

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

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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

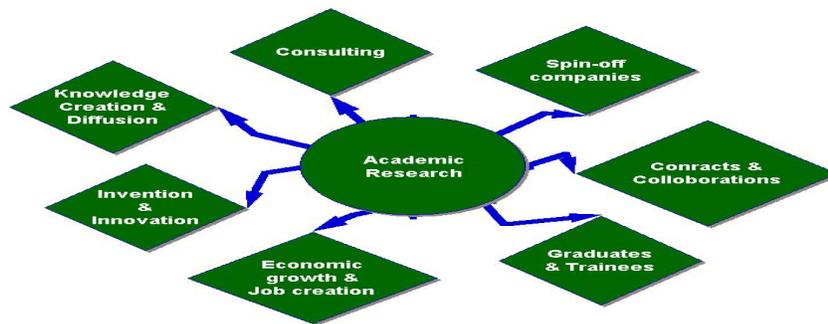
In the past six decades, collaboration among business and industry, government, and universities has helped transform the world around us. Research at universities is now widely recognized to play an important role in local, regional, and state economies. Extensive literature exists on the impact of university-business-government partnerships. But, in spite of all of the interest, the scope and breadth of university research and the role it plays in the Florida economy are poorly understood. Current studies indicate that university research is one of the most important contributors to economic growth, efficiency, and productivity, and to quality of life, although it is among the least examined and understood.

Technological innovation and well-trained, high-tech workers flow from our universities to the entire spectrum of industry and commerce. Additionally, considerable socio-economic and quality of life gains (e.g., health care, environmental quality enhancements, human services advances) also stem from our university labs and research centers. These gains often go unexamined, unreported, and therefore unrealized by policy makers and the general public.

To facilitate understanding the linkages between university research, economic growth and advancement, 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 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 United States's rise to its position as the world's only superpower. University research has expanded knowledge and created new tools and technologies to help the United States lead the world in the digital information, biotechnology, and nanotechnology age, to improve health, to restore and protect the environment, to assure healthy food, and to create better planes, trains, and automobiles (NASULGC, 1996). Figure 1 created by CEFA staff presents an overview of some of the most important products and activities that emerge 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 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 research and development has increased by more than a factor of four 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% (NSF,2002) with the most rapid growth in recent years as industry has learned to capitalize on the support it garners from the university research labs (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	122,730	194,462	291,663

*Federally Funded Research and Development Centers (FFRDC),2003

Assessment of the Economic Impact of University Related Research

There are several alternative and complementary methods of evaluating the economic and social value of university-related research to the U.S. economy and the quality of life of its citizens. Most researchers use cost-effectiveness analysis, economic impact assessment, or benefit-cost (B/C) 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 on the value of university research to the U.S. economy and quality of life of its citizens. Studies are summarized in four groups: 1) the economic impact assessment and benefit-cost analysis of university research, 2) universities as technological and innovation incubators and industrial partners, 3) non-quantitative economic externalities of university research, and 4) university research impact on the development of student human capital.

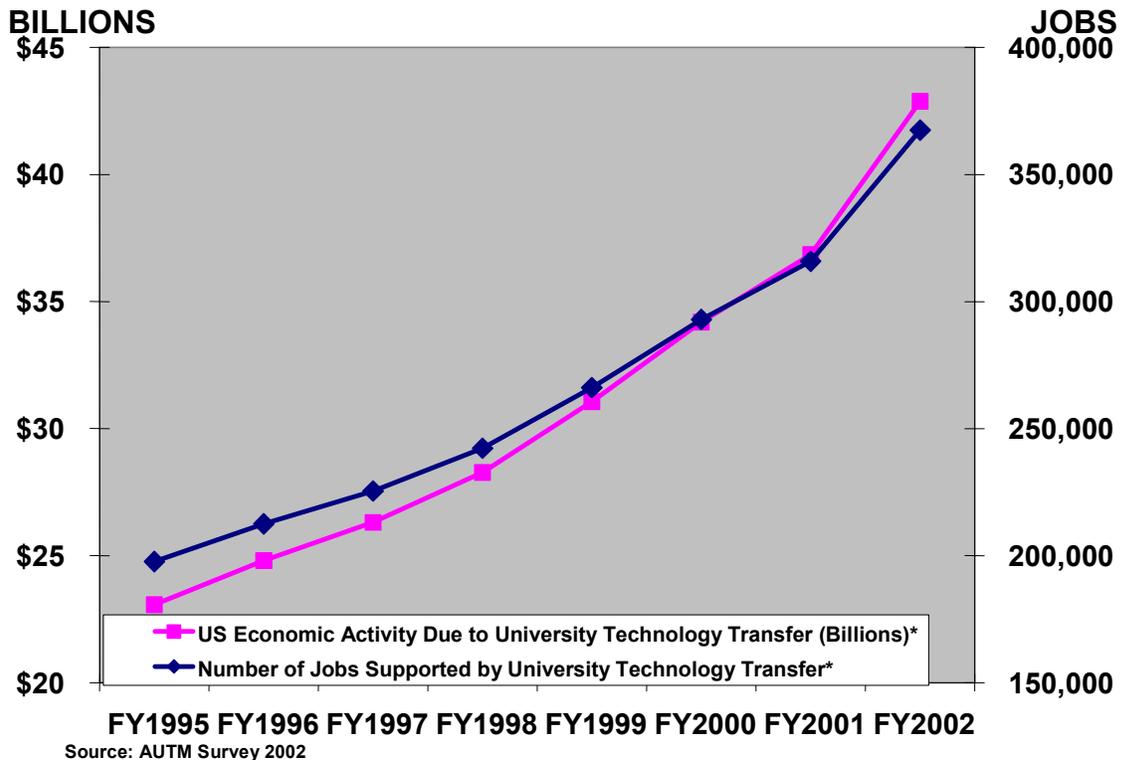
1) Economic Impact Assessment and Benefit-Cost Analysis of University Research

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 *Licensing Survey* and collects data on 222 of the major research university organizations in the U.S. and Canada. The fiscal year 2000 has been used by researchers (Payne, & Siow, A. (2003).) to estimate commercial-related application of academic research in those surveyed universities. Payne et al. estimate both total U.S. economic activity and number of jobs related to technology transfer from academic institutions. Figure 2 provides a profile of that analysis and extends it to impacts from FY 1995 to FY 2002.

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 in FY 1995 to \$43 billion in FY 2002) and an increase of 169,802 jobs (increasing from 197,605 in FY1995 to 367,407 by FY2002).

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



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, 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 centers and institutes (C&Is) within the Florida University system (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 Institute Expenditure Economic Impact, 2001

Florida Centers and Institutes Expenditures Economic Impact Assessment						
State of Florida 2001 Research Investment	Gross Regional Product (Millions of 2001\$)	Wages and Salaries (Millions of 2001\$)	Jobs	Tax Revenues (Millions of 2001\$)	ROI	Benefit/Cost Ratio
\$88.8	\$274	\$245	6,955	\$18	217%	2.17

In Summary, State of Florida 2001 investments in University Research Centers generated:

- 6,955 jobs
- Increase in Gross Regional Product of \$2.17 for every dollar of state support
- Disposable income increase of \$1.96 for every dollar of state support
- \$18 million in tax revenues
- The return on investment (ROI) of 217%
- A final benefit cost ratio of 2.17

The study concluded that the funding of the Florida State University System Centers and Institutes 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 Impact of UC Research on Gross State Product Growth, 2002-11

California State University Research Economic Impacts				
UC Research Productivity Gains 2002-2011 (Billions \$)	UC Research Related Job Creation 2002-11	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 ten years of UC research resulted in:

- \$5.2 billion in economic productivity.
- 1.3% of all California GNP 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 spending 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. The 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 1994-1995 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 timeframe 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) University Research as an Economic and Technological Innovation Incubator and Industrial Partner

This technique entails use of survey, case study, and quantitative methods to track technological innovation across existing companies and 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; Kennedy & Davis, 2003; Mowery, Nelson, Sampat, & Ziedonis, 1999).

Numerous researchers have followed the development of a particular product line or individual researcher graduating from specific universities and evaluated the economic and social value of bold ideas and individuals that germinated in the research 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 all economies of the world.

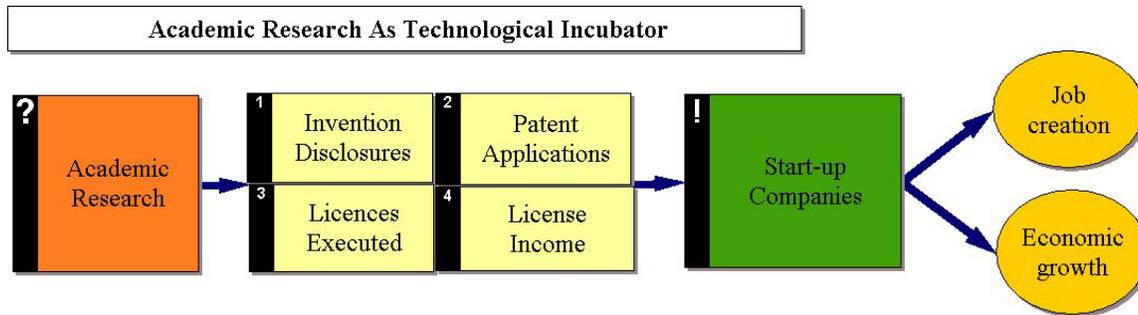
One study (Bank Boston, 1997) evaluated the value on the economy and employment from companies generated by Massachusetts Institute of Technology (MIT) graduates and faculty. They estimated that “If the companies founded by MIT graduates and faculty formed an independent nation, the revenues produced by the company's 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 university-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



Payne, A. A., & Siow, A. (2003).

The Association of University Technology Managers (AUTM) conducts an annual survey to collect data on commercial application of academic research in U.S. and Canadian universities. The *FY 2002 Licensing Survey* collected data of 222 organizations and found the following for the fiscal year 2002 (AUTM, 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 the business as of the end of fiscal year 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 percent increase in new licenses and options executed in fiscal year 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 spinning out from this research increased from 241 in 1994 to 450 by 2002, an increase of 89% over this period while the number of patents applied for climbed by 219%.from 2,429 to 7.741 over the same period.

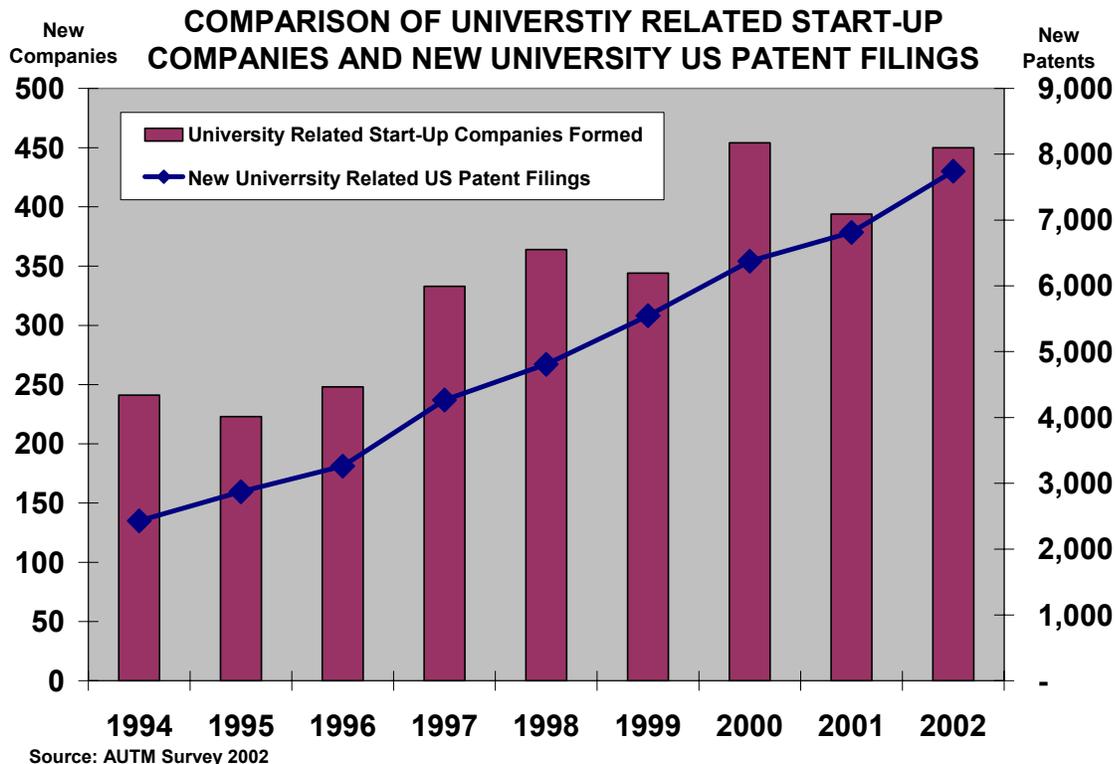


Figure 4. New University Patents and Start-Up Companies Formed, 1994 – 2002

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, at 1996 constant dollar value, to a university results in 10 published articles and 0.2 patents.

3) Non-Quantitative Economic Externalities (Socioeconomic: health care, social services, environmental quality and services, quality of life) of University Research

A wide range of non-quantified quality of life evaluations have been completed to document and highlight developments undertaken in university research forums. For example, improved knowledge of other cultures from archaeological or anthropological evaluations, as well as the 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, handicapped outreach). University researchers are noticeably improving the quality life in ways that economic models cannot capture.

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

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

The report estimates the rate of return from NIH-funded research to be 25 to 40 percent 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) and intangible costs of pain and suffering caused by disease.

Additional researchers (Davis, T., 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 quality of life of treated citizens is provided by these services in ways that benefit/cost analysis does not often 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 and Harrington, 2003) 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:

- Child abuse/neglect was reduced 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 and Harrington, 2003) 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

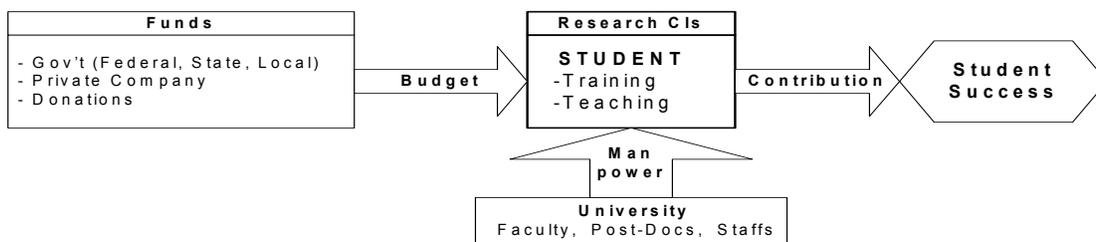
university plays an important role in sustaining present society through providing a competent workforce, new technology, and various knowledge bases. Instruction, research, and public service are in fact the major functions of the university.

Historically, American colleges and universities were established as teaching institutions, especially for undergraduate instruction (Geiger, 1990; Whiston & Geiger, 1992). According to Gross’s 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 consist of research, teaching and training, and public service, which are closely related with each other. According to the findings by the Florida Council for Education Policy, Research and Improvement (CEPRI, 2003), research and training account for 81.8% of student activities in the research centers and institutes in Florida public universities. Student success in higher education is a result of excellent training as well as instruction.

Not many 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 they 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 review examines four types of studies in the U.S. and Canada that evaluate the economic and 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 and 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:

- Federally funded R&D (in nominal terms) has almost tripled since 1970.
- Federally funded university research has increased by a factor of four over the same period.
- Contributes significantly to the regional, state and the national economies. Some of these impacts from just the 222 major universities across the U.S. and Canadian over the seven years FY1995 to FY 2002 include university research generated:
 - Gross Regional Product increases almost doubling from \$23 billion \$43 billion.
 - Annual job creation across the economy from 197,605 to 367,407.

In Florida a study of 512 public university Centers and Institutes concluded that one year \$88.8 million of C& I funding resulted in creation of:

- 6,955 jobs
- \$274 million in higher Florida Gross Regional Product
- \$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 University of California (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.
- 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.

2) In the areas of universities as technological and innovation incubators and industrial partners
University research:

- Serves as a technological innovator and 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 non-quantitative economic externalities of 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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