's economy as well. For Florida's economy to do well, funding for academic R&D within the SUS is of the utmost importance.

Since academic R&D is so important to a state's economy, it is worthwhile to examine where Florida ranks compared to other states in the nation. Figure 1 shows the amount of academic total R&D Florida and the other states received in 2002. Florida ranked 11th in total spending of $1.07 billion. California was ranked first with $4.76 billion, and South Dakota came in last with only $38.15 million. The top three ranked states in academic R&D are also the three largest states in terms of population. Florida, however, is the fourth largest state in terms of population, but ranked number 11. Therefore, it may be useful to examine rankings adjusting for population (i.e., evaluated on a per capita basis).

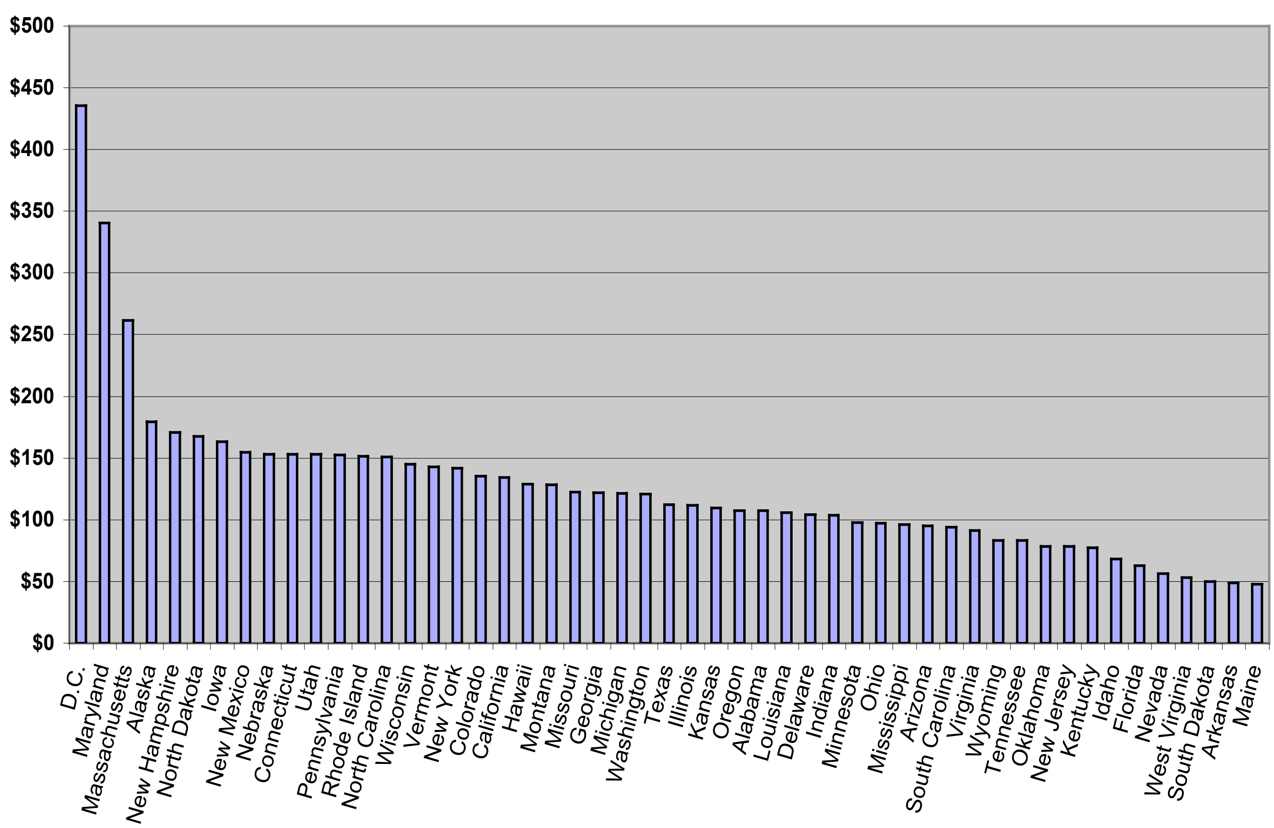
Figure 1. State Rankings of Academic R&D, 2002



State Rankings of Academic R&D per Capita

Ranking states by academic R&D per capita allows for the data to be "normalized," allowing for more appropriate comparisons. Academic R&D per capita is the total dollar value of academic R&D divided by the total population in that state in that year. Figure 2 provides the amount of academic R&D per capita for each of the 50 states and the District of Columbia. Florida ranked number 46 in academic R&D per capita in 2002 with a figure of $62.81 per person; the District of Columbia, with a total $435.63, ranked the highest. This is not surprising since there are a few notable academic institutions in that area and the population is quite small. Maine came in last with $47.60. Florida was not the only large state that fell in the rankings when adjusting academic R&D for the size of the population. New York, California, and Texas all dropped on the academic R&D per capita rankings to 17th, 19th, and 26th, respectively.

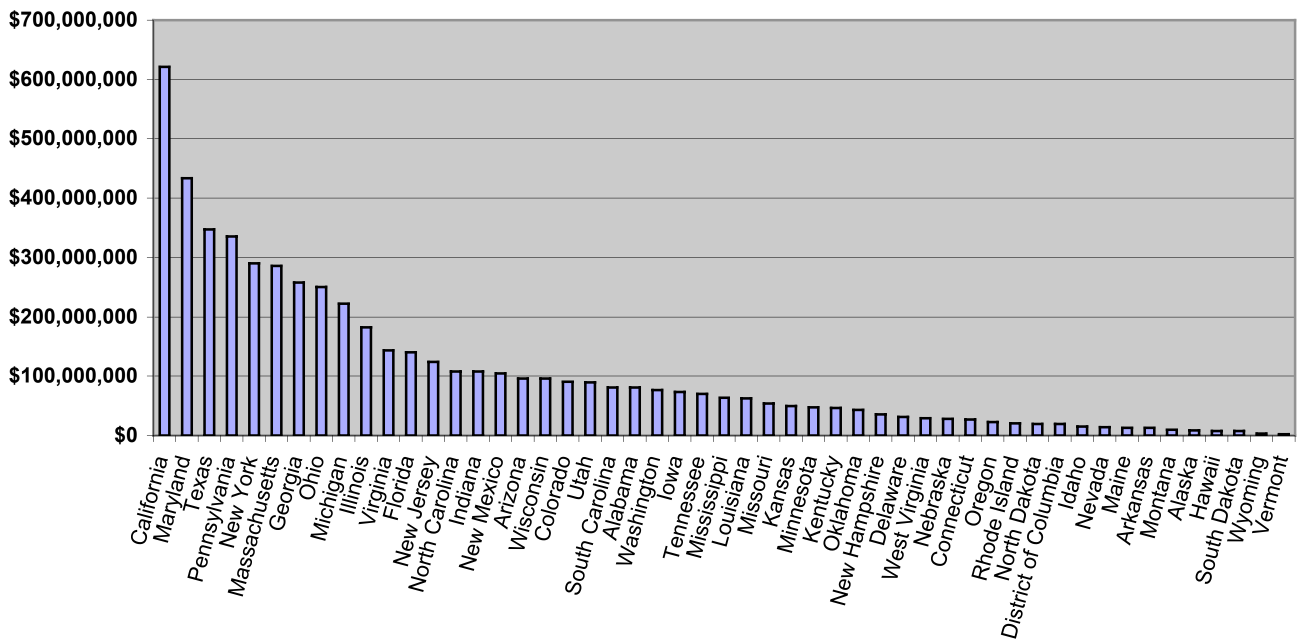
Figure 2. State Rankings of Academic R&D per Capita, 2002



State Rankings of Academic R&D in Engineering

Engineering is one of the most important areas of academic R&D. Engineering research provides us with advances in science and technology that move our technology and economy forward and can also substantially enhance our quality of life. From new products to new ways of doing things, engineering advances can allow our economy to remain competitive. Since engineering R&D is so important to a state's economy, it is worthwhile to examine where Florida ranks compared to other states in the nation. Figure 3 shows how much academic R&D states received for engineering in 2002. Florida ranked 12th totaling $140 million for 2002; California ranked first with $622.6 million; and Vermont came in last with only $2.07 million.

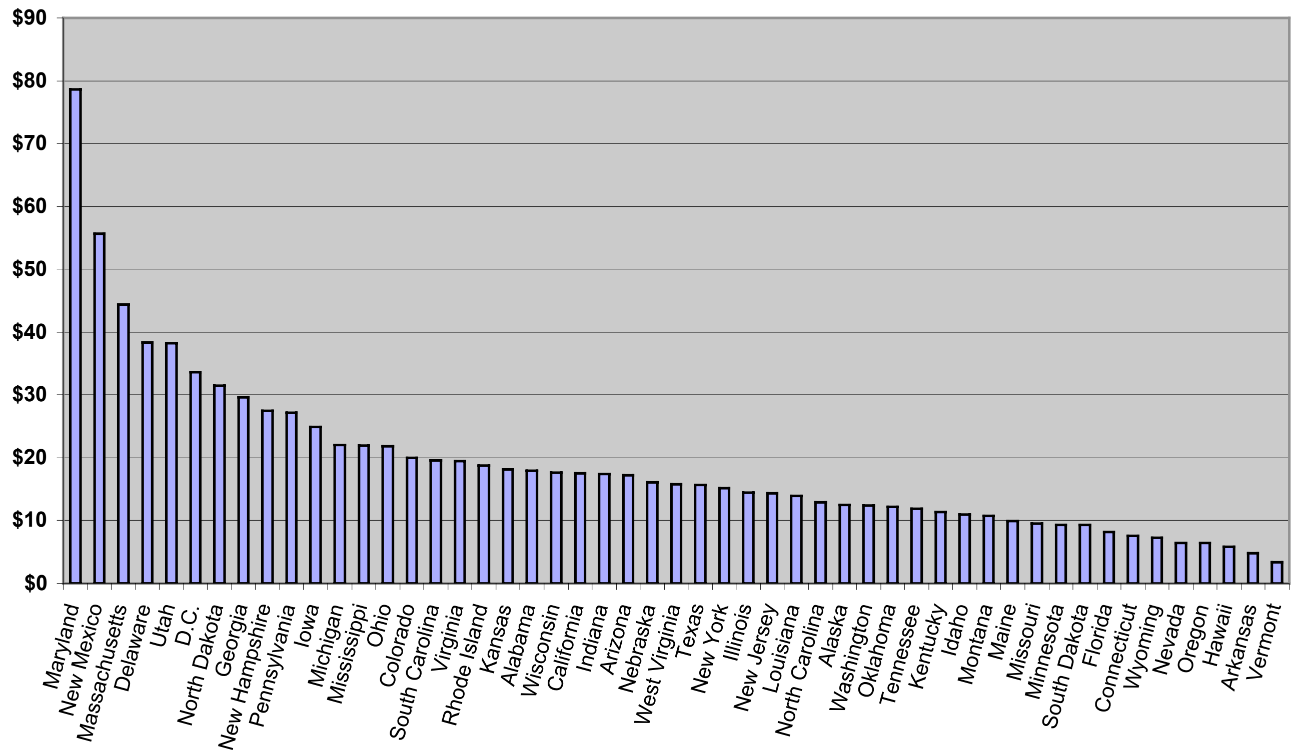
Figure 3. State Rankings of Academic R&D in Engineering, 2002



State Rankings of Academic R&D in Engineering per Capita

Ranking states by engineering R&D per capita also allows for the data to be "normalized," allowing for more appropriate comparisons. Engineering R&D per capita is the total dollar value of engineering R&D divided by the total population in that state in that year. Figure 4 provides the amount of academic R&D in engineering per capita for each of the 50 states and the District of Columbia. Florida ranked 44th in the nation with a figure of $8.23; Maryland, with a total $78.63, was first; and Vermont was last at $3.35 per person.

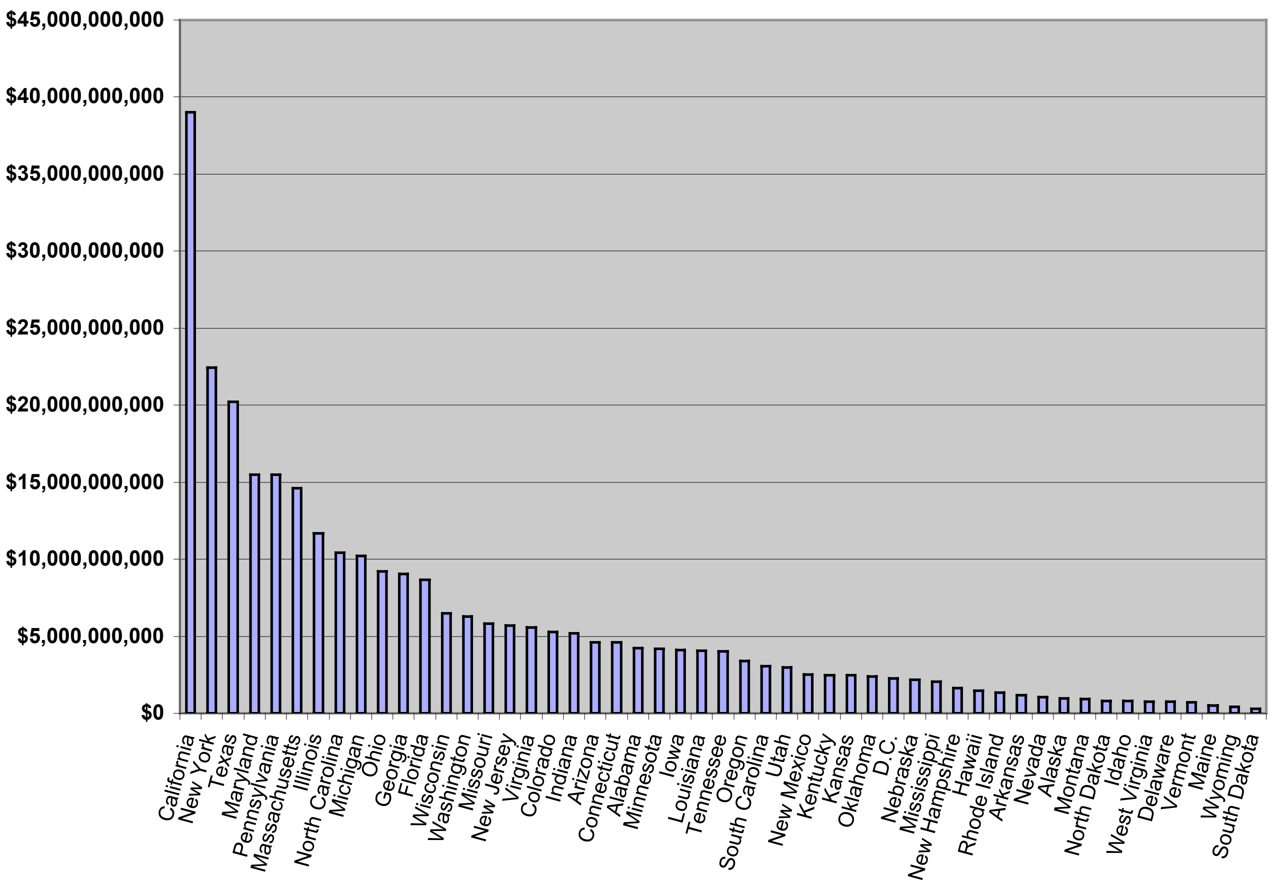
Figure 4. State Rankings of Academic R&D in Engineering per Capita, 2002



State Rankings of Total Cumulative Academic R&D Over Time

Since states may experience different levels of academic R&D for varying years, it is useful to look at cumulative R&D over time. Since academic R&D is so important to a state's economy, it is worthwhile to examine where Florida ranks compared to other states in the nation in cumulative academic R&D. Figure 5 shows the amount of cumulative academic R&D states received over the 1995–2004 period. The values for 2003 and 2004 were estimated based on past trends in R&D in each state. Florida ranked number 12 with cumulative academic R&D totaling $8.68 billion for the 1995 to 2004 period. California ranked first with $39 billion; whereas South Dakota came in last with only $304 million.

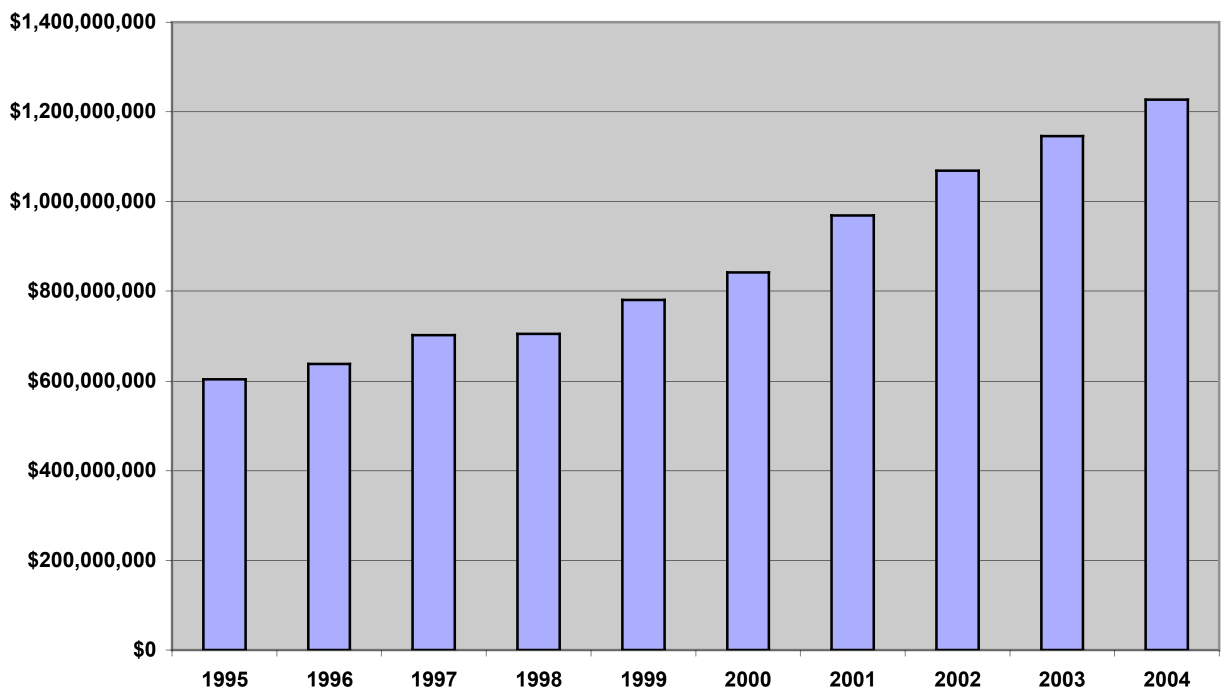
Figure 5. State Rankings of Total Cumulative Academic R&D for 1995–2004



Florida Annual Academic R&D Over Time

Academic R&D in Florida has increased over time. Figure 6 shows the annual amount of academic R&D in Florida between 1995 and 2004. Again, 2003 and 2004 were estimated based on past trends. Academic R&D grew slowly in the late 1990s until the 1999 to 2002 period, when it increased substantially. In 1995, Florida's academic R&D totaled $604 million and later climbed to $1.07 billion in 2002. This represents an increase of 77%. Over the same period, R&D grew nationally from $22.1 billion in 1995 to $36.3 billion in 2002, an increase of 63%.

Figure 6. Total Academic R&D in Florida, 1995–2004*



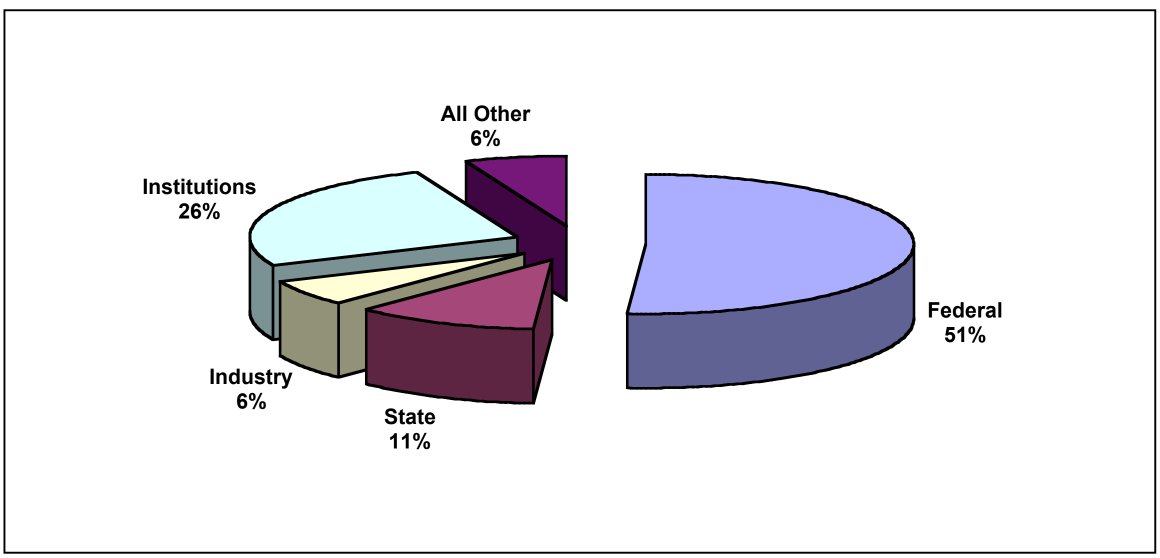
*2003 & 2004 Estimated

Economic Impact Modeling

Board researchers examined FHE's expenditure impacts on the Florida economy. The approach allows the REMI model to redistribute expenditures according to sectors (based on actual historical data). For the expenditure approach, FHE's actual FY 2003–04 higher education sector expenditures were used to calculate the economic impact. This approach allowed us to achieve a greater level of detail by capturing the economic impacts of the system via the specific expenditure path through the higher education sector provided by the REMI model. Thus, the expenditure approach was the selected method for this analysis.

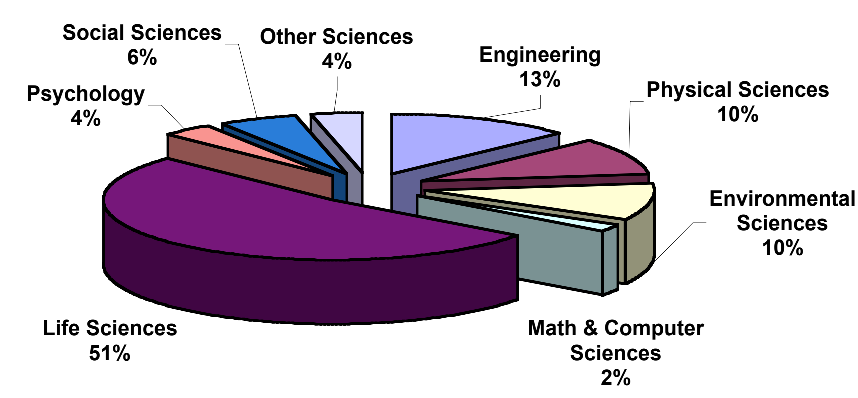
Sources of academic R&D included the federal government, private industry, institutions, the state, and other sources. Figure 7 provides a percentage breakdown by source of FHE FY 2003–04 funding. For the purpose of the economic impact analysis, the economic category used for this analysis was the higher Florida education sector within the REMI model. The dollar value of these respective categories is identified in the appendix.

Figure 7. Florida Higher Education Academic R&D Sources of Funding for FY 2003–04



Furthermore, one can examine the academic disciplines for which the R&D was spent. Figure 8 depicts the distribution of academic R&D by discipline. The discipline receiving the most academic R&D was the life sciences, with 51%. This is not surprising given that research breakthroughs in this area literally extend and improve the quality of the life of Floridians across the state. Engineering at 13%, physical and environmental sciences at 10% each, and social sciences at 6% were followed by other sciences and psychology at 4%, and math and computer sciences last with about 2% received.

Figure 8. Academic R&D by Academic Discipline FY 2003–04



Model Assumptions

This report provides estimates of only the direct, pecuniary/financial benefits (or "return") generated for Florida (output, income, employment, taxes) as a result of the "investments" that the public sector of the state makes in FHEs via state appropriated funds and investments in higher education research through the Florida Legislature and state public agencies. The "returns" that are estimated using this analysis are exclusively associated with outputs, income, employment, and taxes generated from the direct and secondary increases in statewide economic activity estimated through REMI, stimulated by the total of the FHE state, local, federal, private, and other internal and external contracts, grants, and other awards brought into the universities during FY 2003–04. This analysis excludes "returns" to the state that are not financial benefits (these are known as "nonpecuniary/nonmarket" or "intangible" externality benefits). These intangible benefits include those associated with the teaching, research, and public service activities of FHEs as well as the potential socioeconomic externalities described earlier. Therefore, the assumptions used to estimate the economic return to the state through its investments in FHEs in this report can be characterized as conservative.

It is important, however, to recognize that the benefits to the state of Florida associated with these FHE intangible benefits (e.g., value of new medications or high tech products produced and commercialized, quality of life enhancements, teaching, research, publications, presentations, public service, and a host of other cultural and amenity values) are significant. The amenity values or benefits to the community of having a research university present (and enhanced by the multifaceted activities of FHEs) can also be significant.

The model assumptions are

1. The base model assumes a constant rate of growth for the economy;
2. The expenditure approach model used actual FY 2003–04 FHE expenditures (which includes all categories of spending: salaries, expenses, etc.);
3. Total SUS investment (expenditures) in FY 2003–04 was $149.9 million;
4. This state investment leverages an additional $1.21 billion in external contracts and grants, fees, and private expenditures yielding a total of $1.36 billion in FY 2003–04 for all expenditures made by FHEs statewide;

5. In the absence of FHEs, the SUS investment ($149.9 million) would be reallocated to other Florida state spending activities; and
6. REMI results were expressed in terms of impacts on GRP, employment, personal (disposable) income, and state tax revenues.

Economic Impact Results of the REMI Analysis

Staff assumed that in the absence of state expenditures allocated to support FHEs, the initial state's public-sector investment of $149.9 million would be reallocated to support other state needs. As our modeling strategy, we used the university FHE's expenditures to calculate the economic impact via specific higher education model sector expenditure path.[3] The initial model results were expressed in fixed 1996 dollars. To update the results to a FY 2003–04 base year, the dollars were inflated using a REMI-generated Consumer Price Index (CPI). Because expenditure multipliers often require many years to completely exhaust their iterative impacts, discounting analysis was used to present the economic impacts over the period FY 2003–04 to FY 2034–35. The real discount rate used was 2.5%.[4]

The need to discount both the benefits and the opportunity cost estimates using a real discount rate stems from the fact that the value that we place on income and expenditures depends on when they occur (e.g., a dollar received a year from now is worth less than the dollar received today because of the time-value of money). Future values need to be converted to the common basis of today's value, referred to as the present value, in order to appropriately compare them. The present value of a stream of future values is the sum of the present values of

[3]A number of different Florida REMI model economic sectors were tested before the higher education sector was finally selected as the most representative of the several evaluated.
[4]Real discount rate is the difference between the yield on a long-term treasury and the CPI.

each element of the stream. The following results present the positive net economic impact of FHEs on Florida. The present value (*PV*) of a future cost or benefit is determined by the formula:

$$PV = \frac{s}{(1+r)n}$$

Where *PV* is the net present value of the discounted benefits or costs, *s* is the sum of the benefits, *r* is the discount rate, and *n* is the number of periods in the analysis.

The following results present the positive net economic impact of FHE on the state of Florida economy.

Table 1 summarizes the total economic impact of FHEs on the Florida economy. The table shows the discounted present value of the direct and indirect economic impacts (of direct FHE spending) on employment, GRP, real disposable income (wages), and taxes from the FHE external expenditures made during FY 2003–04. GRP or state output is the dollar value of final goods and services produced across the Florida economy over a 35-year time period from the FHE FY 2003–04 time period spending. Increases in personal (or disposable) income translate into more economic activities and local and state tax revenues as well. In addition to GRP, income, and taxes, FHEs spending generate a significant amount of employment across the state. The REMI model assumes that changes in employment affect wages. These changes in wages affect in-migration (i.e., population) and labor supply, which in turn affects employment levels. The employment results are expressed in terms of jobs (annual job years of employment). GRP and real disposable income results are expressed in terms of FY 2003–04 dollars. The amenity value that FHEs add to the state—through services such as education, research, public education, and fine arts, among others—makes Florida more attractive, which also encourages in-migration.

In addition, employment opportunities and other economic factors affected by Florida's FHE also encourage in-migration.[5]

The results of REMI modeling indicates that the $1.36 billion total FY 2003–04 FHE spending across the state resulted in statewide increases of state GRP by $3.8 billion. This FHE-generated rise in state output created considerable direct and indirect increases in employment across the state as well. Table 1 indicates REMI results estimate an increase in 76,661 jobs created from these FHE spending increases. In turn, this employment increase also generated higher wage and salary earnings for Floridians. Figure 9 illustrates that disposable incomes increased by $1.8 billion from these total FHE contracts, grants, and awards.

Table 1. Expenditure Model Results for Employment, Present Value of Discounted Benefits GRP, Disposable Income, Population, and State Taxes Generated by Florida FHEs for FY 2003–04

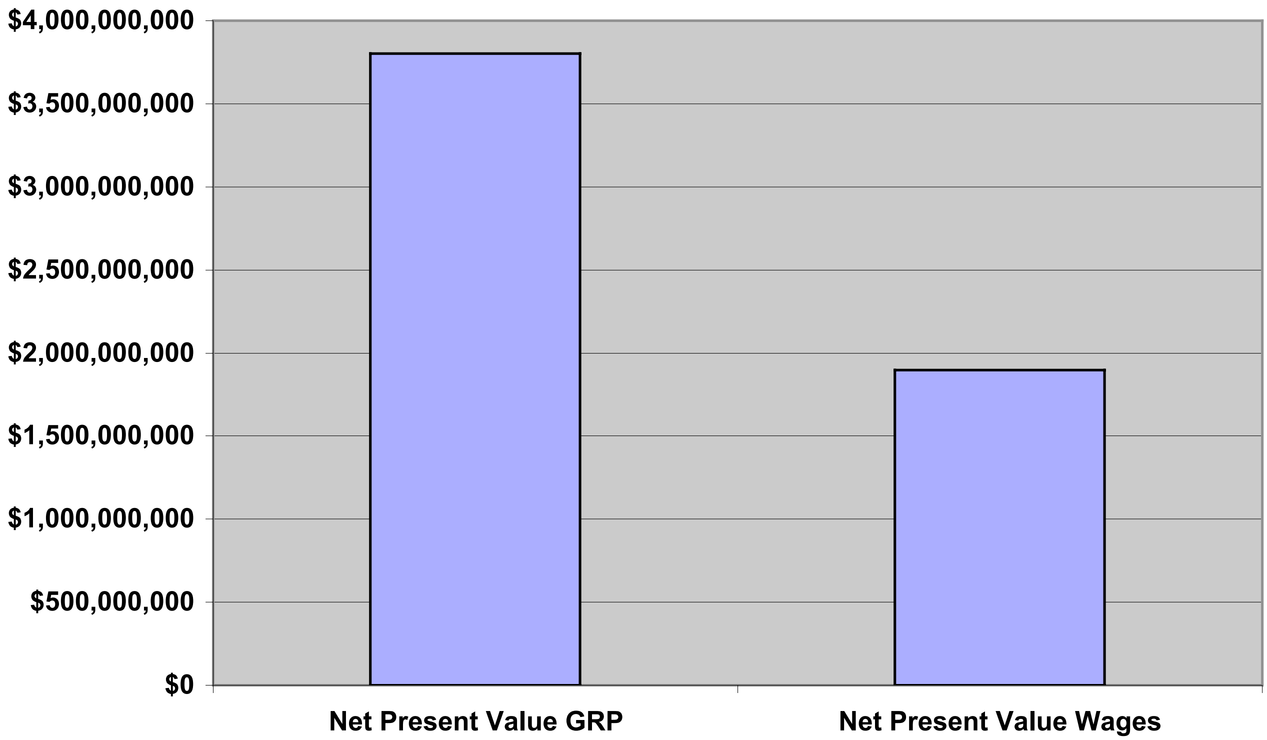
Summary of REMI-Generated Revenue Approach Results for FHE (Education Approach, 2004–2035)	
Net Present Value of GRP	**$3,801,518,168**
Net Present Value of Taxes	**$218,397,219**
Net Present Value of Wages	**$1,897,231,318**
Number of Jobs	**76,661**

*Note: REMI output results for employment are in terms of job years (one job/year).

These increases in state output resulted in higher state tax yields. On average, for each $1,000 of GRP generated in FY 2003–04, the Florida Department of Revenue (DOR) collected $57.45 (http://sun6.dms.state.fl.us/dor/tables/f2fy2003.html) in state and local taxes.

[5] For example, Florida's total population is forecasted to increase by 1,511 from economic in-migration as individuals move to Florida to participate in the better economy that would result from the impacts of the FHE FY 2003–04 spending.

Figure 9. FY 2003–04 FHE Economic (GRP) and Wages Results, Higher Education Approach



Benefit/Cost Ratio Calculations

The calculation of the benefit/cost ratio (the B/C) is most commonly used for economic evaluations (i.e., by economists) while the return on investment is more commonly used for financial evaluations, such as internal rate of return, etc. However, both are valid (though slightly different) ways to express the relationship between costs (initial investment) and benefit (return).[6] The focus of this assessment is on the B/C evaluation of higher education R&D spending in the state's public and private universities.

The initial REMI evaluation used the total FHE FY 2003–04 research expenditures (regardless of source) of $1.36 billion expended during FY 2003–04 as the input to the economic

[6]The B/C ratio is an expression of the level of the return of benefits over costs, whereas the internal rate of return expresses a rate or percentage return (per unit of time such as annual rate of return) of benefit levels over initial investment (cost).

impact assessment. This input resulted from the initial state investment of $149.9 million combined with all the other FHE (private, federal, etc.) leveraged funds of $1,209,425,854.

The "benefits" to the state of Florida from a conservative perspective were defined as the economic stimulus (estimated by REMI) resulting from the total $1.36 billion FHE FY 2003–04 expenditures (initial state investment and those leveraged by the state's investment). The "costs" to the state of Florida were defined as the economic stimulus (estimated separately by REMI) resulting from initial state investment ($149.9 million) assumed to be redistributed to alternative state spending (i.e., a measure of the opportunity cost). The REMI model and our subsequent analysis calculated the 35-year, net present value of the opportunity cost of the initial state investment of $149.9 million to be $349 million. In summary, if funding for FHE research were reallocated elsewhere (away from research) across Florida's higher education system, the state economy, according to REMI output results (see Table 2) would result in a decline of state output of $3.45 billion. That would include a decline of $3.8 billion from the state and nonstate leveraged research funding along with the off-setting increase of $349 million (opportunity cost stimulating growth) elsewhere across the higher education system from reinvestment of those FHE research funds. The decline in FHE research funding output stimulus would also be accompanied with an overall net decline of $1.9 billion in wages and 76,661 in jobs as well.

- Benefit to the state = $3.8 billion
- Cost to the state (opportunity cost of $149.9 million) = $349 million
- $B/C_{REMI} = 10.89$

Conclusions

The results of the economic analysis using the REMI model indicated that FHE research spending contributes significantly to the Florida economy. The economic benefits extend to job creation, generation of GRP, personal income, and state taxes, from the expenditures made by all types of FHEs. The following are the primary FHE research expenditure benefit contributions from all funding sources:

- For every dollar of state and local government support spent on FHE research, GRP increases by $10.89;
- For every dollar of state and local government support spent on FHE research, income increases by $5.43;
- Given the FY 2003–04 state investment, FHE research expenditures result in an additional $218 million in tax revenues and 76,661 jobs;
- The B/C REMI for FHE is 10.89; and
- The benefits of public-sector higher education research are substantially greater than the state of Florida investment cost.

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Listing of 172 Industrial Sectors Used in the REMI Model

1. Logging
2. Sawmills and planning mills
3. Millwork, plywood, and structural members
4. Wood containers and miscellaneous wood products
5. Wood buildings and mobile homes
6. Household furniture
7. Partitions and fixtures
8. Office and miscellaneous furniture and fixtures
9. Glass and glass products
10. Hydraulic cement
11. Stone, clay, and miscellaneous mineral products
12. Concrete, gypsum, and plaster products
13. Blast furnaces and basic steel products
14. Iron and steel foundries
15. Primary nonferrous smelting and refining
16. All other primary metals
17. Nonferrous rolling and drawing
18. Nonferrous foundries
19. Metal cans and shipping containers
20. Cutlery, hand tools, and hardware
21. Plumbing and nonelectric heating equipment
22. Fabricated structured metal products

23. Screw machine products, bolts, rivets, etc.
24. Metal forgings and stampings
25. Metal coating, engraving, and allied services
26. Ordnance and ammunition
27. Miscellaneous fabricated metal products
28. Engines and turbines
29. Farm and garden machinery and equipment
30. Construction and related machinery
31. Metalworking machinery and equipment
32. Special industry machinery
33. General industrial machinery and equipment
34. Computer and office equipment
35. Refrigeration and service industry machinery
36. Industrial machinery
37. Electric distribution equipment
38. Electrical industrial apparatus
39. Household appliances
40. Electric lighting and wiring equipment
41. Household audio and video equipment
42. Communications equipment
43. Electronic components and accessories
44. Miscellaneous electrical equipment
45. Motor vehicles and equipment

46. Aerospace

47. Ship- and boatbuilding and repairing

48. Railroad equipment

49. Miscellaneous transportation equipment

50. Search and navigation equipment

51. Measuring and controlling devices

52. Medical equipment, instruments, and supplies

53. Ophthalmic goods

54. Photographic equipment and supplies

55. Watches, clocks, and parts

56. Jewelry, silverware, and plated ware

57. Toys and sporting goods

58. Manufactured products

59. Meat products

60. Dairy products

61. Preserved fruits and vegetables

62. Grain mill products and fats and oils

63. Bakery products

64. Sugar and confectionery products

65. Beverages

66. Miscellaneous food and kindred products

67. Tobacco products

68. Weaving, finishing, yarn, and thread mills

69. Knitting mills
70. Carpets and rugs
71. Miscellaneous textile goods
72. Apparel
73. Miscellaneous fabricated textile products
74. Pulp, paper, and paperboard mills
75. Paperboard containers and boxes
76. Converted paper products, except containers
77. Newspapers
78. Periodicals
79. Books
80. Miscellaneous publishing
81. Commercial printing and business forms
82. Greeting cards
83. Blankbooks and bookbinding
84. Service industries for the printing trade
85. Industrial chemicals
86. Plastics materials and synthetics
87. Drugs
88. Soap, cleaners, and toilet goods
89. Paints and allied products
90. Agricultural chemicals
91. Miscellaneous chemical products

92. Petroleum refining

93. Miscellaneous petroleum and coal products

94. Tires and inner tubes

95. Rubber products and plastic hose and footwear

96. Miscellaneous plastic products

97. Footwear, except rubber and plastic

98. Luggage, handbags, and leather products

99. Metal mining

100. Coal mining

101. Crude petroleum, natural gas, and gas liquids

102. Oil and gas field services

103. Nonmetallic minerals, except fuels

104. Construction

105. Railroad

106. Railroad transportation

107. Trucking and warehousing

108. Local and interurban passenger transit

109. Air transportation

110. Water transportation

111. Pipelines, except natural gas

112. Passenger transportation arrangement

113. Miscellaneous transportation services

114. Communications

115. Electric utilities

116. Gas utilities

117. Water and sanitation

118. Banking

119. Depository institutions

120. Insurance carriers

121. Insurance agents, brokers, and services

122. Nondepository; holding and investment offices

123. Security and commodity brokers

124. Real estate

125. Eating and drinking places

126. Retail trade, except eating and drinking places

127. Wholesale trade

128. Hotels and other lodging places

129. Laundry, cleaning, and shoe repair

130. Personal services

131. Beauty and barbershops

132. Funeral services and crematories

133. Electrical repair shops

134. Watch, jewelry, and furniture repair

135. Miscellaneous repair services

136. Private households

137. Automotive rentals, without drivers

138. Automobile parking, rapier, and services

139. Advertising

140. Services to buildings

141. Miscellaneous equipment rental and leasing

142. Personnel supply services

143. Computer and data processing services

144. Miscellaneous business services

145. Producers, orchestras, and entertainers

146. Bowling centers

147. Commercial sports

148. Amusement and recreation services

149. Motion pictures

150. Videotape rental

151. Office of health practitioners

152. Nursing and personal care facilities

153. Hospitals

154. Health services

155. Legal services

156. Engineering and architectural services

157. Research and testing services

158. Management and public relations

159. Accounting, auditing, and other services

160. Educational services

161. Individual and miscellaneous social services
162. Job training and related services
163. Child day care services
164. Residential care
165. Museums, botanical, and zoological gardens
166. Membership organizations
167. Agricultural services
168. Forestry, fishing, hunting, and trapping
169. State and local government
170. State
171. Local
172. Federal civilian

Appendix

The raw data that was used comes from the National Academy of Science (NAS) data sets available at http://www.nsf.gov/sbe/srs/nsf04330/htmstart.htm. The tables below provide a sample of the raw data. There are many advantages of this data set. First, it provides a comprehensive estimate of higher education research revenues and expenditures from both public and private universities across, not only Florida, but for each of the fifty states. Another advantage is that the data and the sources of funding are aggregated into standardized multiple sources (state and local, federal, industrial, and so forth) as shown in Table 2, which displays the academic R&D expenditures by source of funds.

Table 2. Florida Academic R&D Expenditures by Source of Funds

Total	$1,069,023,000
Federal	$547,592,000
State and Local	$116,491,000
Industry	$65,421,000
Institutions	$275,420,000
Other Sources	$64,099,000

Additionally, the data is in standardized major categories of spending (scientific, engineering, social sciences, and so forth) as shown in Table 3, which displays the academic R&D expenditures by academic discipline.

Table 3. Florida Academic R&D Expenditures by Academic Discipline

Total	$1,069,023,000
Engineering	$140,010,000
Physical Sciences	$107,540,000
Environmental Sciences	$104,903,000
Math & Computer Sciences	$23,075,000
Life Sciences	$557,585,000
Psychology	$37,680,000
Social Sciences	$59,222,000
Other Sciences	$39,008,000

Attachment

Literature Review of the Economic and Social Impact of Higher Education Research Funding

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June 11, 2004

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Literature Review of the Economic and Social Impact of Higher Education Research Funding

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

Alan Greenspan

Chairman, U.S. Federal Reserve, 2004

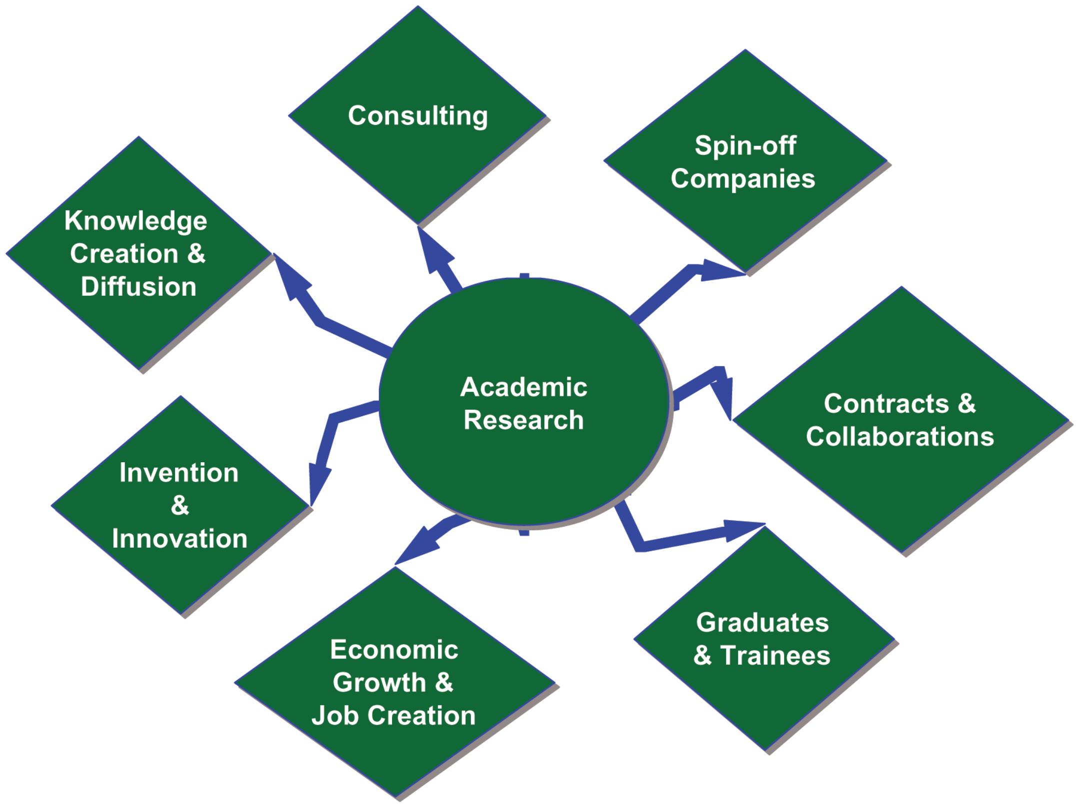
Introduction and Research Focus

In the past six decades, collaboration among business and industry, government, and universities has helped transform the world around us. Research at universities is now widely recognized to play an important role in local, regional, and state economies. Extensive literature exists on the impact of university-business-government partnerships. But, in spite of all of the interest, the scope and breadth of university research and the benefits it provides to society overall are poorly understood. University research is one of the most important contributors to economic growth, efficiency, and productivity, as well as to quality of life.

Technological innovation and well-trained, high-tech workers flow from our universities to the entire spectrum of industry and commerce. Additionally, considerable socioeconomic and quality of life gains (e.g., health care, environmental quality enhancements, human services advances) stem from our university labs and research centers. These gains often go unexamined, unreported, and therefore unrecognized by policy makers and the general public. To facilitate an understanding of how university research affects economic growth and quality of life, the economics staff of the Leadership Board for Applied Research and Public Service (the Board) is undertaking a comprehensive evaluation of these linkages. The first step in this evaluation is a review of the literature, which is summarized in this document.

Since the end of World War II, university research funded by the federal government and industry has improved the quality of life for every American through inventions and innovations. The computer and the Internet, vaccines, drugs, and medical equipment all originated through university research. This university research is one of the driving forces behind the rise of the United States to its position as the world's only superpower. University research has expanded knowledge and created new tools and technologies to help the U.S. lead the world in the digital information, biotechnology, and nanotechnology age; improve health; restore and protect the environment; assure healthy food; and create better airplanes, trains, and automobiles (National Association of State Universities and Land-Grant Colleges [NASULGC], 1996). Figure 1, created by Center for Economic Forecasting and Analysis (CEFA) staff, presents an overview of some of the most important products and activities that have emerged from university-funded research.

Figure 1. University Research Outcomes



Source: CEFA, 2004.

Total federal research and development (R&D) spending has increased by 58% since 1980, having increased from $69.7 billion to $120.2 billion. In fiscal year (FY) 2004, it is estimated the federal government will spend $26.4 billion on basic research, $26.3 billion on applied research, $63.10 billion on development, and $115.8 billion on research and development. As shown in Table 1, federal funding for university R&D has increased by more than a factor of 4 from $9.2 billion (9% of total) in 1970 to almost $37.5 billion (13% of total) in 2002. Industrial funding for university research has also fluctuated from 2% to 8%, with the most rapid growth in recent years as industry has learned to capitalize on the support it garners from university research labs (National Science Foundation [NSF], 2002).

Table 1. Funding for Research and Development (millions of constant 2002 dollars)

	FY 1970 Actual	FY 1980 Actual	FY 1990 Actual	FY 2002 Prelim
Federal	15,816	15,190	20,042	21,566
Industry	66,986	83,849	137,362	210,848
Colleges and Universities	9,206	12,521	21,660	37,491
FFRDCs*	5,444	7,988	10,121	10,448
Nonprofits	2,578	3,183	5,277	11,310
TOTAL	100,030	122,731	194,462	291,663

*Federally Funded Research and Development Centers (FFRDC), 2003
Source: NSF, Division of Science Resources Statistics.

Assessment of the Economic Impact of University-Related Research

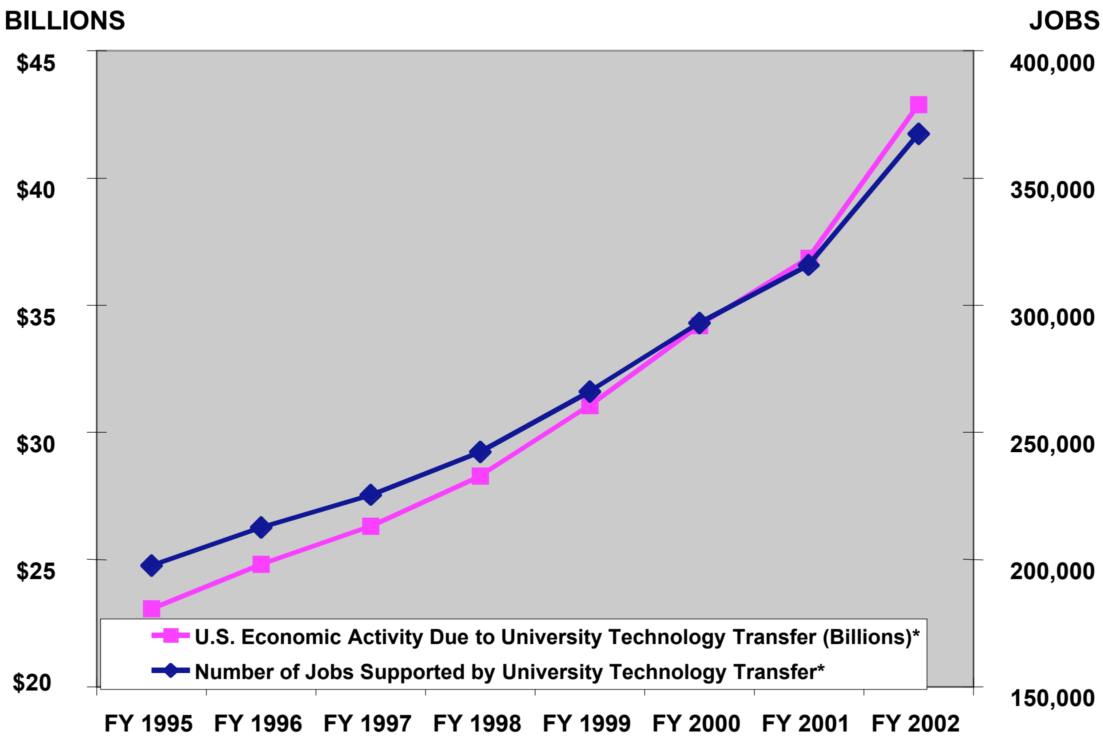
There are several alternative and complementary methods of evaluating the economic and social value of university-related research. Most researchers use cost-effectiveness analysis, economic impact assessment, or benefit-cost analysis. Each method addresses a specific interest of researchers undertaking the evaluation, as no single method is sufficiently comprehensive to capture all potential effects. The following sections summarize the most significant findings of leading national researchers. Studies are summarized in four groups: (1) economic impact assessment and benefit-cost analysis of university research, (2) universities as technological and innovation incubators and industrial partners, (3) nonquantitative economic externalities (socioeconomic: health care, social services, environmental quality and services, and quality of life) of university research, and (4) university research impact on the development of student human capital.

(1) Economic Impact Assessment and Benefit-Cost Analysis of University Research

Measuring the economic impact of direct expenditures captures the direct, indirect, and induced effects of research funding flowing into the university from public, private, and internal sources. Economic impact assessment measures the amount of economic stimulus flowing from these funds in terms of numbers of jobs created, numbers of students employed, dollars of economic sales, and generation of taxes that stimulate the local and regional economies.

No comprehensive estimate is available from university research labs on how many jobs or how much economic activity is generated every year from academic research investments in the U.S. However, the Association of University Technology Managers (AUTM) publishes an annual *AUTM Licensing Survey: FY 2000* and collects data on 222 of the major research university organizations in the U.S. and Canada. The survey has been used by researchers (Payne & Siow, 2003) to estimate commercial-related application of academic research in those surveyed universities. Payne and Siow estimate both total U.S. economic activity and the number of jobs related to technology that transfer from academic institutions. Their research estimates that major university research-funded technological advances alone in the past eight years account for increases in the U.S. economic activity of $20 billion dollars (increasing from $23 billion in FY 1995 to $43 billion in FY 2002) and an increase of 169,802 jobs (increasing from 197,605 in FY 1995 to 367,407 by FY 2002). Figure 2 provides a profile of that analysis and extends it to impacts from FY 1995 to FY 2002.

Figure 2. Total U.S. Economic Activity and Employment Related to Major University Research



Source: AUTM Survey, 2002; Payne and Siow, 2003.

Some researchers have focused on the direct, indirect, and induced economic impact from only one research university, while others have evaluated impacts from statewide university systems. A summary of several of the larger state university research system evaluations follows.

Florida. Researchers at the Council for Education Policy, Research and Improvement (CEPRI), in collaboration with the Leadership Board for Applied Research and Public Service, conducted a study to measure the contribution of 512 research centers and institutes (C&Is) in Florida's public universities to the Florida economy. The study measured job creation, generation of gross regional product, and generation of personal income and state taxes from the $88.8 million of general revenue expended in 2001 by the State of Florida to all types of C&Is within the State University System (SUS) (CEPRI, 2003). Table 2 provides the study findings of the primary economic impacts of C&I expenditures from all funding sources in Florida leveraged from this state funding for 2001.

Table 2. Florida Centers and Institutes Expenditure Economic Impact, 2001

State of Florida 2001 Research Investment	Gross Regional Product (Millions of 2001 $)	Wages and Salaries (Millions of 2001 $)	Jobs	Tax Revenues (Millions of 2001 $)	Return on Invest-ment	Benefit-Cost Ratio
$88.8	274	245	6,955	18	217%	2.17

Source: CEPRI, 2003.

In summary, State of Florida 2001 investments in university research centers generated

- 6,955 jobs
- an increase in gross regional product of $2.17 for every dollar of state support
- a disposable income increase of $1.96 for every dollar of state support
- $18 million in tax revenues
- a return on investment (ROI) of 217%
- a final benefit-cost ratio of 2.17.

The study concluded that the funding of the Florida SUS C&Is yields substantially higher benefits than the State of Florida investment costs.

California. Table 3 presents the dynamic economic impact of University of California (UC) research expenditures on the state economy. This assessment evaluates the economic impact of spin-off companies, research innovation, and new products as well as additional research revenues not examined in the Florida study.

Table 3. Dynamic Economic Impact of UC Research on Gross State Product Growth, 2002–2011

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

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

This study concludes that 10 years of UC research resulted in

- $5.2 billion in economic productivity
- 1.3% of all California GRP growth
- 104,000 new jobs
- formation of 160 new companies.

Other benefits include

- $216 million in industry-university contracts for 2001
- 2,600 UC inventions from 1999 through 2001
- 7% of all R&D completed in California is on a UC campus
- UC researchers brought in a total of $3.89 ($2.63 of federal and $1.26 of private funding) for each dollar of state-funded R&D in 2000–2001.

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

Canada. Martin (1998) found that the dynamic impacts of academic research in Canada are well beyond their estimated static impacts. (Static impacts cover the change in gross domestic product [GDP] and employment, while the dynamic impacts include the improvement in productivity and in the quality of life as a result of accumulation of knowledge and advancement in technology through invention and innovation.) This study estimated that in 1994–95, university research in Canada generated $5 billion of GDP and created 81,000 jobs, which is almost 1% of Canada's 1994–95 GDP and more than 0.5% of total job creation. However, the dynamic impact of university research estimated as $15.5 billion each year was well beyond the static impact. The economic impact studies ranged from a short time frame using research development expenditures to determine economic impact, to more extensive analyses including socioeconomic benefits of the academic research to the state and local economy. All related studies confirm the significant direct and indirect impacts of academic research on the local economy in terms of the increase in the production, employment, invention, innovation, and human capital.

(2) Universities as Technological and Innovation Incubators and Industrial Partners

This technique uses survey, case study, and quantitative methods to track technological innovation across existing companies. It is also used to track graduates and faculty forming new companies developing commercial products stemming from existing university research. The critical role that university research plays in both technological development and economic growth has received increased attention in the past few decades and has been well documented by numerous researchers (Brooks & Randazzese, 1998; Florida & Cohen, 1999; Davis & Kennedy, 2003; Mowery, Nelson, Sampat, & Ziedonis, 1999).

Numerous researchers have followed the development of a particular product line or individual researcher graduating from specific universities to determine the economic and social value of bold ideas that germinated in the research environment, as well as that of the individuals shaped by that environment. This approach to evaluation of university research relates to what is often considered the primary mission of university applied research: To partner with industry and create products across all fields of human endeavor. Innovations of this sort include development of computers and the Internet and extensive biomedical and electronic technological advances that have touched virtually all sectors of our economy and the economies of the world.

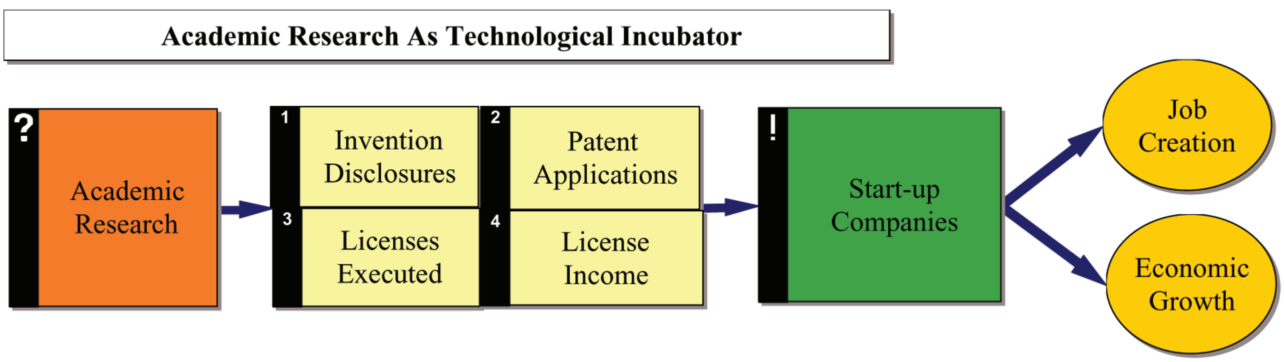
One study (BankBoston, 1997) evaluated the value on the economy and employment from companies generated by Massachusetts Institute of Technology (MIT) graduates and faculty. They estimated that "if the companies founded by MIT graduates and faculty formed an independent nation, the revenues produced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

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

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

Berman (1990) examined the economic impact of industry-funded university R&D from 1953 to 1986. He found that industry-funded research increased the industry R&D expenditures. The funded research resulted in technological innovation in industry. In literature, a new concept, "entrepreneurial university," is used to emphasize the importance of academic research as a driving force behind economic growth (Huggins & Cooke, 1997). Figure 3 presents academic research as an incubator in the economy.

Figure 3. Academic Research and Start-up Companies

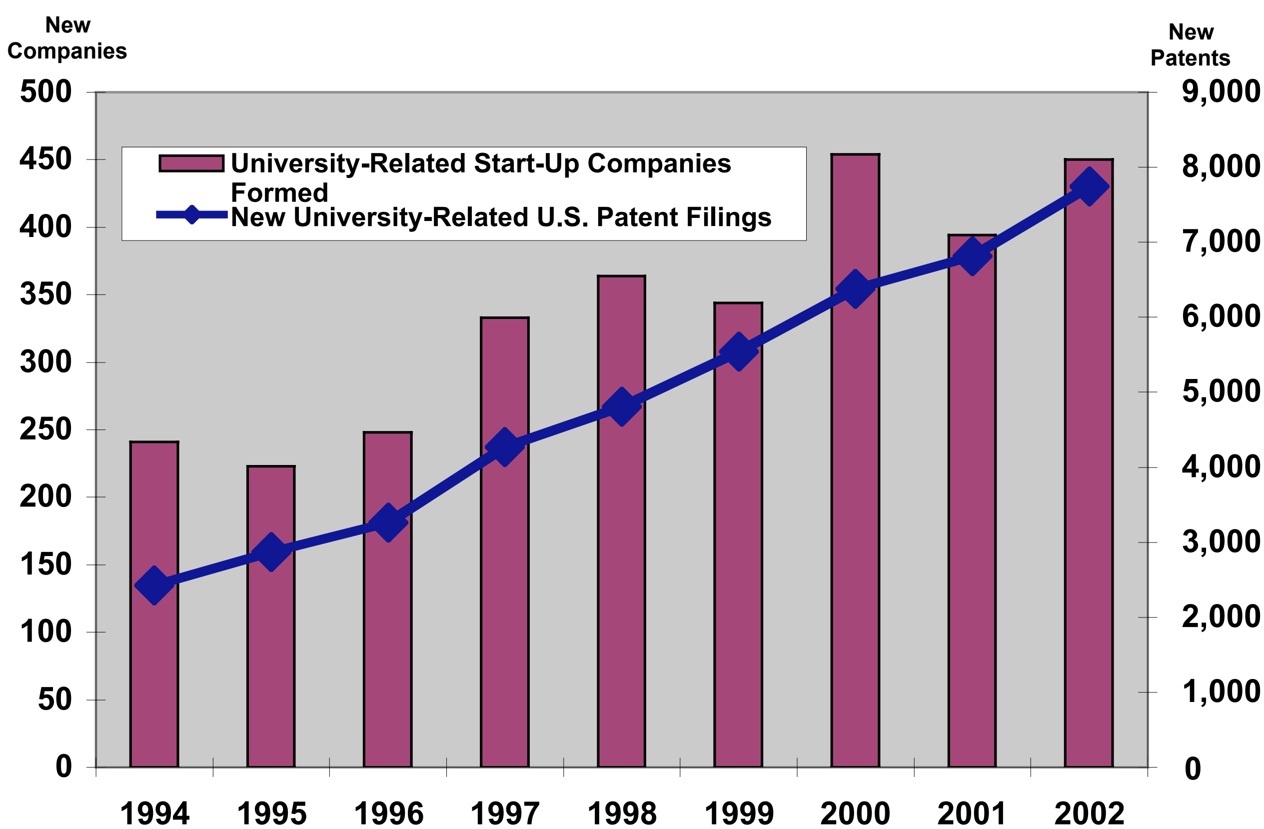


Source: Payne and Siow, 2003.

AUTM conducts an annual survey to collect data on commercial application of academic research in U.S. and Canadian universities. The *AUTM Licensing Survey: FY 2002* collected data of 222 organizations and found the following for FY 2002: (1) 15,573 invention disclosures were reported, 7,741 new U.S. patent applications were filed, and 3,673 U.S. patents were issued; (2) 569 new commercial products were launched, which brings the total number of new products to well over 2,000 between 1998 and 2002; (3) 450 new companies were established as a result of academic research in addition to 3,870 spin-off companies since 1980. More than half of those start-up companies were still in business as of the end of FY 2002; (4) universities generated over $1 billion in royalties on product sales; and (5) 4,673 new licenses and options were executed, bringing a 15.2% increase in new licenses and options executed in FY 2002.

Figure 4 summarizes the number of new company start-ups formed from 1994 to 2002 as well as the number of new U.S. patents applied for by the universities in the survey over that period. The number of new companies resulting out from this research increased from 241 in 1994 to 450 by 2002, an increase of 89% over this period, while the number of patent applications climbed by 219% from 2,429 to 7,741 over the same period.

Figure 4. New University Patents and Start-up Companies Formed, 1994–2002



Source: AUTM Survey, 2002.

In a recent empirical study, Payne and Siow (2003) estimated the effects of federal research funding on research outcomes for 68 universities. Their results suggest that an increase of $1 million in federal research funding to a university results, at 1996 constant dollar value, in 10 published articles and 0.2 patents.

(3) Nonquantitative Economic Externalities (Socioeconomic: Health Care, Social Services, Environmental Quality and Services, and Quality of Life) of University Research

A wide range of nonquantified quality-of-life evaluations has been completed to document and highlight developments undertaken in university research forums. For example, knowledge of other cultures from archaeological or anthropological evaluations, as well as developments in artistic and social science disciplines improve the quality of life. University research funding supports "quality" assessment projects ranging from environmental damages mitigation to social services research (e.g., medical care across all areas of service for all ages, enhancements in elder care, child care, and handicapped outreach). University researchers are noticeably improving the quality of life in ways that economic models cannot capture.

In FY 2001, the National Institutes of Health (NIH) received $20.3 billion to support its mission to expand our knowledge of living beings; to lead development and improvement of strategies for the diagnosis, treatment, and prevention of disease; to reduce the burdens of disease and disability; and to assure a continuing cadre of outstanding scientists for future advances (Joint Economic Committee [JEC], 2000).

In May 2000, the U.S. Congressional JEC issued "The Benefits of Medical Research and the Role of NIH," which states that the benefit of increased life expectancy in the U.S. as a result of advances in health care creates annual net gains of about $2.4 trillion (in 1992 dollars). The Committee concluded that, "if only 10 percent of these increases in value ($240 billion) are the result of NIH-funded medical research, it indicates a payoff of about 15 times the taxpayers' annual NIH investment of $16 billion" (JEC, 2000).

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

Additional researchers (Davis & Kennedy, 2003) have documented university research-related gains for all citizens in the areas of

- environmental quality
- arts and culture
- library and information technologies access
- community outreach and volunteerism
- athletics, recreation, and youth summer recreation.

Many other researchers have evaluated human services outreach provided by universities and have concluded that considerable value and enhancement to the lives of treated citizens is provided by these services in ways that benefit-cost analysis often does not capture. These (and other university-based research activities) can yield considerable value over time to both the clients cared for and the public sector sponsoring the research. For example, researchers (Lynch & Harrington, 2003a) evaluated a North Florida Mental Health Pilot project that assists depressed young and low-income mothers and children after abuse has been reported. Lynch and Harrington concluded that the intervention yielded

- elimination of child abuse/neglect—from 97% of children prior to treatment to 0% of the children completing the pilot project
- reunification with the family or permanent placement for all children completing the pilot who were not in parental custody at the beginning of the project
- improvement in developmental functioning of 58% of children, reducing the need for costly special education services
- final benefit-cost ratio of 6.39.

Another study (Lynch & Harrington, 2003b) concluded that the benefit-cost ratio for a second Pilot Maternal Depression Project was 5.31, indicating that for every dollar invested by the state in this project $5.31 was saved by the state.

(4) University Research Impact on the Development of Student Human Capital

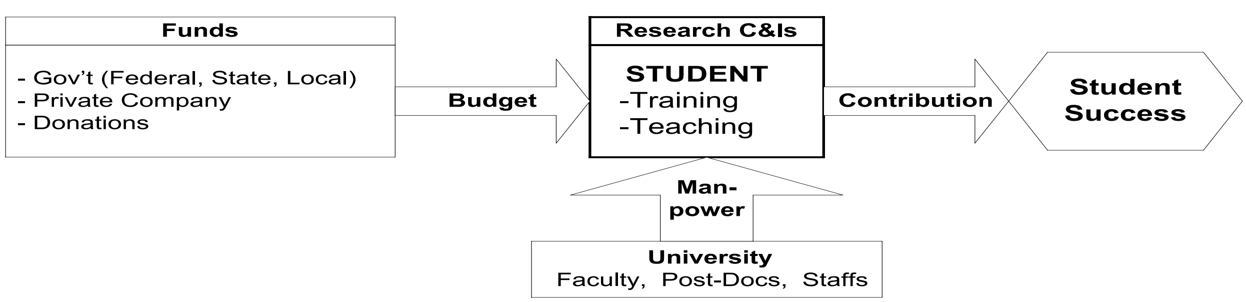
Excellent classroom instruction, sufficient training opportunities, and adequate prospects for engaging in public service are necessary conditions defining student success in a university and their ultimate success thereafter as productive workers in the knowledge economy. As a social institution, a university plays an important role in sustaining present society through providing a competent workforce, new technology, and various knowledge bases. Instruction, research, and public service are, in fact, the major functions of the university.

Historically, American colleges and universities were established as teaching institutions, especially for undergraduate instruction (Geiger, 1990; Whiston & Geiger, 1992). According to Gross's (1968) research on the goals of the university published in 1968, pure research ranked 7th and applied research ranked 12th out of 47 goals of universities. Training students in the methods of scholarship and scientific research ranked 6th, higher than either pure research or applied research.

Today the university's goals of research, teaching and training, and public service are closely related with each other. According to the findings by the CEPRI (2003), research and training account for 81.8% of student activities in the research C&Is in Florida public universities. Student success in higher education is a result of excellent training as well as instruction.

Few empirical studies on university research-related human capital development exist. Many studies, however, have identified (and some have quantified) the unique role university research plays as part of a broader student development process. For example, Weick (1976) developed a structural model of the general linkage of student success stemming from university-based and funded research training and teaching (Figure 5). This structural model clearly links the ultimate success and productivity of university students affiliated with C&Is to the research mission of the university. Through C&Is, students develop and nurture skills developed with the basic knowledge acquired in class. Other studies have gone on to provide empirical evidence of this success. Further research impacts on student human capital development growth will be instrumental in fully defining the current and future economic and socioeconomic impact of universities in Florida.

Figure 5. Structural Model of Student Success from University-Based and Funded Research Training and Teaching



Source: Weick, 1976.

Conclusion

This literature reviews four types of studies in the U.S. and Canada that evaluate the socioeconomic impact of university research. Funding university research has been shown to be a good investment for the regional, state, and national economy; for stimulating scientific and industrial developments; and for important gains generated in a variety of quality of life indicators. University research also serves as a technological innovator, incubator, and industrial partner; increases diffusion of new knowledge and new technologies; creates a wide range of new products and new companies; creates a better-trained workforce and more educated citizens; and helps build a better quality of life with significant gains in health care, environmental quality, gains in the arts and culture, and physical fitness and recreation.

In conclusion this literature review finds

(1) In the areas of economic impact, assessment and benefit-cost analysis of university research indicates the following:

- Federally funded university research has increased fourfold since 1970.
- Universities contribute significantly to the regional, state, and national economies. Some of these impacts from just the 222 major universities across the U.S. and Canada over 7 years, FY 1995 to FY 2002, include university research generated
  - GRP increases almost doubling from $23 billion to $43 billion.
  - annual job creation across the economy from 197,605 to 367,407.

In Florida, a study of 512 SUS C&Is concluded that one year $88.8 million of C&I funding resulted in creation of

- 6,955 jobs
- $274 million in higher GRP

- $245 million in higher disposable income
- $18 million in new tax revenues
- 217% return on investment
- 2.17 final benefit-cost ratio

In California, a study indicated that university research resulted in creation of

- $5.2 billion in economic productivity
- 1.3% of all California GNP growth attributable to UC research activity gains
- 104,000 jobs created
- 2,600 UC inventions over 1999–2001
- 160 new companies founded on the basis of UC new technology licensing agreements
- 7% of all R&D completed in California is on a UC campus
- $3.89 ($2.63 of federal and $1.26 of private funding) for each dollar of state-funded R&D in 2000–2001.

(2) In the areas of universities as technological and innovation incubators and industrial partners, university research

- serves as a technological and innovation incubator and industrial partner
- increases diffusion of new knowledge and new technologies
- creates a wide range of new products and new companies

(3) In the areas of nonquantitative economic externalities, university research helps build a better quality of life with significant gains in health care, environmental quality, gains in the arts and culture, and physical fitness and recreation across the nation.

(4) In the areas of impact on the development of student human capital, university research creates a better-trained workforce through educating students and faculty across all areas of research and more educated citizens.

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