The Economic Impact of Research at the University of Connecticut and the University Health Center

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Executive Summary

Research at the University of Connecticut (UConn) and the University Health Center (UCHC) has a significant impact on Connecticut's economy. More than $188 million in external funding flowed into UConn and UCHC research programs in FY2003. This flow of funds in large measure leverages the graduate programs at UConn and UCHC that in turn employ faculty and graduate students, as well as administrative and support staff in the research enterprise. Through multiplier effects across the state, these research dollars create more than 5,113 jobs, adding $397 million in new GSP and $283 million in new personal income each year in the long run. That is, absent UConn and UCHC research activity, employment in Connecticut would be lower by about 5,113 jobs each year in the long run. This result assumes that the flow of research dollars is constant in inflation-adjusted terms into the future. Similarly, absent UConn and UCHC research activity, Connecticut would experience reduced gross state product and personal income levels from now on of about $397 million in GSP and $283 million in personal income each year in the long run.

More than these hard numbers, research activity at UConn and UCHC enriches the educational experience of undergraduate and graduate students alike. It makes them purveyors of new ideas in industry, government, and the arts. It inspires students to pursue a life of learning and research as a vocation. Were it not for the UConn and UCHC research enterprise, the graduate programs at the University of Connecticut and the University Health Center would largely disappear, fundamentally changing the character of the University and its contribution to the state and the nation. Thus, research funding in large measure leverages the UConn and UCHC graduate programs, bringing in tuition money ($94 million), employing graduate students (they spend $46 million annually), and creating spin-off firms (150 new jobs). UConn research leverages the undergraduate program as well by creating research opportunities for undergraduates with faculty and in research centers. In "Engines of Economic Growth: The Impact of Boston's Eight Research Universities on the Metropolitan Boston Area,"[1] Appleseed, Inc., assessed the economic impact of all university activity. The report amply reveals the value of collaboration among departments, colleges, and the private sector, as well as the incubation of new ventures. The report stresses "that participation in cutting-edge research doesn't just enhance [undergraduate and] graduate students' educational experience — it turns them into instruments of technology transfer."

[1] For a copy of this report, visit www.masscolleges.org or contact one of the universities.

In sum, the research activity at UConn and UCHC enriches the lives of all those engaged in the research enterprise and those in Connecticut-based spin-off firms. It benefits Connecticut firms that use technologies developed at UConn and UCHC. In turn, Connecticut becomes a more attractive place to live and work and for businesses to locate and expand because of the high quality and availability of Connecticut's educated workforce. Ultimately, the research enterprise at UConn and UCHC strengthens Connecticut's competitive position in the increasingly knowledge-based global economy.

Introduction

What is research? Who pays for it? Who does it benefit and how? What does it produce? What is its economic value? Webster defines research as "*n*. 1. diligent and systematic inquiry or investigation into a subject in order to discover or revise facts, theories, applications, etc.: *recent research in medicine*. 2. a particular instance or piece of research. --*v.i.* 3. to make researches; investigate carefully. --*v.t.* 4. to make an extensive investigation into: *to research a matter thoroughly*." In the context of a research university, it is clear that the diligent and systematic inquiry into a variety of subjects to discover or revise facts, theories, and applications is at the core of its mission. Such inquiry flows from faculty pursuing their interests and performing what is required of them in the research university environment. It occurs at the undergraduate and graduate levels in courses, in lab and studio work, and in independent study. It emerges from centers that employ students, faculty, and full or part time staff (neither students nor faculty) engaged in various lines of inquiry.

Research occurs in all disciplines and departments in the research university. It reveals itself through publication in refereed journals, non-refereed periodicals (*Nature, Scientific American*), patents, computer codes, models, chemical and mathematical formulae, narratives and music scores, sketches in unpublished notebooks and mimeos, in conferences, seminars, concerts, and gallery showings. Research produces new ideas, new products, and new procedures and processes that impact society in many ways. Broadly, research improves our quality of life through a greater variety and higher quality of goods and services, through enriching our intellectual environment, and adding to our artistic resources in music, art, and dance. One can think of the discovery through university research of vitamins, antibiotics, and medical procedures, for example.

The ideas research produces are broadly accessible; they thus can be captured and put to use by anyone capable. The ideas themselves are thus non-rivalrous; thus, their creators cannot necessarily capture all the benefits that may flow from them. One can charge for the conference or the journal or the concert in which new ideas are presented, but cannot collect the entire benefit that someone or some firm may reap as a result of putting the idea or a concept that flowed from that idea into practice. The mere existence of a patent may be sufficient for someone other than the creator to benefit. Nevertheless, foundations, governments, and firms pay for research in part because of the (ostensibly beneficial) public nature of its product, and in

part to maintain a competitive advantage over rival firms or countries. Some firms stand to gain enormously if they can produce cures for cancer, AIDS or Alzheimer's disease and other fatal diseases. Are the products of all research good for humanity? Are we better off with genetically modified food, refrigeration and air conditioning that use Freon, and stem cell therapies? Are we better off with Beethoven, Rap, or Pollack? All new ideas are always good for everyone, everywhere. Nevertheless, we assume in this analysis that university research produces beneficial results for humanity while acknowledging the controversial nature of certain research.

The economic value of university research is difficult to assess. The funds that flow into the process benefit directly those engaged in it through wages, salaries, and tuition waivers (a forgone expense). Research activity often requires the purchase of intermediate goods and services and thus indirectly benefits firms outside the university. For example, research often leads to the purchase of software, computers, legal consultation, glassware, reagents, data, surveys, and so on from outside the research lab or center. People pay to attend concerts, exhibits, conferences, and seminars, but the only measurable benefit in such cases is the payments for having access to the new knowledge in such venues. That is we assume people would not attend or participate in such activities unless they were worth at least as much as the cost of attending. Students engaged in research ultimately will leave the university; they are perhaps more productive workers in their jobs than those graduates who did not participate in research during their tenure at university. Teaching by faculty engaged in research is presumptively better informed and more interesting than that by faculty not so engaged. Teaching by faculty engaged in research perhaps produces graduates more curious and productive in their careers, who may themselves choose research as a career. Some faculty research is not funded (externally) at all; it is merely a normal product of their work at the research university and may only manifest in journals. Promotion, tenure, retention and merit-based pay increases relate to research productivity.

While recognizing the true breadth and depth of university research, this study can focus only on that segment of university research funded externally, thus understating significantly the true breadth and depth of such research and, necessarily, providing a conservative estimate of its full economic value. Moreover, despite the fact that the very nature of research means that their

benefits potentially flow far beyond the borders of the state, this study seeks to estimate the impact of funded research only with the borders of the state of Connecticut.

Studies of University Research Value

The Association of Universities and Colleges of Canada[2] studied the economic impact of Canadian university research on that country's economy. Martin and Trudeau (1998) looked at university research as producing skilled workers and new knowledge that not only generated direct effects through university employment and business-to-business activity (purchases of goods and services necessary for research), but also the less direct effects that improve total factor productivity (TFP), that is, impacts that improve the productivity of both labor and capital. Martin and Trudeau make this argument by asserting that graduates of research universities are more productive in their jobs, and some of the knowledge created in university finds its way into new products and processes, making capital more productive as well. They estimate the contribution of Canadian TFP to GDP growth using OECD estimates and the contribution of Canadian university research to Canadian TFP growth. The authors divide the latter between an increase in the productivity of human capital (university graduates and those earning higher degrees) attributable to university research, and the increase of productivity of the other factors of production. They allocate the increase in graduates' earnings to university research based on its share in the total cost of producing a graduate. The authors estimate that university research accounts for 30 percent of total Canadian research and development.

This approach seems reasonable; however, not all graduates of research universities engaged in research, especially graduates who earned only the baccalaureate during their university tenure. Not even all masters' level students engage in research; doctoral students by definition engage in research. There is no disagreement with the proposition that university graduates are more productive in their careers than those who do not go beyond high school. However, are university graduates who engaged in research in university more productive in their careers than university graduates who did not? This effect, if measurable, has not been

[2] A summary is available at http://www.aucc.ca/publications/auccpubs/research/research_e.html. Martin, F. and Marc Trudeau (1998). "*The Economic Impact of Canadian University R&D*," AUCC Publications, 350 Albert St., Suite 600, Ottawa, ON K1V 9K6.

documented to our knowledge. Furthermore, the increased wage that university graduates enjoy irrespective of their engagement with research is not necessarily or exclusively related to their presumed productivity contribution. Labor supply and demand and other factors such as who one knows enter into wage determination. Masters' level graduates simply because they are fewer in number command more attention from prospective employers. Moreover, in the U.S., those holding post-baccalaureate degrees have captured nearly 80% of the increase in national income in the last 25 years; those men without a college degree have seen their incomes decline despite a significant increase in the supply of such labor. Thus the market has "judged" holders of college degrees and advanced degrees to be significantly more valuable than those who have not earned such degrees. Given the income statistics based on educational level, it is presumptively clear that there is a strong relationship. But this does not of course speak directly to the value of university research per se. And there is far less difference in income levels based on college of graduation.[3]

Nevertheless, Martin and Trudeau (1998) make a useful contribution to the analysis of the value of university research. They readily admit quality of life improvements, but do not estimate them. They constructively point out that one must consider the net new contribution of university research because some research is undertaken in any case by firms, governments and faculty who may not be compensated other than via their wage. In addition, public and private resources channeled to university research are diverted from other potentially productive uses. Finally, Martin and Trudeau (1998) assume all Canadian university graduates remain in Canada.

In "Engines of Economic Growth: The Impact of Boston's Eight Research Universities on the Metropolitan Boston Area,"[4] Appleseed, Inc., assessed the economic impact of all university activity. The report does not separate out economic value of research activity from other economic activity such as student and visitor spending, and faculty, staff, and graduate student employment. However, the report amply reveals the value of collaboration among departments, colleges, and the private sector, as well as the incubation of new ventures. The report stresses "that participation in cutting-edge research doesn't just enhance [undergraduate and] graduate students' educational experience — it turns them into instruments of technology

[3] Carnevale, Anthony P. (2001). "Help Wanted..College Required," Educational Testing Service; and with Donna M. Desrochers (2003), "Standards for What..The Economic Roots of K-16 Reform," www.ets.org/research/publeadpubs.html

[4] For a copy of this report, visit www.masscolleges.org or contact one of the universities.

transfer." The report describes how university research promotes private investment in the region in research facilities and incubator and spin-off companies. The Bayh-Dole Act clarified universities' right to patent, license, and collect royalties on products of federally-funded research that generate revenue for further research and teaching.

The Center for Business and Economic Research (CBER) at the University of Kentucky (UK) estimated the economic impact of external research funding (not including state funding that could have been directed elsewhere). Apparently, the CBER used total funds directed at UK research from out-of-state sources to drive the IMPLAN model that provides statewide economic effects in terms of employment, personal income, and gross state product. There was no evaluation of the value of licensing, royalty revenue, tech transfer, or improvements to quality of life.

Bessette (2003)[5] suggests a method for calculating return on investment (ROI) in university research that accounts for its economic impact. The need arises as public and private funding entities demand greater accountability, as reflected in the 1993 Government Performance and Results Act (GPRA). GRPA holds among other things that all universities are public, based on the amount of direct and indirect funding public and private colleges receive, and should follow GRPA guidelines reflecting accountability whether they are public or private by ownership.

ROI is the total economic output (benefit) of sponsored projects less net operating cost (the difference of operating costs and investment) as a fraction of investment. If investment equals operating cost, ROI is the ratio of economic output to investment (expressed as a percentage). The economic output of research accrues to public and private investors and these outputs may differ for each investor group. For example, private investors regard new products sold, the value of license agreements, process improvements, the number of trained graduates hired, new firms formed, and, knowledge spillovers that generate revenues in creating new products or varieties as economic outputs in the ROI estimation. Public investors regard new jobs created, jobs retained, and new tax revenues, subsequent rounds of research workers' spending, and the ripple effects of business-to-business spending (goods and services purchases for research) as economic outputs in their ROI calculus. Investments may be cash or in-kind

[5] Bessette, Russell W. (2003). "Measuring the Economic Impact of University-based Research," *Journal of Technology Transfer*, 28, 355-361.

assets that have a cash equivalent. This paper suggests the scope of economic effects that the impact of university research should encompass.

Research at UConn

In fiscal year 2003, the University of Connecticut received $188.3 million (excluding financial aid) in external funding for research and sponsored activities of which the Storrs and Regional Campuses received $92.1 million (49%) and the Health Center received $96.2 million (51%). The table below shows the sources and distribution of funds for research and sponsored activities.[6]

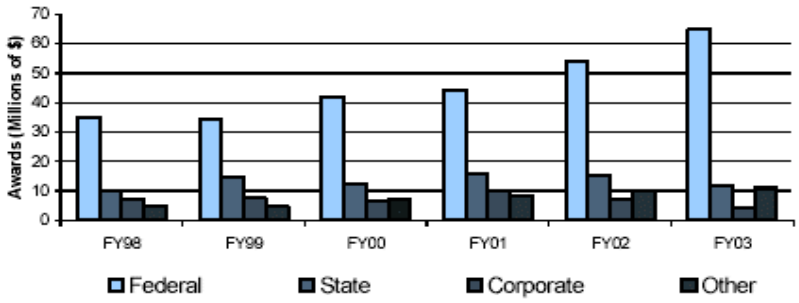
Sources for the $188.3 million in FY03		
Federal: 70.4%	State: 13.3%	Private/Other: 16.3%
Sponsored Activities at Main Campus & Regional Campuses		
Research		86%
Education and Training Programs appreciate		5%
Public Service and Other		9%
Sponsored Activities at the Health Center		
Research		84%
Clinical Trials		5%
Education and Training Programs		10%
Other		1%
Sponsored Awards by Discipline at Main Campus & Regional Campuses		
Life Sciences		37.6%
Physical Sciences & Engineering		29.2%
Social Sciences		30.0%
Humanities/Fine Arts		0.4%
Other		2.8%

[6] For this and more detailed information, see www.research.uconn.edu/profile2.html

Exhibit 1 shows the external funding history of the University of Connecticut at Storrs and the regional campuses (UConn). This report does not include awards to the University of Connecticut Health Center (UCHC). UConn received awards of $86.8 million in FY02 and $92.1 million in FY03 through external contracts and grants processed by the Office for Sponsored Programs (OSP).

EXHIBIT 1: EXTERNAL TOTAL AWARDS TO UCONN FY98 - FY03

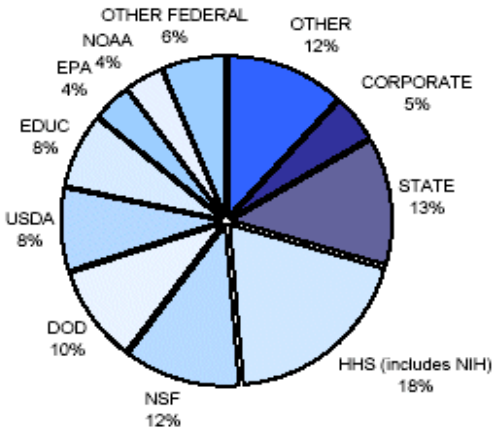
	FY98	FY99	FY00	FY01	FY02	FY03
	million $					
Federal	35.0	34.5	42.1	44.4	54.0	76.0
State	10.1	14.5	12.2	16.1	15.4	6.5
Corporate	7.0	7.5	6.8	10.1	7.1	3.0
Other	4.6	4.7	6.9	8.3	10.3	6.6
Totals	56.7	61.2	68.0	78.9	86.8	92.1



External funding was 62% greater in FY03 than in FY98. In FY 2002 and FY 2003, 62% and 70%, respectively, of the awards were from federal sources. Corporate sources constituted less than 9% of the awards in both years. Both the NIH budget and the awards to UCHC increased 100% in the same period. From FY98-FY02, external support (gifts, grants, and contracts) grew from 14.8% to 17.0% of total revenue at UConn. During the same period, external support constituted between 18.8% and 27.1% of revenue at UConn's peer institutions, that is, at Colorado State, Iowa State, Rutgers, and Louisiana State Universities, and the Universities of Massachusetts, Missouri, Iowa, Tennessee, and West Virginia.

Exhibit 2 provides more detail on the sources of federal awards.

EXHIBIT 2: SOURCE DISTRIBUTION OF UCONN AWARDS FY03



National statistics put this information on sources of research funds in perspective. In FY03, the federal government expended $59 billion for defense R&D and $53 billion for non-defense R&D. The National Institutes of Health (NIH) research funding constituted 50% of non-defense R&D expenditures. The National Science Foundation (NSF) and the U.S. Department of Agriculture (USDA) provided 7% and 4%, respectively, of the non-defense R&D awards nationally. [The American Association for the Advancement of Science (AAAS) analyses of federal FY03 budgets provides the basis for this breakdown.]

Defense is not the major source of research funding at UConn; this is true for most universities. However, UConn's researchers depended less on NIH and more on NSF and USDA than researchers nationally. To generate these awards, UConn Principal Investigators (PIs) prepared and the Office of Sponsored Programs (OSP) submitted:

- 1,136 proposals requesting $374 million in FY01
- 1,069 proposals requesting $334 million in FY02
- 1,245 proposals requesting $400 million in FY03

PIs requested over $300,000 in the average proposal.

Exhibit 4 provides further details on UConn's external awards. The number of awards was greater in FY03 than FY02 but the average size of awards declined.

EXHIBIT 4: TOTAL AVERAGE RESEARCH AWARDS

	FY02	FY03
Direct Costs	$ 74.8 million	$ 78.0 million
F&A	$ 11.9 million	$ 14.1 million
Total Awards	$ 86.8 million	$ 92.1 million
Number of Awards Granted	763	853
Average $/Award	$ 114 thousand	$ 108 thousand

NSF annually publishes a comparison of research and development expenditures by all U.S. universities; the last expenditures published are for FY01. These tabulations combine the research expenditures of UConn and UCHC. In FY01, they totaled $164 million and ranked the University of Connecticut combined 68th out of 601 institutions in terms of total research expenditures. The University of Connecticut (all campuses) was 46th out of 150 public universities in terms of research expenditures. The average award received by UConn faculty was $114,000 and $108,000 in FY02 and FY03, respectively.

In FY02, research and development expenditures amounted to $172 million and UConn's rank was 74 out of 617 institutions.[7] The University of Connecticut (all campuses) was 51st out of 150 public universities in terms of research and development expenditures.

The average grant received by UConn faculty was about one-half of the median NSF award and much smaller than the average NIH award. The average NIH annual award nationally during these years was more than $300,000. A grant for three years from NIH would be in the form of three annual awards. The median annual NSF grant nationally in FY02 and FY03 was $80 thousand and $99 thousand, respectively. The median duration of NSF grants was 2.55 years.

Biomedical Research at the UConn Health Center

UCHC scientists conduct innovative basic science, clinical, epidemiological, and biobehavioral research on a budget of more than $48 million a year. They translate their discoveries into advances in patient care and license new technologies to the private sector. UCHC scientists work collaboratively with researchers at private companies and other institutions, making their expertise, facilities, and equipment available to assist the former in

[7] See http://www.nsf.gov/sbe/srs/nsf04330/tables/tabb32.xls.

their work. Some of the spinoff companies UConn and UCHC spawned are AlexiPharma Inc. in Mystic, Evergen Biotech in Tolland, Hepaticus Inc. in Rocky Hill, Image Content in Glastonbury, ImCorp in Storrs, Inframat Corporation in Farmington, Nour Heart in Bloomfield, and, Spafas in Mansfield. These firms employ approximately 150 people.

Technology Transfer

As the May 3, 2004 edition of the UConn Advance reported, technology transfer programs move university science to the marketplace. Technology transfer has increased in recent years from 45 invention disclosures in 1999 to between 70 and 80 per year currently. UConn and UCHC sign between 12 and 16 new options and licenses annually, and gross revenues have increased to $725,000. Three organizations assist technology transfer at the University. The Center for Science and Technology Commercialization (CSTC) works with faculty and administrators at each campus to convey the need for and the advantages of technology commercialization. CSTC staff specializes in evaluating inventions from the physical and life sciences and assist with patenting and business development. CSTC and UConn R & D staffs scrutinize each technology to determine the best development path for that particular case in terms of generating the highest return possible. CSTC is the department of the University that handles its intellectual property, and is responsible for negotiating all licensing opportunities at the University.

The Research and Development Foundation, a subsidiary of the UConn Foundation, evaluates technologies that can become potential businesses, recruits venture capital to start new businesses, and provides consulting to get new businesses going. The Technology Incubation Program assists and accelerates the successful establishment entrepreneurial firms. Incubator space is available in Storrs and Farmington and will be soon at Avery Point. These organizations complement each other in bringing UConn and UCHC innovation to commercialization. The nine companies mentioned above generate new purchases, employment, taxes, personal income, and value-added through ripple effects across Connecticut.

Methodology

To estimate the value of UConn and UCHC ongoing research activity, we imagine that the UConn and UCHC research enterprises cease to exist. This thought experiment measures the counterfactual economic effect of removing the combined enterprise from Connecticut's economy and measuring the difference between the current (baseline) economy and one absent the research enterprise. This approach captures the instantaneous economic value of the ongoing research activity at UConn and UCHC. We assume that equipment, bricks, and mortar remain while people involved with research walk away. There is no alternative use of the facilities because this exercise is not an opportunity cost experiment. That is, it is not one that considers the next best use of the facilities. Thus, we assume research-related employment, purchases, patents, license and royalty fees, and the increased quality of life due to UConn and UCHC research activity cease for all time. This implies that to a large extent the University graduate program collapses (except for, we assume, graduate degree programs in business, allied health, nursing and law) at each campus and the Health Center. We take the expenditure approach that tracks spending of research funds that flow through the University and stimulate Connecticut economic activity through employment, procurement, consumer spending, and quality of life improvements.

We assume most graduate students at the Storrs campus and those at UCHC involved in the master's and doctoral programs in biomedical science, dental science, and public health would not be here were it not for research activity. We estimate total full time equivalent (FTE) graduate students as the average of spring and fall 2003 graduate students pursuing a degree (4,128 at the Storrs, the branch campuses, and UCHC); summer 2003 is not considered. These students spend money on a variety of goods and services that is absent in the counterfactual exercise. As well, we subtract their tuition and fees that reduce the University administrative employment and requisite capital and intermediate goods and services (bricks and mortar, computers and supplies) in support of research activity. We do not consider the effect of the lack of a research enterprise on the undergraduate population that undoubtedly be negative and therefore our results are conservative.

FY2003 Components (Drivers) of Impact

Faculty Employment

For purposes of this study, we assume a faculty/graduate student ratio of 14 to 1. The current overall ratio is about 18 to 1. The former implies that 295 faculty taught the 4,128 degree seeking graduate students in the fall/spring 2003 academic year. We assume this faculty is engaged in research and would not be at UConn and UCHC were it not for their research enterprise. It is conceivable that with the loss of faculty that the University would be less attractive, might not be able to sustain the same level of enrollment, and may have a poorer quality profile of students. We do not model this scenario. In addition, the counterfactual of research faculty would diminish property tax revenues and property values; we do not model this scenario. Neglecting these effects makes our analysis conservative.

Graduate Student Spending and Employment

We estimate there were on average 3,007 graduate students at Storrs and 1,121 graduate students elsewhere in the system in the fall/spring 2003 academic year. These students spent more than $42 million on goods and services during 2003 (an average of $10,192 per student) irrespective of their employment at UConn and UCHC. It is true that not all these graduate students were engaged in research. According to the Dean of the Graduate School, about 45% of graduate students had assistantships (spring 2004 data), and of these 832 were involved in research activity, 1,009 were involved in teaching, and 296 were involved in both activities. There are undoubtedly some graduate students engaged in research who do not have an assistantship, but their number is unknown.

In addition, graduate tuition and fees pay for administrative employment and the goods and services that support their effort. In particular, absent the University's research enterprise, the Office of Sponsored Programs (OSP), the Center for Science and Technology Commercialization and the Research and Development Foundation and other administrative and support personnel would not exist. We assume 75% of master's and doctoral enrollments come from outside Connecticut. This implies that the 4,128 graduate students described above (master's and doctoral students in all programs except allied health, law, nursing, and business administration) spent $94,539,456 in tuition and fees in 2003. We assume the (counterfactual)

absence of research at UConn and UCHC would forfeit that revenue. We have omitted medical and dental students who we assume are not engaged in research (344 master's and doctoral students at UCHC's biomedical science, dental science, and public health programs are included).

Occupational Supply

We assume 76% of graduate students receiving advanced degrees remain in Connecticut and provide their labor services to Connecticut firms, non-profits, the public sector (teachers, researchers and administrators). This fraction is consistent with alumni association findings. We estimate in 2003 there were 116 graduates in the life sciences area, 186 in the health diagnosing and treating practices, 265 in management occupations, 195 in primary, secondary, and special education, 80 engineers, 21 in the art and design occupations, 42 in other health professionals and technology areas, 121 social workers, 55 other teachers and instructors, 26 in mathematical science occupations, 43 physical scientists, 145 lawyers, and, 150 in miscellaneous professional services.[8] Having a ready supply of qualified labor reduces search costs for Connecticut employers and enhances the probability that they remain and expand in Connecticut.

College Age Population

The Connecticut Economic Model, REMI,[9] provides a demographic module that estimates changes in population due to changes in economic activity in a region. Special populations such as college students or prisoners are a challenge for the cohort survival part of a demographic model. If a region has several thousand 15-34 year olds due to the presence of a college or university, this sub-population will "grow old" in the area (unless specially handled) even though many of these students leave the area shortly after graduation. The same concept is true for prisoners. Such institutions replenish their sub-populations regularly. In addition to the demographic consequences, failure to identify a (change in the) college population may lead to erroneous (changes in) labor force estimates because college students participate at a reduced rate (prisoners do not participate at all).

[8] http://vm.uconn.edu/~wwwoir/deg02-03.pdf. These are REMI occupational categories.
[9] See Appendix for a description of REMI.

The REMI model incorporates a procedure to deal with student populations that appropriately adjusts the population downward for those areas with universities and upward for other areas. Regions with college populations have a larger special (that is, one that does not age with the rest of the population) sub-population, which is subtracted from cohort survival. We assume that there were 4,128 graduate students in 2003 (half male, half female) representing the college age sub-population whose average age was 23 years.

Goods and Services Purchases for Research

UCHC and UConn purchased $7,208,928 of goods and services from Connecticut firms in 2003 to support research. Among other things, glassware, reagents, office supplies, computers, software, and legal or other services are necessary inputs to the research process. These purchases in turn help expand businesses receiving UCHC and UConn research funds. For purposes of this study, we assume that this amount was spent in equal amounts in (REMI industry categories) computer and data processing services, business services not elsewhere classified, research and testing services, and, other colleges and universities.

The Amenity Value of UConn/UCHC Research

UConn and UCHC received $188.3 million in research awards in FY03. This represents a willingness to pay for the prospective benefits of the sponsored research. In turn, this represents the minimum improvement in Connecticut's quality of life, that is, one valuation of research is at least what people are willing to pay for it. It is true that a fraction of the total awards is actually expended during the fiscal year, but we assume it is the prospective value to the state that attracts (and keeps) individuals and firms to (in) Connecticut. Each year we have witnessed increasing awards that are expended in some cases over years into the future, but people migrate or remain because of the expected value (in terms of quality of life, new business, new employment) of the current (and continuing) awards. In addition, faculty and graduate students at the University of Connecticut and the UConn Health Center are expected to produce journal articles, monographs, computer codes, music scores, and other output containing research results, demonstrating their research productivity irrespective of grant or contract funding. This effort by definition leaks out of the state and is largely uncompensated other than by salary. It is also true that University faculty consult for their own benefit

irrespective of the flow of grants and contracts. Thus, the $188.3 million FY2003 award total is a conservative estimate of the quality of life improvement the research generates. We do not estimate, in addition, the UConn Health Center's engagement in translational research in which new treatments are made available to Connecticut residents. Therefore, the quality of care and the access to this care is increased through the research effort of UCHC.

Employment in Spin-off Firms

We estimate that the number of jobs in the spin-off firms mentioned above is about 150. These firms are in the miscellaneous professional services REMI industry category.

Results

Table 1 below shows the total, statewide economic effect of research activity at the University of Connecticut and the UConn Health Center. For this study, we report the long run equilibrium values of economic variables. That is, in the counterfactual analysis we use year 2035 values representing the expected annual increases above the baseline forecast. These results reflect CCEA's estimate of the ongoing (long run) economic value of the University's research enterprise that Connecticut captures. In other words, were it not for UConn's research enterprise, Connecticut's economy would experience losses in the amounts given in Table 1. The total effect refers to the direct effects (e.g., employment and purchases required for research) plus the indirect and induced effects due to the ripples (multipliers) of the direct effects. Gross state product (GSP) represents the increase in the value of all goods and services produced in the state in a year. Sales represent the increased business Connecticut firms captured as a result of University and Health Center research activity in FY2003. Personal income represents the increase in gross income Connecticut residents received as a result of University and Health Center research activity in FY2003. Employment (population, labor force) represents the increase in the number of jobs (individuals, people working or looking for work) in the state as a result of University and Health Center research activity in FY2003. State revenues represent the increase in all revenues received by the state and local revenues represent the increase in revenues received by aggregate of all municipal governments, while expenditures represent the corresponding increases in expenditure at those levels of government.

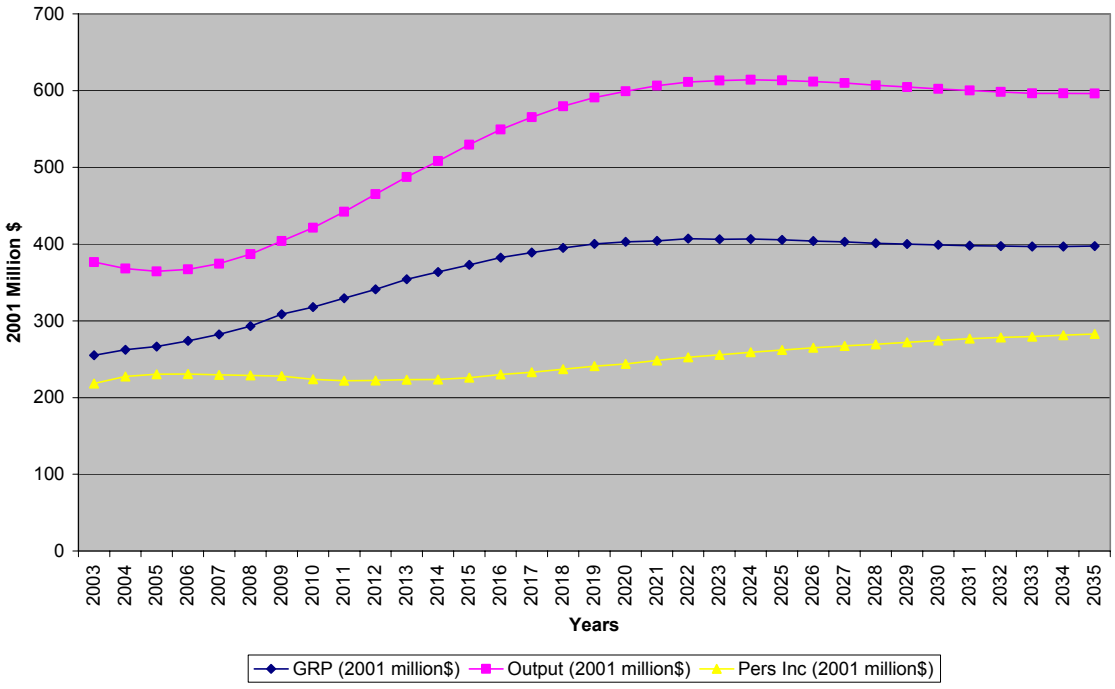
Table 1: Economic Impact of UConn & UCHC Research

Economic Variable	Annual Increase	Net Present Value
GSP (2001 million$)	$397.3	$5,479
Sales (2001 million$)	$596.2	$7,821
Personal Income (2001 million$)	$282.8	$3,813
Employment (Jobs)	5,113	NA
Population (Individuals)	8,769	NA
Labor Force (Individuals)	6,093	NA

The net present value for monetary variables represents the discounted present value (at 5%) of the stream of values each year of the study period (2003 through 2035). In other words, over 33 years, the net present value of GSP is $5.48 billion meaning UConn's research activity creates this much new value added in Connecticut in today's money terms. For reference (order of magnitude comparison), Connecticut's GSP in 2003 was $172.4 billion (the latest official 'prototype' figure from BEA) and Connecticut's personal income in 2003 was $150.8 billion (same source). Connecticut's employment in 2003 was approximately 1.62 million people.

Figures 1 and 2 display the time paths of the above variables from 2003 through 2035. These plots represent the dynamic response of the Connecticut economy to the counterfactual absence of research activity at UConn and UCHC. Figure 1 displays the time paths of gross state product, personal income and sales. The positive numbers represent what Connecticut

Fig.1: UConn & UCHC Research Impact: GSP, Personal Income & Sales



would lose were it not for the UConn and UCHC research enterprise. There is a gradual rise in each variable, but sales (industrial output) rises faster than GSP and personal income. This is due to the dominant effect of business-to-business activity as a result of the UConn and UCHC research enterprise. The horizontal axis represents the baseline Connecticut economy with current UConn and UCHC research activity; therefore, distances above the horizontal axis represent changes from the baseline forecast of the Connecticut economy reflecting the magnitude of the counterfactual loss of the UConn and UCHC research enterprise. The interpretation is then that these time series represent the value over time of UConn and UCHC research at current levels (assuming the FY2003 external funding level continues indefinitely in inflation adjusted terms into the future) to the Connecticut economy.

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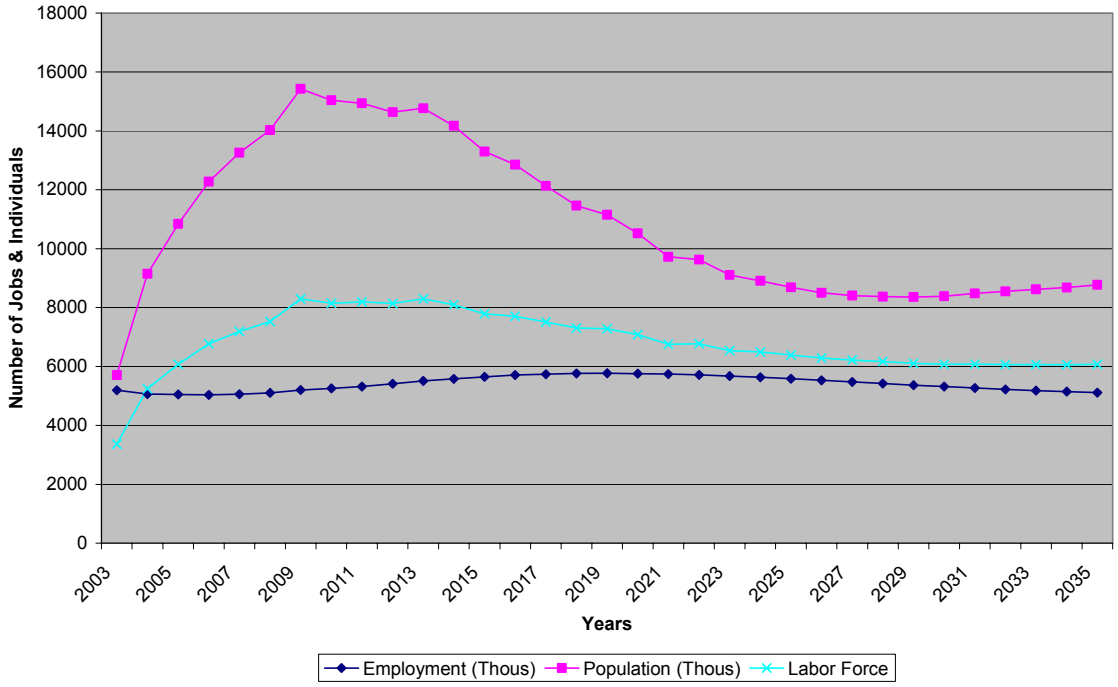
Figure 2 depicts employment (new jobs), new population and increases in the labor force relative to the baseline forecast of the Connecticut economy. Population rises rapidly in the first few years because of the dominant effect of the amenity value or quality of life enhancing value of UConn and UCHC research.

Fig. 2: UConn & UCHC Research Impact: Jobs, Population & Labor Force



Conclusion

Research at UConn and UCHC has a significant impact on Connecticut's economy. More than $188 million in external funding flowed into the UConn and UCHC research programs in FY2003. This flow of funds in large measure leverages the graduate programs at UConn and UCHC that in turn employ faculty and graduate students, as well as administrative and support staff in the research enterprise. Through multiplier effects across the state, these funds create more than 5,113 jobs and add $397 million in new GSP and $283 million in new personal income in the long run. That is, absent UConn and UCHC research activity, Connecticut would experience reduced employment levels form now on of about 5,113 jobs each year in the long run. Similarly, absent UConn and UCHC research activity, Connecticut would experience reduced gross state product and personal income levels form now on of about $397 million in GSP and $283 million in personal income each year in the long run.

More than these hard numbers, research activity at UConn and UCHC enriches the educational experience of undergraduate and graduate students alike. It makes them purveyors of new ideas in industry, government, and the arts. Were it not for the UConn and UCHC research enterprise, the graduate program at the University of Connecticut would largely disappear and fundamentally change the character of the University and its contribution to the state and the nation. Thus, external research funding in large measure leverages the UConn and UCHC graduate programs, brings in tuition money ($94 million), employs graduate students (they spend about $46 million), and creates spin-off firms (about 150 new jobs).

Research activity at UConn and UCHC enriches the lives of workers in the research enterprise and those in Connecticut-based spin-off firms. It benefits Connecticut firms that use technologies developed at UConn and UCHC. In turn, Connecticut becomes a more attractive place to live and work and for businesses to locate and expand because of the high quality and availability of Connecticut's educated workforce. In short, the research enterprise at UConn and UCHC makes Connecticut a more competitive state in the increasingly knowledge-based global economy.

Appendix: The REMI Model

The REMI Model

The Connecticut REMI model is a dynamic, multi-sector, regional model developed and maintained for the Connecticut Center for Economic Analysis by Regional Economic Models, Inc. of Amherst, Massachusetts. This model provides detail on all eight counties in the State of Connecticut and any combination of these counties. The REMI model includes all of the major inter-industry linkages among 466 private industries, aggregated into 49 major industrial sectors. With the addition of farming and three public sectors (state and local government, civilian federal government, and military), there are 53 sectors represented in the model for the eight counties.

The REMI model is based on a nationwide *input-output* (I/O) model that the U.S. Department of Commerce (DoC) developed and continues to maintain. Modern input-output models are largely the result of groundbreaking research by Nobel laureate Wassily Leontief. Such models focus on the inter-relationships between industries and provide information about how changes in specific variables—whether economic variable such as employment or prices in a certain industry or other variables like population affect factor markets, intermediate goods production, and final goods production and consumption.

The REMI Connecticut model scales the U.S. I/O "table" results according to traditional regional relationships and current conditions, allowing the relationships to adapt at reasonable rates to changing conditions. Listed below are some salient structural characteristics of the REMI model:

- REMI determines consumption on an industry-by-industry basis, and models real disposable income in Keynesian fashion, i.e., with prices fixed in the short run and GDP (Gross Domestic Product) determined solely by aggregate demand.

- The demand for labor, capital, fuel, and intermediate inputs per unit of output depends on relative prices of inputs. Changes in relative prices cause producers to substitute cheaper inputs for relatively more expensive inputs.

- Supply and demand for labor in a sector determine the wage level, and these characteristics are factored by regional differences. The supply of labor depends on the size of the population and the size of the workforce.

- Migration—that affects population size—depends on real after-tax wages as well as employment opportunities and amenity value in a region relative to other areas.

- Wages and other measures of prices and productivity determine the cost of doing business. Changes in the cost of doing business will affect profits and/or prices in a given industry. When the change in the cost of doing business is specific to a region, the share of local and U.S. market supplied by local firms will also be affected. Market share and demand determine local output.

- "Imports" and "exports between states are related to relative prices and relative production costs.

- Property income depends only on population and its distribution adjusted for traditional regional differences, *not* on market conditions or building rates relative to business activity.

- Estimates of transfer payments depend on unemployment details of the previous period, and total government expenditures are proportional to population size.

- Federal military and civilian employment is exogenous and maintained at a *fixed* share of the corresponding total U.S. values, unless specifically altered in the analysis.

Because the variables in the REMI model are all related, a change in any one variable affects many others. For example, if wages in a certain sector rise, the relative prices of inputs change and may cause the producer to substitute capital for labor. This changes demand for inputs, which affects employment, wages, and other variables in those industries. Changes in employment and wages affect migration and the population level that in turn affect other employment variables. Such chain-reactions continue in time across all sectors in the model. Depending on the analysis performed, the nature of the chain of events cascading through the

model economy can be as informative for the policymaker as the final aggregate results. Because REMI generates extensive sectoral detail, it is possible for experienced economists in this field to discern the dominant causal linkages involved in the results.