

Economic Impacts Of Technology Transfer: Two Case Studies From The U.S. Department Of Defense

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Abstract

Virtually all publicly funded research institutions in the United States, both universities and government laboratories, engage in technology transfer. Their overriding rationale typically is to spur economic growth, create jobs, and contribute to national economic competitiveness. Despite this, public research institutions rarely attempt to directly measure the economic impact of their technology-transfer activities. Rather, they usually rely on surrogate indicators, such as invention disclosures, patent applications, patents issued, license agreements, and licensing revenues. There are relatively few studies of the direct economic impacts from technology transfer. This article presents two related case studies of economic impacts resulting from technology transfer between Department of Defense (DoD) laboratories and the private sector in the United States. These studies were conducted during the 2009-2010 period. One examined the impact of 326 technology-transfer agreements involving all branches of DoD; the other the impact of 103 Navy agreements. The article first presents essential background information on technology transfer and efforts to measure its economic impacts in the United States. Next, it provides a brief overview of DoD technology transfer. Then it presents the two case studies, comparing and contrasting their methodologies and results. Both studies demonstrate that the conversion of DoD inventions into new products and services is generating impressive levels of economic output and job creation.

(1) Introduction

Virtually all publicly funded research institutions, whether universities or government laboratories, engage in technology transfer. Their official rationale, usually stated explicitly, is to benefit the society that funded their research-and-development (R&D) activities by enabling the resulting inventions to be converted into useful products and services. Among the most important specific goals are (1) spurring economic growth through technological innovation, (2) creating and retaining jobs, and (3)

contributing to national economic competitiveness.

Despite this, for reasons presented below, public research institutions rarely attempt to directly measure the economic impact of their technology-transfer activities. Rather, they usually rely on surrogate indicators, such as numbers of license agreements and start-up companies, and licensing revenues. There are relatively few studies of specific, direct economic impacts from technology transfer.

This article presents two related case studies of economic impacts resulting from technology transfer between the United States Department of Defense (DoD) and the private sector. The article first presents essential background information on technology transfer and efforts to measure the economic impacts of this activity. Next, it provides a brief overview of DoD technology transfer. Then it presents the two case studies and their results, comparing and contrasting the two studies. It concludes with a brief commentary on the value of such studies to public research institutions.

(2) Background: Technology Transfer and Metrics in the United States

The foundation for modern-day technology transfer in the United States was established by landmark legislation during the 1980s. This legislation was specifically designed to stimulate innovation, patenting, and technology transfer by publicly funded research institutions.

Prior to 1980, the U.S. government retained patent rights to inventions resulting from federally funded R&D. This was true both for the private sector as well as for U.S. universities, whose principal source of research funding was federal agencies. While companies could license government-owned patents, the process was cumbersome and only non-exclusive licenses were available. As a result, few federally funded inventions entered the marketplace.¹

1. Allen, J. (2009) 'A long, hard journey: from Bayh-Dole to the Federal Technology Transfer Act,' *Tomorrow's Technology Transfer*, Vol. 1, No. 1, pp. 21-32.

To counteract this situation, in 1980 the U.S. Congress passed two major pieces of legislation: the Stevenson-Wydler and Bayh-Dole acts. These two acts established technology transfer as a key activity of both federal laboratories and universities and began to rapidly transform the U.S. innovation enterprise.

The Stevenson-Wydler Act, officially the Technology Innovation Act of 1980, mandated the establishment of a technology transfer office at each federal laboratory having a total annual budget of more than \$20 million. These offices were charged with disseminating information on the R&D being conducted within their labs and with attempting to transfer federally owned or originated technology to state and local governments and the private sector.²

The Bayh-Dole Act (officially, the University and Small Business Patent Procedures Act) was signed into law shortly after the Stevenson-Wydler Act. Its primary intent was to promote the commercialization and productive use of inventions resulting from federal R&D funding.³ Prior to this legislation, universities and small businesses did not have any rights to inventions that they conceived or reduced to practice under federal grants and contracts. The Bayh-Dole Act conferred such rights. It enabled these organizations to retain title to any inventions resulting from funding from the federal government.

In addition, the Bayh-Dole Act authorized and encouraged federal agencies to patent and license out their own inventions. An overriding goal of the Bayh-Dole Act was to use the incentives of the U.S. patent system to induce the private sector to commercialize both federally funded and federally developed inventions.⁴

Other landmark legislation in the 1980s extended the Stevenson-Wydler and Bayh-Dole acts and helped to spur innovation. For example, the Federal Technology Transfer Act of 1986 made technology transfer the responsibility of all federal laboratory scientists and engineers and required royalty sharing with laboratory inventors, to promote patenting and licensing. In addition, it gave laboratory directors the authority to negotiate license agreements for patented inven-

tions made at the laboratory.⁵

Altogether, these legislative acts in the 1980s established a strong national infrastructure for technology transfer. Prior to 1980, very few technology transfer offices existed in the country's federal laboratories and universities.⁶ However, by the end of the decade, nearly all federal labs and universities in the United States had a technology transfer office and were actively engaged in technology transfer with the private sector.

Simultaneously, there was a related imperative to measure the economic impacts of public-institution R&D and technology transfer in the United States. This imperative resulted from the convergence of three important trends: First, beginning in the early 1980s, there was deepening concern in the United States over the loss of national economic competitiveness to Asian and European competitors. Second, the collapse of the Soviet Union during the 1989-1991 period opened the door to a notable reorientation in national technology policy—away from the Cold War preoccupation with military security toward broader strategic goals,

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2. TIA (2000) *Technology Innovation Act of 1980* (also known as the Stevenson-Wydler Act). Public Law 96-480. For full text of act, see: <http://www.csrees.usda.gov/about/offices/legis/techtran.html>.

3. USBPPA (2000) *University and Small Business Patent Procedures Act* (also known as the Bayh-Dole Act). Public Law 96-517. For full text of act, see: <http://www.utsystem.edu/ogc/newsletter/PL%2096-517.pdf>.

4. Allen, J. (2009) 'A long, hard journey: from Bayh-Dole to the Federal Technology Transfer Act,' *Tomorrow's Technology Transfer*, Vol. 1, No. 1, pp. 21-32.

5. FTTA (1986) *Federal Technology Transfer Act of 1986*. Public Law 99-502. For commentary on this act, see: <http://thomas.loc.gov/cgi-bin/bdquery/z?d099:HR03773:@.L&summ2=m&%7CTOM:/bss/d099query.html>.

6. Hamermesh, R., Lerner, J., and Kiron, D. (2007) *Technology Transfer at U.S. Universities*. Report 9-807-124. Cambridge, Massachusetts: Harvard Business School, Harvard University.

7. NAS (1993) *Science, Technology and the Federal Government: National Goals for a New Era*. Report, Committee on Science, Engineering, and Public Policy, National Academy of Sciences. Washington, DC: National Academy Press. NAS (1992) *The Government Role in Civilian Technology: Building a New Alliance*. Report, Panel on the Government Role in Civilian Technology, National Academy of Sciences. Washington, DC: National Academy Press. Carnegie Commission (1993) *Science, Technology, and Government for a Changing World*. Concluding Report. New York, New York: Carnegie Commission on Science, Technology and Government. Carnegie Commission (1992) *A Science and Technology Agenda for the Nation: Recommendations for the President and Congress*. Interim Report. New York, New York: Carnegie Commission on Science, Technology and Government. Rood, S. (1998) *Government Laboratory Technology Transfer: Process and Impact Assessment*. PhD dissertation. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

including economic competitiveness.⁷ Third, the alarming growth of the U.S. budget deficit from 1980 to the early 1990s created pressure for greater accountability in federal R&D investments, to ensure that these investments were contributing to economic growth.⁸

The convergence of these trends produced two interconnected results: (1) a renewed commitment to strategic government R&D investments, in order to spawn technology innovations that would drive new economic growth and job creation, and (2) a new emphasis on evaluating the effectiveness of these investments, to ensure that they were having a positive economic impact. These trends exerted a major influence on technology transfer.

A major function of the hundreds of new technology transfer offices created in U.S. federal labs and universities during the 1980s was to maintain statistics on their technology-transfer activities. This was to enable these research institutions to be evaluated: How effective were they in generating new inventions and transferring them to the private sector for conversion into new products and creation of new companies? More specifically, how successful were they in generating economic growth, creating jobs, and advancing economic competitiveness?

On behalf of the nation's universities, in 1991, the Association of University Technology Managers (AUTM) began to compile annual statistics on technology-transfer metrics in U.S. (and later, Canadian) universities. Statistics gathered included invention disclosures, U.S. patent applications, U.S. patents issued, licenses executed, and royalties received.

Federal research institutions were engaging in similar metric-related data collection. Since passage of the Federal Technology Transfer Act in 1986, federal agencies were required to report their technology-transfer metrics to the President and Congress every two years. Metrics included active cooperative R&D agreements (CRADAs) with industry as well as invention disclosures, patent applications, patents issued, licenses executed, and royalties received.⁹

Today, U.S. universities and federal laboratories still use virtually the same indicators to measure their technology-transfer performance as they did in the 1980s.¹⁰ These institutions have had difficulty going beyond counting surrogate indicators to measure the

effectiveness of their technology-transfer operations. There are relatively few studies of specific, direct economic impacts resulting from technology transfer.

Reasons for this dearth of economic-impact studies include: (1) the long time lags between technology-transfer events and the successful commercialization of new products; (2) the multiple difficulties and significant costs of assessing economic impacts resulting from technology transfer; and (3) the fact that, after technologies have been transferred to the private sector, subsequent commercialization activities and economic impacts are largely beyond the public institution's direct purview and control.

9. DOC (2002) *Summary Report on Federal Laboratory Technology Transfer*. Washington, DC: Office of the Secretary, US Department of Commerce. DOC (2011) *Federal Laboratory Technology Transfer, Fiscal Year 2009: Summary Report to the President and Congress*. Prepared by the National Institute of Standards and Technology. Washington, DC: Office of the Secretary, US Department of Commerce.

10. For example, see AUTM (2010) Association of University Technology Managers, Highlights from the *AUTM U.S. Licensing Activity Survey Summary: FY2009*. Obtained through the Internet: http://www.autm.net/AM/Template.cfm?Section=Licensing_Surveys_AUTM&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=5239.

11. For example, see Pressman, L., Guterman, S., Abrams, I., Geist, D. and Nelsen, L. (1995) 'Pre-production investment and jobs induced by MIT exclusive patent licenses: a preliminary model to measure the economic impact of university licensing,' *Journal of the Association of University Technology Managers*, Vol. 7, pp. 28-46. Crow, M. and Bozeman, B. (1998) *Limited By Design: R&D Laboratories in the U.S. Innovation System*. New York: Columbia University Press. Ruttan, V. (2001) *Technology Transfer from the University of Minnesota: Estimating the Economic Impact*. Staff Paper P01-10. St. Paul, Minnesota: Department of Applied Economics, College of Agricultural, Food, and Environmental Sciences, University of Minnesota. Tassey, G. (2003) *Methods for Assessing the Economic Impacts of Government R&D*. Planning Report 03-1. Washington, DC: National Institute of Standards & Technology. Lowe, R. and Quick, S. (2004) 'Measuring the impact of university technology transfer: a guide to methodologies, data needs, and sources,' *Journal of the Association of University Technology Managers*, Vol. 16, pp. 43-59. Langford, C., Hall, J., Josty, P., Matos, S. and Jacobson, A. (2006) 'Indicators and outcomes of Canadian university research: proxies becoming goals?,' *Research Policy*, Vol. 35, pp. 1586-1598. Arundel, A. and Bordoy, C. (2008) *Developing Internationally Comparable Indicators for the Commercialization of Publicly Funded Research*. UNU-MERIT Working Paper 2008-075. Maastricht, The Netherlands: United Nations University, Maastricht Economic Research Institute on Innovation and Technology. Obtained through the Internet: <http://www.merit.unu.edu/publications/wppdf/2008/wp2008-075.pdf>. Matsumoto, M., Yokota, S., Naito, K. and Itoh, J. (2010) 'Development of a model to estimate the R&D output of public research institutes,' *R&D Management*, Vol. 40, No. 1, pp. 91-100. Hughes, M.E., Howieson, S.V., Walejko, G., Gupta, N., Jonas, S., Brenner, A.T., Holmes, D., Shyu, E., and Shipp, S. (2011) *Technology Transfer and Commercialization Landscape of the Federal Laboratories*. IDA Paper NS P-4728. Washington, DC: Institute for Defense Analyses (IDA), Science and Technology Policy Institute.

8. Link, A. (1999) 'A suggested method for assessing the economic impacts of university R&D: including identifying roles for technology transfer officers,' *Journal of the Association of University Technology Managers*, Vol. 11, pp. 37-51. Rood, S. (1998) *Government Laboratory Technology Transfer: Process and Impact Assessment*. PhD dissertation. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

The problem of measuring the economic impacts of technology transfer has received serious academic attention for more than 20 years.¹¹ Following Jaffe's earlier analysis, Langford *et al.* present a strong critique of the surrogate indicators that are currently widely used.¹² As they note, indicators commonly used by technology transfer offices are proxies or correlates for the desired end result, which is economic impact. These indicators are not important in themselves. For example, the number of new patents or start-up companies has no real value unless they prove to be commercially viable. These indicators are used because they are presumed to demonstrate that the research institution is producing innovations that ultimately result in economic growth, new or retained jobs, and increased economic competitiveness.

One risk of using proxies or correlates as performance indicators is that these surrogate indicators end up becoming the end goals. For example, using the number of new patents as a key measure of success may lead to patenting for patenting's sake, resulting in more patents but not more commercially viable patents.¹³

Since 2006, AUTM has been exploring adoption of new metrics for technology transfer. Its primary motivation has been to move beyond the current emphasis on licensing-related statistics to metrics that more effectively articulate the contributions of research institutions to the economic health of their regions and nation.¹⁴ AUTM has been undertaking this effort with foreign counterparts, including Unico-Praxis (formerly UNICO) in the United Kingdom and the Alliance for Commercialization of Canadian Technology (ACCT). It also has been interacting with the Association of Public and Land Grant Universities (APLU) and several federal agencies to identify meaningful new metrics.¹⁵

12. Jaffe, A. (1998) 'Measurement issues,' In: Branscomb, L. and Keller, J. (eds.) *Investing in Innovation: Creating a Research and Innovation Policy that Works*, (pp. 64-84), Cambridge, Massachusetts: MIT Press. Langford, C., Hall, J., Josty, P., Matos, S. and Jacobson, A. (2006) 'Indicators and outcomes of Canadian university research: proxies becoming goals?', *Research Policy*, Vol. 35, pp. 1586-1598.

13. Langford, C., Hall, J., Josty, P., Matos, S. and Jacobson, A. (2006) 'Indicators and outcomes of Canadian university research: proxies becoming goals?', *Research Policy*, Vol. 35, pp. 1586-1598.

14. AUTM (2009) *AUTM's Proposal for the Institutional Economic Engagement Index*. Unpublished draft proposal. Deerfield, Illinois: Association of University Technology Managers. Obtained through the Internet: http://www.autm.net/New_Metrics/4063.htm.

Recently, Fraser deployed a useful model in arguing for improved measurements of technology-transfer effectiveness.¹⁶ He drew on a logic model originally employed by the U.S. White House's Office of Management and Budget (OMB) to measure the effectiveness of government programs. The OMB model distinguishes between four key program components: inputs, outputs, outcomes, and impacts.¹⁷

According to Fraser, technology-transfer inputs include the number of invention disclosures, patent applications, and patents issued. Outputs include the number of signed license and other technology-transfer agreements, and licensing income. Outcomes include results such as the number of new products in the marketplace and the amount of sales. Impacts include both economic impacts, such as new or retained jobs, annual payroll from these jobs, and local or regional economic development—as well as more intangible benefits such as increased productivity, improvements in patient care, and lives saved. Fraser argues that technology transfer offices should focus on outcomes and impacts, not inputs and outputs, when evaluating the success of technology transfer.¹⁸

While it may be unrealistic to expect publicly funded research institutions to systematically track their economic impacts, representative case studies can play a valuable role in confirming the rationale for technology transfer—that it can result in significant economic growth, employment, and economic competitiveness. Case studies also can help to verify that proxy and correlate indicators of economic impact are, in fact, valid indicators. It is in this context that the article presents two related case studies of economic impacts resulting from technology transfer between the DoD and the private sector.

(3) DoD Technology Transfer

The U.S. Department of Defense is among the largest R&D organizations in the world. In fiscal year

15. Bostrom, D. (2009) 'Metrics in the US and an update on AUTM's activities.' Presentation at ACCT Canada 5th Annual Meeting, November 8-10, 2009. Victoria, British Columbia, Canada. Obtained through the Internet: www.acctcanada.ca/Documents/2009/Bostrom.pdf.

16. Fraser, J. (2009) 'Communicating the full value of academic technology transfer: some lessons learned,' *Tomorrow's Technology Transfer*, Vol. 1, No. 1, pp. 9-20.

17. OMB (1995) *Primer on Performance Measurement*. Report. Washington, DC: Office of Management and Budget. Obtained through the Internet: <http://govinfo.library.unt.edu/npr/library/resource/gpraprmr.html>.

18. Fraser, J. (2009) 'Communicating the full value of academic technology transfer: some lessons learned,' *Tomorrow's Technology Transfer*, Vol. 1, No. 1, pp. 9-20.

(FY) 2011, its expenditures for “science and technology” (basic, applied, and medical research as well as technology development) were estimated at U.S. \$14 billion.¹⁹ Roughly a third of DoD’s basic and applied research budget is expended by its nationwide network of approximately 100 laboratories, some 40 percent is spent on R&D contracts with industry, and the remainder consists of grants to universities and non-profit research institutions.²⁰

DoD’s laboratories generate significant numbers of new inventions each year in all major technology fields. In FY 2009, for example, DoD labs disclosed 831 new inventions. That same year, DoD filed a total of 690 patent applications and was issued 404 patents.²¹

As with other U.S. federal research laboratories and universities, license agreements are the main mechanism through which DoD’s patented and patent-pending inventions are transferred to the private sector. However, cooperative research and development agreements (CRADAs) are the technology-transfer mechanism most frequently employed by DoD. CRADAs enable DoD labs to collaborate with industry to jointly develop technologies having both commercial and military applications. CRADAs have intellectual property provisions that enable companies to license DoD-developed inventions resulting from joint research or to acquire exclusive rights to commercialize the co-developed intellectual property.

DoD also actively engages in technology transfer in the opposite direction. It funds industry to develop new technology for specific DoD applications, referring to transfer of that technology to DoD as “spin on” or “spin in”—as opposed to the “spin out” of traditional lab-to-industry technology transfer. Small R&D companies participate actively. Among the largest programs are the Small Business Innovation Research (SBIR) and related Small Business Technology Transfer (STTR) programs. Together, DoD’s SBIR and

STTR programs provide approximately \$1.5 billion to small U.S. companies to investigate and develop new technology to meet DoD needs.²²

In 1993, the U.S. Congress charged DoD with ensuring that technology developed for national security purposes was transferred to the private sector. The twofold purpose was (1) to help fulfil military needs, and (2) to enhance the national industrial base and contribute to U.S. global competitiveness. Like other U.S. federal agencies, DoD reports its technology-transfer metrics to the President and Congress every two years. As with other federal agencies, metrics include new and continuing CRADAs as well as invention disclosures, patent applications, patents issued, licenses executed, and royalties received.²³

These metrics provide valuable information on the relative performance of different DoD labs and permit a comparison of DoD’s performance with that of other federal agencies. However, such metrics provide little insight into the *actual economic impacts* resulting from transfer of DoD innovations to industry.²⁴ The following two economic-impact studies represent an effort to overcome this shortcoming. They were intended as representative case studies—to confirm that DoD’s technology transfer is resulting in significant economic growth and job creation.

(4) TechLink Economic-Impacts Study

The first study commissioned by DoD evaluated the economic impacts from technology-transfer partnerships brokered for DoD by an outside organization, TechLink. TechLink is a federally funded technology-transfer center at Montana State University, Bozeman. Since 1999, TechLink has served as a DoD “partnership intermediary.” Its primary focus is helping DoD labs nationwide to license their inventions to U.S. industry. TechLink brokers or facilitates approximately half of all DoD license agreements with industry. In addition, it helps to establish other types

19. Carney, J. P. (2011) ‘Department of Defense.’ *AAAS Report XXXVI: Research and Development FY 2012*. Washington, DC: American Association for the Advancement of Science, pp. 59-66.

20. Carney, J. P. (2011) ‘Department of Defense.’ *AAAS Report XXXVI: Research and Development FY 2012*. Washington, DC: American Association for the Advancement of Science, pp. 59-66.

21. DOC (2011) *Federal Laboratory Technology Transfer, Fiscal Year 2009: Summary Report to the President and Congress*. Prepared by the National Institute of Standards and Technology. Washington, DC: Office of the Secretary, U.S. Department of Commerce.

22. DTIC (2011) *Exhibit R-2, RDT&E Budget Item Justification: PB 2011*. Washington, DC: Office of Secretary Of Defense, U.S. Department of Defense. Information at Internet site: http://www.dtic.mil/descriptivesum/Y2011/OSD/0605790D8Z_PB_2011.pdf.

23. DOC (2011) *Federal Laboratory Technology Transfer, Fiscal Year 2009: Summary Report to the President and Congress*. Prepared by the National Institute of Standards and Technology. Washington, DC: Office of the Secretary, U.S. Department of Commerce.

24. Swearingen, W. and Dennis, J. (2009) ‘U.S. Department of Defense technology transfer: the partnership intermediary model,’ *International Journal of Technology Transfer and Commercialization*, Vol. 8, pp. 270-285.

of DoD technology-transfer partnerships, including CRADAs and R&D contracts with small companies for development of new technologies.

In 2009, DoD requested that TechLink undertake a study of the economic impacts resulting from its ten years of technology-transfer activities on DoD's behalf. The study was seeking to answer, for each TechLink-brokered agreement, the following key questions: (1) Did any new products, product improvements, or services (including R&D services) result from this agreement? (2) What were the total sales resulting from these new products, improved products, or services? (3) How many jobs were created or retained?

Methodology

To help undertake this study, TechLink contracted with an independent market research specialist who was provided with contact information for all companies that TechLink had partnered with DoD. The market research specialist contacted each of the companies during the March-August 2009 period. Companies contacted were administered a questionnaire focusing on the economic outcomes of the technology-transfer partnership(s) that TechLink had brokered or facilitated between the company and DoD (*i.e.*, the license agreements, CRADAs, or R&D contracts). Companies were informed that their responses would be treated as confidential information and that these responses would be aggregated with others, without company names, before submission to DoD. Only four of the 170 companies declined to participate in the study, yielding 166 companies—a response rate of nearly 98 percent.

With 72 of the companies on the list, TechLink had established more than one technology-transfer agreement. Among this group of “repeat customers,” the average was 3.2 agreements. Companies in this group were asked about the economic impacts of *each separate agreement*. In all, the market research specialist gathered data on the economic outcomes of 326 technology-transfer agreements.

The study period was effectively 2000-2007. TechLink began operations as a DoD partnership intermediary in August 1999; however, it brokered only four minor DoD technology-transfer agreements prior to 2000. In addition, most partnerships established after 2007 had not yet had time to yield significant economic results when study was conducted in 2009.

The data gathered from companies were grouped into two key categories: *total sales*, and *jobs* created or retained. Total sales consisted of sales of new products and services directly attributable to TechLink-brokered license agreements, CRADAs, or R&D

contracts. Many of the companies that licensed DoD technology or co-developed technology with DoD received subsequent R&D contracts from the federal government to further develop the technology for a specific application. All R&D contracts were treated as sales in this economic-impact study.

The data gathered by the independent market research specialist on the economic outcomes of the 326 individual technology-transfer agreements were audited by a Certified Public Accountant. Where the accountant discovered apparent anomalies, TechLink staff followed up by contacting the companies to verify or clarify the data reported. The final dataset was then provided to the Bureau of Business and Economic Research (BBER) at the University of Montana, Missoula, which specializes in economic analysis and forecasting for government, business, and non-profit organizations.

The BBER employed a widely used and well-documented economic modelling software program, IMPLAN[®], to estimate the multiplier effects of TechLink's technology-transfer activities.²⁵ The IMPLAN model is precise, using economic data and multipliers specific to the region and industry being studied. For example, it differentiates between 509 different industry sectors, using categories recognized by the U.S. Department of Commerce. IMPLAN is used by more than a thousand government, private-sector, and academic organizations to model the multiplier effects of economic activity. It differentiates between three different types of economic effects: direct, indirect, and induced.

Direct effects consist of the increase in revenue or employment resulting from a specific economic activity—in this case, production resulting from technology transfer. *Indirect effects* consist of inter-industry purchases along the supply chain, as companies purchase from each other to accommodate increases in the demands for their products and services. *Induced effects* result from payroll, as employee households of both the initial production (direct effect) and the employees along the supply chain (indirect effects) spend their earnings on goods and services. The sum of the direct, indirect, and induced effects is the total economic impact. IMPLAN uses two primary measures of economic impact: (1) *output*, which is the value of production; and (2) *employment*, which consists of the jobs created.²⁶

25. MIG (2011) *MIG, Inc. Web site*. Complete information about IMPLAN on Internet: <http://implan.com>.

26. IBRC (2009) *The Economic Contribution of the Department of the Navy Technology Transfer Program*. Report. Bloomington, Indiana: Indiana University, Kelley School of Business, Indiana Business Research Center.

Although IMPLAN is scalable to individual county and state levels, the BBER used the national IMPLAN model. The overall goal was to determine the economic impacts attributable to TechLink's technology-transfer activities for DoD at the national level.

Results

The study found that direct output (sales) resulting from the 326 TechLink-brokered technology-transfer agreements totaled \$239.7 million at the time of the study. Results are presented in Table 1. All dollar figures are reported in 2009 dollars using sector-specific inflators provided by the Bureau of Economic Analysis and the Bureau of Labor Statistics and embedded in the IMPLAN model.

Output. Economic output consists of sales, plus or minus inventory adjustments.²⁷ It is the total value of purchases by intermediate and final consumers. As Table 1 shows, the \$239.7 million in direct sales generated almost \$490 million in sales nationwide from indirect and induced sales. Overall, for every dollar in sales attributable to TechLink-brokered technology-transfer agreements, an additional \$2 in sales was generated economy-wide from indirect and induced sales. The total economic output or sales was estimated at \$729 million.

Employment. The study found that 1,258 jobs were directly sustained to support the \$239.7 million in total sales. Over 3,000 additional jobs were added to the economy by indirect, inter-industry sales and jobs generated from the induced effects of household spending. For each job directly attributable to TechLink-brokered technology-transfer agreements, an additional 2.4 jobs were created economy-wide. Overall, an estimated 4,290 jobs resulted from TechLink's technology-transfer agreements for DoD. Employee compensation associated with jobs created from direct sales was found to average \$73,279 per worker.

(5) Navy Economic-Impacts Study

The second study was commissioned by the Department of the Navy (DoN) to quantify the economic impacts of technology transfer from Navy laboratories. It was intended to be an illustrative case study: the goal was to measure the

economic benefits resulting from at least 100 representative Navy technology-transfer agreements. The DoN study shared many of the same characteristics as the TechLink study and, in fact, overlapped with it. Like the first study, it used the national IMPLAN model, enabling the economic impacts to be directly compared. However, the DoN study's data collection methodology differed substantially from that in the TechLink study, providing a valuable opportunity to compare both approaches and results.

Methodology

The Navy contracted with the Indiana Business Research Center (IBRC) at Indiana University's Kelley School of Business in Bloomington, Indiana, to conduct the study. Like the BBER, which assisted with the TechLink study, the IBRC specializes in economic analysis for business, government, and non-profit organizations.

The Navy gave the IBRC rudimentary data on more than 2,000 Navy tech-transfer agreements established between 1999 and mid-2009. These agreements consisted of CRADAs and license agreements. Because of confidentiality concerns, the Navy did not give the IBRC any contact information for these companies.

IBRC researched the companies using the Web and business information databases, such as Dun and Bradstreet, to verify their continuing existence and to generate contact information. Approximately 800 companies were eliminated from further consideration because of inadequate information. Most were older companies. The research team subsequently decided to focus on more recent partnerships—those between 2005 and 2009. The reasoning was that newer technology-transfer partners were more likely to still be in existence or to be traceable (for example, if they had been acquired by another company or had changed their name). That left a total of 622 company candidates for the study.

IBRC used a Web-based survey. The Navy technology transfer offices sent invitations to participate in the survey to the president of each of the 622 Navy partner companies in the candidate pool. A total of 84 companies (14 percent) completed the survey. To reach the desired sample size of at least 100, the IBRC

27. Strictly speaking, economic output is not the same as sales. For example, output in the retail sector is not equal to sales; it is equal to the gross margin on sales. That said, for the pertinent industries in these studies, output is the same as sales.

Table 1. Nationwide Economic Impact, DoD/TechLink T2 Case Study, 2009

	Direct	Indirect	Induced	Total
Economic Output (Sales)	\$239.7 million	\$191.6 million	\$297.7 million	\$729.0 million
Employment	1,258 jobs	1,041 jobs	1,991 jobs	4,290 jobs

added economic information from 19 Navy license agreements and CRADAs covered by the TechLink study during the IBRC's 2005-2009 time frame. Consequently, the IBRC study ended up with a total of 103 Navy technology-transfer projects.

The IBRC applied the national IMPLAN model to the data submitted by the 84 companies surveyed. It then incorporated results from the 19 Navy cases extracted from the TechLink study in order to estimate economic ripple effects of the total pool of 103 Navy projects. Both the IBRC and TechLink used the same economic impact model, IMPLAN. The results of the IBRC study follow.

Results

The IBRC study confirmed that the financial impact of Navy technology transfer extended well beyond the companies with which it signed agreements.²⁸ Results were highly consistent with those from the TechLink study. These results are summarized in Table 2.

Output. Direct sales resulting from the 103 Navy technology-transfer agreements totalled around \$200 million at the time of the study (see Table 2). These sales generated an additional \$345 million in indirect and induced sales. The total economic output was estimated at \$545 million.

Employment. The Navy study found that the direct output of \$200 million sustained an estimated 670 jobs in the 103 companies with technology-transfer agreements. The average compensation for each of these positions was estimated at \$79,300. The ripple effects from inter-industry purchases and employee household spending generated an additional 1,960 jobs. For each job directly attributable to the Navy technology-transfer agreements, an additional 2.9 jobs were created economy-wide. Overall, an estimated 2,630 jobs resulted from the 103 Navy technology-transfer agreements.

(6) The two studies compared

The TechLink and IBRC studies were undertaken in notably different ways. Despite this, they exhibited strikingly similar results. Table 3 compares these two studies.

The periods covered by the TechLink and IBRC studies differed but overlapped.

The TechLink study was undertaken in 2009; the IBRC study in 2010. Both focused on technology-transfer agreements established earlier that decade. The TechLink study covered a longer period, nominally 2000-2009 (but effectively 2000-2006, as previously noted). By contrast, the IBRC study covered a later, shorter period: 2005-2009.

The types of technology-transfer agreements covered in the two studies differed substantially. The TechLink study, unlike the IBRC study, included technology transfer from industry to DoD through R&D contracts. Some 43 percent of the 326 TechLink agreements involved R&D contracts, 37 percent were licenses, and 20 percent were CRADAs. In the IBRC study, licenses accounted for 25 percent of the Navy technology-transfer agreements and CRADAs comprised the remainder.

The data collection methodologies also differed substantially. The TechLink study involved a highly labor-intensive approach: direct, personal interviews by phone, usually followed by multiple follow-up phone calls and email exchanges in order to obtain the necessary information. This time-consuming approach took approximately six months but yielded an impressively high response rate of nearly 98 percent. By contrast, IBRC conducted a Web-based survey of 622 companies (culled from an initial list of over 2,000 companies) and received 84 responses—a 14 percent response rate. This relatively low response rate resulted from IBRC being handicapped by the lack of contact information for the companies.

The two studies gathered the same basic economic data needed to drive the national IMPLAN model. Both studies revealed that the economic impacts resulting from DoD technology transfer are substantial. DoD technology transfer is clearly a significant engine of technology-based economic development in the United States.

At the time of the study, the average agreement in the TechLink study had generated \$2.24 million in economic output and created or retained slightly over 13 jobs. The comparable per-agreement figures in the IBRC study were even more impressive: \$5.4 million in economic output and 26 jobs created or retained.

28. IBRC (2009) *The Economic Contribution of the Department of the Navy Technology Transfer Program*. Report. Bloomington, Indiana: Indiana University, Kelley School of Business, Indiana Business Research Center.

Table 2. Nationwide Economic Impact, Navy T2 Transfer Case Study, 2010

	Direct	Indirect	Induced	Total
Economic Output (Sales)	\$200 million	\$190 million	\$155 million	\$545 million
Employment	670 jobs	910 jobs	1,050 jobs	2,630 jobs

Table 3. Comparison Of The TechLink And IBRC Studies

	TechLink Study	IBRC Study
Time Period Covered	2000-2009	2005-2009
Types of Tech Transfer Agreements Considered	TechLink-brokered agreements for DoD (including Army, Navy, Air Force, and independent agencies) <ul style="list-style-type: none"> • 44% R&D contracts • 36% licenses • 20% CRADAs 	Navy-only agreements <ul style="list-style-type: none"> • 25% licenses • 75% CRADAs
Data Collection Methodology	Phone interviews with 166 companies gathering data on 326 technology-transfer agreements (72 companies had multiple agreements)	Voluntary Web-based survey of 622 companies. Data from 84 total respondents was supplemented with data from 19 TechLink/Navy T2 agreements
Response Rate	98%	14%
Data Collected	<ul style="list-style-type: none"> • Total and military sales • Employment • Reasons agreements terminated (licenses) • Attitudes toward T2 with DoD 	<ul style="list-style-type: none"> • Sales and employment • Cost savings (CRADAs) • Motives • Technology readiness level (CRADAs) • Company profile (size and type) • Prior experience with DoD T2
Economic Analysis Methodology	National IMPLAN model	National IMPLAN model
Economic Impact per T2 Agreement (at time of study, most agreements were ongoing)	<ul style="list-style-type: none"> • \$2.24 million in economic output • 13 jobs created or retained 	<ul style="list-style-type: none"> • \$5.4 million in economic output • 26 jobs created or retained
Average Job Compensation (for jobs attributable to direct sales)	\$73,279	\$79,300

Given that many of these agreements are ongoing (license agreements typically remain in effect until the patent expires), the total economic impact of the average agreement will be substantially larger during its effective lifetime.

Per-agreement differences between the two studies can be partly attributed to the different types of technology-transfer agreements covered and also to the fact that approximately 55 percent of the companies in the TechLink study were very small R&D companies, with fewer than 10 employees. Only 11 percent of the companies in the IBRC study had fewer than 10 employees and the average company was significantly larger than the average in the TechLink study. In addition, because of the voluntary, Web-based nature of the IBRC study and the resulting low response rates, the IBRC responses may have been skewed toward companies that had achieved highly positive outcomes from

their technology-transfer agreements.

The average compensation of the positions sustained by the direct sales of the technology-transfer partners was similarly high in both studies: \$73,279 in the TechLink study and \$79,300 in the IBRC study. These comparatively high salaries are explained by the higher-than-average compensation levels prevailing in the research, science, and technology fields.

(7) Conclusion

Economic-impact studies can play a valuable role in affirming the societal value of public research institutions and their technology-transfer activities. They can confirm that these institutions substantially benefit society through converting their inventions into new products and services—spurring economic growth, generating jobs, and contributing to national economic competitiveness. These studies also can help

verify that the proxy and correlate indicators used by technology transfer offices are, in fact, valid indicators of economic outcomes and impacts.

In addition, economic-impact studies can provide other high value to public-research institutions. First, they can be used to demonstrate that engaging in technology transfer with that institution can lead to profitable outcomes. This can help to attract other licensees and research partners. These studies also can help garner political support, by providing proof to administrators, elected officials, government overseers, and, ultimately, the taxpaying public, that financial support of the institution and its technology transfer office is a good investment. Finally, they can be used as a vehicle to gather other valuable information from technology-transfer partners, enabling the technology transfer office to improve its marketing to industry and its overall effectiveness. ■

References

- Allen, J. (2009) 'A long, hard journey: from Bayh-Dole to the Federal Technology Transfer Act,' *Tomorrow's Technology Transfer*, Vol. 1, No. 1, pp. 21-32.
- Arundel, A. and Bordoy, C. (2008) *Developing Internationally Comparable Indicators for the Commercialization of Publicly-Funded Research*. UNU-MERIT Working Paper 2008-075. Maastricht, The Netherlands: United Nations University, Maastricht Economic Research Institute on Innovation and Technology. Obtained through the Internet: <http://www.merit.unu.edu/publications/wppdf/2008/wp2008-075.pdf>.
- AUTM (2010) Association of University Technology Managers, Highlights from the AUTM U.S. Licensing Activity Survey Summary: FY2009. Obtained through the Internet: http://www.autm.net/AM/Template.cfm?Section=Licensing_Surveys_AUTM&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=5239.
- AUTM (2009) *AUTM's Proposal for the Institutional Economic Engagement Index*. Unpublished draft proposal. Deerfield, Illinois: Association of University Technology Managers. Obtained through the Internet: http://www.autm.net/New_Metrics/4063.htm.
- Bostrom, D. (2009) 'Metrics in the U.S. & an update on AUTM's activities.' *Presentation at ACCT Canada 5th Annual Meeting*. November 8-10, 2009. Victoria, British Columbia, Canada. Obtained through the Internet: www.acctcanada.ca/Documents/2009/Bostrom.pdf.
- Carnegie Commission (1993) *Science, Technology, and Government for a Changing World*. Concluding Report. New York, New York: Carnegie Commission on Science, Technology and Government.
- Carnegie Commission (1992) *A Science and Technology Agenda for the Nation: Recommendations for the President and Congress*. Interim Report. New York, New York: Carnegie Commission on Science, Technology and Government.
- Carney, J. P. (2011) 'Department of Defense.' *AAAS Report XXXVI: Research and Development FY 2012*. Washington, DC: American Association for the Advancement of Science, pp. 59-66.
- Crow, M. and Bozeman, B. (1998) *Limited By Design: R&D Laboratories in the U.S. Innovation System*. New York: Columbia University Press.
- DOC (2011) *Federal Laboratory Technology Transfer, Fiscal Year 2009: Summary Report to the President and Congress*. Prepared by the National Institute of Standards and Technology. Washington, D.C.: Office of the Secretary, U.S. Department of Commerce.
- DOC (2002) *Summary Report on Federal Laboratory Technology Transfer*. Washington, DC: Office of the Secretary, U.S. Department of Commerce.
- DTIC (2011) *Exhibit R-2, RDT&E Budget Item Justification: PB 2011*. Washington, D.C.: Office of Secretary Of Defense, U.S. Department of Defense. Information at Internet site: http://www.dtic.mil/descriptivesum/Y2011/OSD/0605790D8Z_PB_2011.pdf.
- FTTA (1986) *Federal Technology Transfer Act of 1986*. Public Law 99-502. For commentary on this Act, see: <http://thomas.loc.gov/cgi-bin/bdquery/z?d099:HR03773:@@L&summ2=m&%7CTOM:/bss/d099query.html>.
- Fraser, J. (2009) 'Communicating the full value of academic technology transfer: some lessons learned,' *Tomorrow's Technology Transfer*, Vol. 1, No. 1, pp. 9-20.
- Hamermesh, R., Lerner, J. and Kiron, D. (2007) *Technology Transfer at U.S. Universities. Report 9-807-124*. Cambridge, Massachusetts: Harvard Business School, Harvard University.
- Hughes, M.E., Howieson, S.V., Walejko, G., Gupta, N., Jonas, S., Brenner, A.T., Holmes, D., Shyu, E., and Shipp, S. (2011) *Technology Transfer and Commercialization Landscape of the Federal Laboratories*. IDA Paper NS P-4728. Washington, DC: Institute for Defense Analyses (IDA), Science and Technology Policy Institute.
- IBRC (2009) *The Economic Contribution of the Department of the Navy Technology Transfer Program*. Report. Bloomington, Indiana: Indiana University, Kelley School of Business, Indiana Business Research Center.
- Jaffe, A. (1998) 'Measurement issues,' In: Branscomb, L. and Keller, J. (eds.) *Investing in Innovation: Creating a Research and Innovation Policy that Works*, (pp. 64-84), Cambridge, Massachusetts: MIT Press.
- Langford, C., Hall, J., Josty, P., Matos, S. and Jacobson, A. (2006) 'Indicators and outcomes of Canadian university research: proxies becoming goals?,' *Research Policy*, Vol. 35, pp. 1586-1598.
- Link, A. (1999) 'A suggested method for assessing the economic impacts of university R&D: including identifying roles for technology transfer officers,' *Journal of the Association of University Technology Managers*, Vol. 11, pp. 37-51.
- Lowe, R. and Quick, S. (2004) 'Measuring the impact of university technology transfer: a guide to

methodologies, data needs, and sources,' *Journal of the Association of University Technology Managers*, Vol. 16, pp. 43-59.

Matsumoto, M., Yokota, S., Naito, K. and Itoh, J. (2010) 'Development of a model to estimate the R&D output of public research institutes,' *R&D Management*, Vol. 40, No. 1, pp. 91-100.

MIG (2011) *MIG, Inc. Web site*. Complete information about IMPLAN on Internet: <http://implan.com>.

NAS (1993) *Science, Technology and the Federal Government: National Goals for a New Era*. Report, Committee on Science, Engineering, and Public Policy, National Academy of Sciences. Washington, D.C.: National Academy Press.

NAS (1992) *The Government Role in Civilian Technology: Building a New Alliance*. Report, Panel on the Government Role in Civilian Technology, National Academy of Sciences. Washington, D.C.: National Academy Press.

OMB (1995) *Primer on Performance Measurement*. Report. Washington, D.C.: Office of Management and Budget. Obtained through the Internet: <http://govinfo.library.unt.edu/npr/library/resource/gprapmr.html>.

Pressman, L., Guterman, S., Abrams, I., Geist, D. and Nelsen, L. (1995) 'Pre-production investment and jobs induced by MIT exclusive patent licenses: a preliminary model to measure the economic impact of university licensing,' *Journal of the Association of*

University Technology Managers, Vol. 7, pp. 28-46.

Rood, S. (1998) *Government Laboratory Technology Transfer: Process and Impact Assessment*. PhD dissertation. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

Ruttan, V. (2001) *Technology Transfer from the University of Minnesota: Estimating the Economic Impact*. Staff Paper P01-10. St. Paul, Minnesota: Department of Applied Economics, College of Agricultural, Food, and Environmental Sciences, University of Minnesota.

Swearingen, W. and Dennis, J. (2009) 'U.S. Department of Defense technology transfer: the partnership intermediary model,' *International Journal of Technology Transfer and Commercialization*, Vol. 8, pp. 270-285.

Tassey, G. (2003) *Methods for Assessing the Economic Impacts of Government R&D*. Planning Report 03-1. Washington, D.C.: National Institute of Standards & Technology.

TIA (2000) *Technology Innovation Act of 1980* (also known as the Stevenson-Wydler Act). Public Law 96-480. For full text of act, see: <http://www.csrees.usda.gov/about/offices/legis/techtran.html>.

USBPPA (2000) *University and Small Business Patent Procedures Act* (also known as the Bayh-Dole Act). Public Law 96-517. For full text of act, see: <http://www.utsystem.edu/ogc/newsletter/PL%2096-517.pdf>.