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Kris Burton
University of Maine, kris.burton@maine.edu

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State Investment in University Research and Commercialization:

What Is Measurable and What Is Meaningful?

by Kris Burton

There are serious challenges in measuring the impact of universities on their state economies and in measuring the return on investment in universities by state legislatures. Kris Burton discusses the metrics currently used in looking at societal investment in research and the commercialization of research results. She asks if more meaningful metrics are needed, and if so, are they possible to obtain?

"You can't manage what you can't measure" is an oft-repeated adage in business, government, sports, and any other statistically driven undertaking. It is often incorrectly attributed to the National Medal of Technology–winning statistician W. Edwards Deming, known as the "Father of the Quality Movement." But what Deming actually said is, "It is wrong to suppose that if you can't measure it, you can't manage it—a costly myth" (Deming 1994: 35). Another equally well-used proverb is the Law of the Hammer: "If all you have is a hammer, everything looks like a nail."

These simple concepts suggest a serious challenge in establishing metrics to measure progress in any endeavor: that which may be easily and discretely measured may be attributed more importance than is merited. And reflexively, the importance of that which is difficult to measure may be overlooked or undervalued in decision making.

This challenge certainly applies when considering the methods and metrics by which universities measure their impact on their state economies and by which state legislatures measure their return on investment in universities. The overall positive economic impact of societal investment in research and the commercialization of research results are generally well known and accepted, but how is impact measured on the state level? What metrics are currently used? Are more meaningful metrics needed, and are they possible to obtain?

ORIGINS OF CONTEMPORARY UNIVERSITY TECHNOLOGY COMMERCIALIZATION

The establishment of the land-grant university system by the Morrill Acts of 1862 and 1890 set the stage for the integral role in the state economy expected from land-grant universities. The original mission was to teach agriculture, military tactics, and mechanical arts. Fast forward through more than 150 years of widely accessible education emphasizing science, technology, and research, these institutions conduct $41 billion in university-based research (APLU 2012). There are established economic metrics for measuring the direct impact of salaries and other multipliers from these institutions. What has been more difficult is measuring the impact of, and return on, research investment on the economy.

In the 1970s, the United States faced double-digit inflation and unemployment due in large part to loss of manufacturing. Experts were predicting the loss of America's lead in high technology to Japan and Germany. U.S. universities and government laboratories were performing approximately $75 billion in research every year, but few products were reaching the market as a result of these activities. At that time, the federal government granted only nonexclusive licenses to companies to use patented research results, and there were few who took advantage of these licenses. Of 28,000 government patents, fewer than 5 percent were commercially licensed.

Legislation sponsored by senators Birch Bayh of Indiana and Bob Dole of Kansas proposed a novel solution to the slow transfer of government-sponsored research results to industry. The 1980 Bayh-Dole Act allowed universities, nonprofits, and small businesses the opportunity to elect ownership of intellectual property resulting from research grants. In electing ownership, universities were expected to file patents and actively seek collaborations with industry to put inventions to use.

Passage of Bayh-Dole created a a largely unfamiliar and somewhat controversial role for for universities. Major universities responded quickly by establishing patent offices to attend to the duties required to secure patents. Administrators quickly realized that obtaining patents is a costly endeavor. A handful of institutions began to have big-money wins that brought pressure on most offices to expand office skill sets beyond patenting to licensing, marketing, and sales. By 1990, patent offices in most cases expanded to become technology transfer offices.

By 2000, outside interest groups began to criticize universities for what was perceived as emphasizing financial return on patent licenses over the promotion of the better good globally. The Association of University Technology Managers (AUTM) responded by launching the Better World Project in 2005, "to promote public understanding of how academic research and technology transfer benefits you, your community and millions of people around the world."[1]

The global economic crisis of 2008 brought the expectations of the Bayh-Dole Act full circle, with increased emphasis on jobs and economic development through university research and technology commercialization. Many technology transfer offices are now integrated into the economic development arm of universities and play an active role in startup formation, business coaching, and education in addition to their established responsibilities. Understanding the evolution of their academic role in technology transfer reveals the logic and progression in the selection of metrics used and reported by universities for measuring impact.

CURRENT PRACTICES IN MEASURING RESEARCH INVESMENT IMPACT

Nearly all university technology transfer offices (TTOs) report common performance metrics based on the metrics collected annually by the AUTM. These include the number of patent applications and issued patents, the number of new invention disclosures, the number of technology licenses and license options completed, new startup companies, and income from licenses. These are typically normalized against annual research expenditures.

These metrics are simple to count and indicative of valid activity. Without research there can be no patents; therefore patents filed become a surrogate measure for research productivity. Patents issued and licensed become an indicator of research novelty and relevance, and royalty received may be an indicator of research value.

These metrics present some weaknesses, however, and do not capture the entire value of technology transfer activities nor of research activities as a whole. Patent applications and issued patents have little to no inherent value without being put to use. Overemphasizing patent applications can compound expenses quickly, and even issued patents can be far too narrow to be of value, or may be obsolete by the time of issuance. Licenses are an important indicator, but encompass only a fraction of the knowledge and value transferred to industry through university research programs. Royalty revenue can be an excellent opportunity to bring some return on investment back to a university, but must be balanced against efficient transfer of knowledge, building long-term industry collaborations, and the general public good. Some universities become very fortunate with a blockbuster patent, but most do not break even on technology transfer activities most years.

In a 2010 study commissioned by NASA to determine best practices in metrics across university, government, and private TTOs, technology consulting firm Fuentek emphasizes the need for qualitative metrics in addition to the traditional quantitative metrics. "Numbers alone are insufficient to demonstrate the value that technology transfer brings to the larger research and development (R&D) organization, the regional or national economy, and the public. High-performing TTOs augment their quantitative metrics reporting with success stories and anecdotes" (Hiser, Pollack, and Schoppe 2010: 1). The report goes on to describe examples such as advantages of new products, cost savings, health and/or safety benefits, human impact, and economic impact (Hiser, Pollack, and Schoppe 2010). Nearly all universities now include these qualitative impact measures in regular reports. In addition to the annual compilation of statistical metrics, AUTM began publishing a national annual *A Better World*

report in 2006 to emphasize the impact of technology transfer on global society.

The University of Maine has the advantage of having integrated TTO activities within the office of Innovation and Economic Development. This integration is a present trend among leading universities, particularly among land-grant universities, which are facing increased expectations to positively and efficiently affect state economies.

Recognizing this trend and the need for an integrated, holistic accounting of university economic impact, and in response to a 2010 report by the National Research Council, *Managing University Intellectual Property in the Public Interest*, which is critical of traditional metrics, the Association of Public Land Grant Universities (APLU) launched the Commission on Innovation, Competitiveness and Economic Prosperity (CICEP) Universities Designation. The commission identified 20 recommended metrics by which a university can best measure its impact on the state and national economy. It expands the traditional AUTM metrics to include measurements related to relationships with industry, workforce development, and business acceleration. The University of Maine expects to receive its CICEP University Designation in 2014.

AUTM also has an institutional economic engagement index that is under development. This index takes an interesting approach, including metrics that are generally overlooked by stakeholders outside of the university, but are crucial to promoting success and avoiding pitfalls. These include items such as institutional policies, for example, conflict of interest and financial, business environment assessment, and accessible web presence.

The Carnegie Foundation's community engagement classification is another integrated measure of impact. This designation "describes collaboration between institutions of higher education and their larger communities (local, regional/state, national, global) for the mutually beneficial exchange of knowledge and resources in a context of partnership and reciprocity."[2] It includes metrics outside those usual for economic development, research and technology transfer impact and is helpful in completing an overall view of the university's footprint on the community. This classification is voluntary and is held by University of Maine.

Additionally, the National Institutes of Health, the National Science Foundation, and the White House Office of Science and Technology Policy have undertaken STAR METRICS™—Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness and Science. This project was developed after a successful pilot project was conducted with several institutions and is in the early stages of adoption. It is aimed at quantifying the impact of federal research and includes economic development metrics not previously collected with parity and consistency, such as social and workforce outcomes.

The identification and selection of metrics that are consistently measurable, yet meaningful, is a topic of ongoing interest. Table 1 summarizes the national initiatives mentioned herein.

TABLE 1: **Examples of National Initiatives to Measure University Research Impact on Technology Transfer and Economic Development**

Organization	Current and New Metrics Initiatives
Association of Public Land Grant Universities	Innovation and Economic Prosperity (IEP) Universities Designation
Associate of University Technology Managers	AUTM Annual Report Better World Project Institutional Economic Engagement Index
Carnegie Foundation	Community Engagement Elective Classification
NIH, NSF and the White House Office of Science and Technology Policy	STAR METRICS™—Science and Technology for America's Reinvestment

CHALLENGES IN MEASURING IMPACTS OF STATE RESEARCH INVESTMENT

It is arguable that the only true measure of an impact on the state economy is tax revenue earned by the state in return for a state investment in research. There has been emphasis lately from state leadership in several states, including Maine, and by private think tanks such as the Brookings Institution (West 2012) to emphasize a dollar-in, dollar-out (DIDO) approach to evaluating research economic impact.

It should be noted that measuring the effectiveness of research expenditure towards its intended purpose is

not a new challenge, nor one particular to states and universities. Businesses and consultants have been engaged in this task for generations, and the academic literature is well stocked with case studies, models, and formulae. There are at least two universal complications with measuring dollar-to-dollar returns on research and development: one is the unpredictable nature of R&D, and the other is the need to know the depreciation or obsolescence rate of the knowledge generated. If industry finds this difficult, states and universities will find it at least equally so. Businesses often decide to reduce R&D risk/expense as much as possible by obtaining technologies and research from universities!

While dollar-in, dollar-out (DIDO) may be the gold standard for accounting return on investment, there are some reasons why perfecting this method is currently difficult and may be an exercise in diminishing returns if the calculations are consistently and forthrightly reported.

Consider the following challenges in reporting DIDO metrics, particularly on an annual basis:

- tracking a single dollar over the lapse in time between award, allocation, expenditure and result
- multiple types of research project results
- stacking and dilution of funds from multiple public and private sources
- wide variety of ways a dollar can be allocated to facilities, equipment, and other expenses
- the impact of direct spending vs indirect spending and selection of economic multipliers, for example, more money from salaries is spent locally than is money spent on equipment unless it is locally sourced
- the induced impact of direct spending on changes in household income
- the unpredictable nature of early-stage research typically undertaken by universities
- accounting for depreciation or obsolescence of results

It might be possible to obtain something acceptably close to DIDO by tracking a dollar through its process and selecting the transaction points where it has the

Measuring the Maine Economic Improvement Fund

Since its establishment in 1997, the Maine Economic Improvement Fund (MEIF) has been a key component in Maine's science and technology plan. Through 2010, independent outside consultants reported a 14:1 return on investment to taxpayers for the state's MEIF investment. The University of Maine, as one of several MEIF recipients, reports that for every dollar invested, the university leverages and imports approximately five research dollars from sources outside Maine.

The legislation governing MEIF requires an annual evaluation of program impact. In its review of the University of Maine System (UMS) fiscal year 2012 MEIF expenditures, the state Office of Program Evaluation & Government Accountability (OPEGA) asked what metrics UMS uses to measure accomplishments attributable to MEIF and whether there are others that might be used. While it is important to maintain consistency of measurement over time, it is also vital to periodically re-evaluate to ensure that what is measured is meaningful and is being used to support policy decisions.

Metrics reported by MEIF recipients include the following, although not all metrics apply to each recipient:

- federal grants leveraged
- other income received from grants, contracts
- private capital received
- patents applied for and obtained
- companies served by region
- company revenue and employees
- publications
- startup companies
- licenses
- students enrolled in STEM
- square footage of R&D facilities
- new equipment

UMS reports all of the above applicable metrics, as well as qualitative details and success stories in its annual report. Compared to the list of common and emerging metrics described in the first sections of this paper, this list hits all of the major elements without duplication or excess granularity. These metrics serve to capture the integrated value of research investment by including company collaborations, student enrollment, and new equipment.

most impact. Consider, for example, a single hypothetical state dollar invested toward the construction and operation of a research facility in year 1 at a state research university. The state dollar is matched with three federal dollars, and perhaps another dollar from private gift sponsorship to complete construction and first year of operation.

Because of the existence of the facility, researchers begin to win federal grants in year 1 or year 2. A federal grant awarded in year 1 is received and expended by the university over years years 2 through 5. An industry-sponsored research project is conducted at the facility concurrently. Both projects pay for portions of staff and student salaries, equipment, facility maintenance, and operation. Jobs are supported during the project, and equipment purchased during the studies becomes the property of the university, which it can use for future projects.

Suppose that in year 4, an invention with commercial potential emerges from the federally funded research project. The university elects to retain ownership of the invention, files a patent, and begins to seek a commercial licensee. The technology, however, needs further development before it is commercially deployable, but no funding is available. The technology remains on the university books for two years until year 6, when an out-of-state commercial partner gets budget-cycle approval to fund the development project. A second patent is filed, paid for by the out-of-state licensee, but owned by the university. The university licenses both patents to the company in their field of use; however, the product from the license is not sold until year 9.

In the meantime, the university licenses the same patents to a local startup in a different field of use, where first revenues are not expected until year 11. The startup employs three people, who are paid primarily by federal Small Business Innovation and Research grants (SBIR), so the university waives initial license fees in favor of a small equity position, which it liquidates in year 16.

The example could go on and multiply the scenario by several research facilities at the university and hundreds of research projects that are awarded, received, and executed over a number of years. DIDO measurements for state tax revenue generated by the single state dollar in year 1 would require obtaining income tax from project salaries and company salaries, company tax (minus credits), and other applicable taxes better left to a tax professional to describe. The point is illustrated that normalizing metrics year over year to find the DIDO would require intensive effort to calculate and obtain data, some of which is not accessible to the university.

Assuming DIDO could be achieved, the present value of investments still maturing or otherwise not captured are lost. For example, the value of unlicensed patents or prerevenue licenses, the benefit to state companies assisted by faculty and staff on nonuniversity or nonresearch projects, the enhanced reputation of the university (which attracts more businesses and students), and the higher value of graduates with research experience to state companies. According to the John William Pope Center, which has made critical, somewhat controversial, but nonetheless thought-provoking arguments about the impact of university research expenditures, "Measuring the returns to research—including losses on research—is an area where microeconomic methods perform very poorly. While one may estimate the effects that the salaries of researchers will have on the local economy, it is difficult to derive the effects of discovery and innovation, which have large random components" (Schalin 2010: 17).

For these reasons, meaningful metrics for evaluating research investments used must include a mix of (1) macroeconomic, that is, looking at the overall health of the economy and return on investment of an entire university over time; (2) microeconomic, measured by metrics that may be readily and consistently counted; and (3) qualitative accounts of impacts made.

CONCLUSION AND LOOKING FORWARD

University facilities allow states to leverage and import external research funds and enable companies to engage in more, broader, lower-risk research than they could undertake solely in-house. The outcome of research is knowledge—knowledge manifested in new processes, materials, and know-how. The knowledge created can be transferred in the form of publications or patents and also by further research collaboration, networking, consultancy, and teaching. Patents and other forms of intellectual property owned by the university may be licensed to private companies, resulting in new or more profitable products and services, which in turn support or create jobs during and after the project, tax revenues, and reinvestment back in research and development.

There are improvements in measuring the impacts of the state's investments in university research that could be implemented immediately, several to consider, and several to watch as they develop. Universities should consider the following actions:

1. Systematize and prioritize the collection and targeted dissemination of qualitative metrics and success stories.
2. Continue to use traditional metrics, but consider a deeper analysis to determine which activities bring the most benefit to each campus and state economy, depending on local assets and needs. For example, relationship-building activities may be more effective than technology-driven activities. Student internships, fellowships, and research opportunities may bring most value in some regions. Increasing research collaborations and industrial relationships focused on areas of strength may bring more impact than striving to increase invention disclosures in a number of different technology areas. Teaching and internship activities may have more impact than certain areas of research. While striving towards DIDO, universities should understand as well as possible the best internal allocation of resources.
3. Consider using an index-based measure of technology transfer activities to augment the traditional count-based measures. Index-based measures quantify the distribution of outcomes rather than their sum, meaning the data is not skewed by unusual outcomes or easily manipulated (Kurman 2011).
4. Engage in national and international efforts, such as those listed in Table 1, to identify and implement best metrics to the extent that they are meaningful to university and state goals.

ENDNOTES

1. Association of University Technology Managers (AUTM). 2014. A Better World Report. http://www.betterworldproject.org/Background_Information.htm [Accessed April 10]
2. Carnegie Foundation. 2014. Community Engagement Elective Classification. http://classifications.carnegiefoundation.org/descriptions/community_engagement.php [Accessed April 10].

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Kris Burton is the director of technology commercialization at University of Maine. As part of the Office of Innovation and Economic Development, she manages relationships between industry and the university and drives the evolution of university discoveries from invention to product. Previous experience includes market and product development at large and small businesses, as well as technology transfer in academia and the federal government.