The Economic Contribution of University/Nonprofit Inventions in the United States: 1996-2017

Prepared for the Biotechnology Innovation Organization & AUTM
by Lori Pressman, Mark Planting, Jennifer Bond,
Robert Yuskavage, & Carol Moylan

The Economic Contribution of University/Nonprofit Inventions in the United States: 1996 – 2017

Prepared for the Biotechnology Innovation Organization (BIO) and AUTM

by Lori Pressman, Mark Planting, Jennifer Bond, Robert Yuskavage, and Carol Moylan,

June 5, 2019

Team Lori Pressman is an independent business development, licensing, and strategy consultant in Cambridge, Massachusetts, a former Assistant Director at the MIT Technology Licensing Office, and a former Chair of the AUTM Survey Statistics and Metrics Committee. Mark Planting is former Chief of Research on the use and development of U.S. input-output accounts at the Bureau of Economic Analysis. Jennifer Bond is a senior science policy analyst, a Senior Fellow with the Council on Competitiveness, and former Director of the Science and Engineering Indicators Program at the National Science Foundation. Robert Yuskavage is former Associate Director for International Economics at the Bureau of Economic Analysis. Carol Moylan is former Associate Director for Industry Economic Accounts at the Bureau of Economic Analysis.

Acknowledgments This model came into being a decade ago under the leadership of David Roessner, Professor Emeritus, Georgia Institute of Technology, who had the foresight to draw together expertise from the Bureau of Economic Analysis at the U.S. Department of Commerce, the Science and Engineering Indicators Program at the National Science Foundation, and AUTM. Thanks also to the Biotechnology Innovation Organization, AUTM, and the National Institute of Standards and Technology for their cumulative support.

Contents

Summary
Using an updated, more complex, and most current input-output "I-O" approach to estimating the economic impact of academic licensing, assuming no detrimental product substitution effects, and summing that impact over 22 years of available data for academic U.S. AUTM Survey respondents,

> total contribution of these academic licensors to industry gross output ranges from $723 billion to $1.7 trillion, in 2012 U.S. dollars;
>
> contributions to gross domestic product (GDP) range from $374 billion to $865 billion, in 2012 U.S. dollars; and
>
> estimates of the total number of person years of employment supported by these academic licensors' licensed-product sales range from 2.676 million to 5.883 million over the 22-year period.

The high end of the range, in particular the $1.7 trillion contribution to gross output, $865 billion contribution to GDP, and providing support for 5.883 million jobs over the 22-year period, is based on an assumption of a 2% earned royalty rate on licensees' product sales.

The low end of the range, in particular the $723 billion contribution to gross output, $374 billion contribution to GDP, and providing support for 2.676 million jobs over the 22-year period, is based on an assumption of a 5% earned royalty rate on licensees' product sales.

A history of using the I-O approach to estimate the economic impact of academic licensing is provided, along with reasons for evolving to the current implementation.

An explanation of the I-O approach is provided, and the assumptions used and the potential effects of the assumptions on the estimates are discussed.

AUTM associated contributions to GDP, calculated using the I-O approach, are compared with U.S. GDP as a whole and with selected industry, as defined by North American Industry Classification System (NAICS) codes, contributions to GDP.

Introduction to the 10th Anniversary Application of the I-O Model to Nonprofit Licensing Activity
This 2019 report marks the 10th anniversary of using an input-output (I-O) model to estimate the economic impact of licensing activity at nonprofit institutions, and the fifth I-O report using AUTM data.[1] AUTM (formerly the Association of University Technology Managers) membership includes individuals who work in technology transfer at universities and other nonprofit academic research organizations, such as academic medical centers.

The model takes microeconomic data, in this case, the annual AUTM survey ("AUTM Survey"[2]) respondent license and earned royalty income, and, in combination with empirically documented patterns of transactions in the U.S. economy, estimates AUTM Survey respondents' and their licensees' contribution to the U.S. economy using standard economic metrics: gross domestic product (GDP), gross output (GO), and jobs. In order to apply

---

[1] There was a 2018 report for the National Institute of Standards and Technology (NIST) using data from the federal laboratories.
[2] The FY2017 Survey is available here: [http://www.autmsurvey.org/id_2017.pdf.](http://www.autmsurvey.org/id_2017.pdf)

these macroeconomic empirical generalizations, it is necessary to make assumptions about the types of products made and sold by AUTM licensees and where and how the products are made. It is also necessary to make assumptions about earned royalty rates in AUTM member license contracts, as reported earned royalties on product sales divided by an assumed royalty rate is used to estimate the dollar value of licensees' product sales.

Prior reports[3] using AUTM data simply put the licensed products in "manufacturing" and assumed that all production of licensed products occurred in the United States. A further simplification was made that none of the sales of the licensed products were to final demand, or what a licensing professional might describe as the last sale in a value chain.

For this report, a decision was made to model the licensees as being in research intensive[4] industries, as defined empirically by their research expenditure patterns, rather than to model them as being in "manufacturing." To better reflect a more globally integrated economy, and by again using empirically gathered data on industry specific patterns (not actual information about where the licensees' products are made), this report revises the modeled location of manufacturing of the licensed products, and their position in a value chain. Finally, it was decided to model the industries of the licensees of the hospitals and research institute AUTM Survey respondents differently from the industries of the licensees of the university AUTM Survey respondents because of the preponderance of health technologies invented at and licensed by the former.[5]

Motive for Developing the I-O Model

The demonstrable benefits of research expenditures are of considerable interest to a variety of stakeholders. Businesses must justify research expenditures to their shareholders as leading ultimately to higher productivity. Governments and nonprofits have an analogous duty to taxpayers. They want to show how their stewardship of taxpayer-funded research contributes to the well-being, including the economic well-being, of their citizens. Recent legislation, Public Law No. 115-435 as of January 14, 2019, the Foundations for Evidence-Based Policymaking Act of 2018,[6] draws attention to the need for empirical studies to inform policymaking.

Some impacts occur close in time and place to when and where the research was performed. Others occur far removed in time and far away geographically from where the research was first done. This report is about research done at U.S. academic institutions and at other nonprofits, subsequently licensed to the private sector, and its ensuing visible economic contribution to U.S. GDP, gross output, and employment. Visibility under this model ends when the requirement to report product sales under the license does.

The nonprofit licensing data were gathered by AUTM members initially for internal office management and benchmarking, and then to help describe the impact of their technology transfer activities outside their home institutions. AUTM has been surveying its members since 1995,[7] using its practitioner-generated survey

[3] Rev 2 in the NIST report, as in this update, considered some nondomestic production and modeled some of the licensed products going to final demand. Though Rev 2 in the NIST report added selected IT industries to the basket of industries, it did not use "research intensive" industries as has been done here. The Rev 2 NIST industries and the research intensive industries overlap but are not the same. See Table S-2, which shows how the industries overlap and differ between the reports.

[4] "Research intensive" means these industries spend a large percentage of their top-line revenue on research. See Li and Hall (2018).

[5] From here on, university AUTM Survey respondents will be called "Universities," and hospital and research institute AUTM Survey respondents will be called interchangeably "Hospitals and Research Institutes," "Hospitals," or "HRIs."

[6] https://www.congress.gov/bill/115th-congress/house-bill/4174. See also Robert Hahn, 2019, "Building Upon Foundations for Evidence-Based Policy," *Science* 364 (6440): 534–535, https://science.sciencemag.org/content/364/6440/534.

[7] The data collected were from 1991–95 in the first survey.

instrument known as the AUTM Survey. In 1998 AUTM started systematically soliciting product commercialization narratives, now called the Better World Project.[8]

Using a combination of AUTM Survey data and product commercialization narratives, AUTM developed various approaches to describing the impacts of its members' activities. For example, to illustrate societal impacts, AUTM has used the Better World Project and tracked start-ups formed and operational and new AUTM member licensed technologies that became available to the public.[9] In the mid-1990s, AUTM developed its own impact model that included measures of preproduction impact,[10] [11] used i) earned royalties and an assumed royalty rate[12] to estimate licensees' sales, and ii) Census Bureau data on salaries at technology companies to estimate jobs supported by licensing activities. These economic estimates were published in the AUTM Survey in the mid- and late 1990s.

The model described in this report grew out of AUTM and the Biotechnology Innovation Organization's (BIO) desire to move beyond practitioner-generated approaches and to describe the economic impact of nonprofit technology transfer activities using standard economic metrics: GDP, GO, and employment. Consequently, in 2009 BIO commissioned David Roessner, Professor of Public Policy at the Georgia Institute of Technology, Sumiye Okubo and Mark Planting, retired economists from the Bureau of Economic Analysis (BEA), and Jennifer Bond, former Director of the Science and Engineering Indicators Program at the National Science Foundation (NSF), to develop an economic impact model using standard economic approaches. This report is based on that model, first published in a 2009[13] report, then in the peer-reviewed journal *Research Policy* in 2013.[14]

History of the Implementation of the I-O Model

Counting the initial 2009 report and the 2013 publication, this is the sixth calculation and evolution of the original model. The changes are described in Table S-1 and summarized below.

The 2012 report[15] included AUTM member Hospitals and Research Institutes (HRIs) and included jobs supported by the licensees' sales. The 2009 report and *Research Policy* paper included only Universities and did not include jobs supported by the licensees' product sales.

The 2015 report[16] was the first report shown in 2009 dollars, and used updated and increased BEA value added ratios, which increased the GDP estimates. The 2015 updated value added ratios better reflected the

---

[8] http://www.betterworldproject.org/

[9] See http://www.autmsurvey.org/id_2017.pdf re definitions of start-ups, start-ups operational and licensed technologies available.

[10] Lori Pressman, Sonia K. Gutterman, Irene Abrams, David E. Geist, and Lita Nelsen, 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,* Volume VII: 49–82.

[11] Peter B. Kramer, Sandy Scheibe, Donyale Reavis, and Louis Berneman, 1997, "Induced Investments and Jobs Produced by Exclusive Patent Licenses: A Confirmatory Study," *Journal of the Association of University Technology Managers,* Volume IX: 79– 97.

[12] Ashley J. Stevens, "Measuring Economic Impact," AUTM Advanced Licensing Course, Arizona, December 1994.

[13] David Roessner, Jennifer Bond, Sumiye Okubo, and Mark Planting, *The Economic Impact of Licensed Commercialized Inventions Originating in University Research, 1996–2007,* September 3, 2009, http://www.bio.org/sites/default/files/BIO_final_report_9_3_09_rev_2_0.pdf, accessed April 23, 2019.

[14] David Roessner, Jennifer Bond, Sumiye Okubo, and Mark Planting, "The Economic Impact of Licensed Commercialized Inventions Originating in University Research," *Research Policy*, May 26, 2013, 10.1016/j.respol.2012.04.015, https://econpapers.repec.org/article/eeerespol/v_3a42_3ay_3a2013_3ai_3a1_3ap_3a23-34.htm, accessed April 23, 2019.

[15] Lori Pressman, David Roessner, Jennifer Bond, Sumiye Okubo, and Mark Planting, *"The Economic Contribution of University/Nonprofit Inventions in the United States: 1996–2010,"* June 20, 2012, https://www.bio.org/sites/default/files/BIOEconomicImpact2012June20.pdf, accessed April 23, 2019.

contribution of research expenditures to the U.S. economy, including their contributions to growth and productivity similar to other capital goods.[17] This change in the treatment of R&D expenditures is the subject of an upcoming paper by Carol Moylan and Sumiye Okubo, and was the fruit of many decades of international consensus and collaboration. Beginning with the I-O accounts released in 2014, BEA recognized R&D expenditures as investment. With the new treatment, R&D expenditures by businesses were reclassified from spending on intermediate inputs to investment. Spending on R&D by nonprofits and by general government was reclassified from consumption to investment.

A key step leading to comfort capitalizing research in the national accounts was devising a way to depreciate intangible research capital, as eventually, more quickly in certain industries than in others, it will become obsolete. Metaphorically, when does research "wear out"? One of the methods developed[18] assumes that (i) firms pursuing profit maximization will invest in research optimally such that the marginal benefit equals the marginal cost, (ii) there are diminishing marginal returns to research expenditures, and (iii) the expected return on an intangible asset is the same as the expected return on a tangible one — and the latter number can be empirically observed for non-financial businesses.

The 2017 report[19] used the same general approach as the 2015 report. While working on the 2017 report, the team began developing and testing a more realistic model that was published for the first time in a 2018 report[20] for the National Institute of Standards and Technology (NIST). In this more realistic and complex model, not all products are assumed to be produced domestically, and at least some of the licensees' sales are considered final sales, permitting use of output multipliers. The team also tested revising the industries used to model the products sold by the licensees, and explicitly incorporated software and IT products and services into the mix.

This 2019 estimate builds on all the prior work, applying the more complex and realistic method published for the first time in the 2018 NIST report to AUTM data. In addition, this 2019 report changes the industries used to model the products sold by the licensees to the research intensive industries identified and studied by the BEA[21] in preparation for treating research as a capital expenditure in the national accounts. These industry changes overlap with, but are not identical to, the industry changes used in what was called "Rev 2" in the NIST report, and are described in Table S-2.

Reasons for Changing the Industries to Research Intensive Industries and Using a More Complex Model

---

[16] Lori Pressman, David Roessner, Jennifer Bond, Sumiye Okubo, and Mark Planting, *The Economic Contribution of University/Nonprofit Inventions in the United States: 1996–2013,* Prepared for the Biotechnology Industry Organization, March 2015, https://www.bio.org/sites/default/files/files/BIO_2015_Update_of_I-O_Eco_Imp.pdf, accessed April 23, 2019.

[17] See Barbara M. Fraumeni and Sumiye Okubo, *R&D in the National Income and Product Accounts: A First Look at Its Effect on GDP*, August 2005; and Marissa J. Crawford, Jennifer Lee, John E. Jankowski, and Francisco A. Moris, *Measuring R&D in the National Economic Accounting System*, November 2014.

[18] Wendy C. Y. Li and Bronwyn Hall, 2018, "Depreciation of Business R&D Capital," *Review of Income and Wealth*, DOI: 10.1111/roiw.12380, https://onlinelibrary.wiley.com/doi/10.1111/roiw.12380.

[19] Lori Pressman, Mark Planting, Robert Yuskavage, Sumiye Okubo, Carol Moylan, and Jennifer Bond, *The Economic Contribution of University/Nonprofit Inventions in the United States: 1996–2015*, prepared for the Biotechnology Innovation Organization and the Association of University Technology Managers, June 2017, https://www.bio.org/sites/default/files/June%202017%20Update%20of%20I-O%20%20Economic%20Impact%20Model.pdf.

[20] Lori Pressman, Mark Planting, Robert Yuskavage, Jennifer Bond, and Carol Moylan, *A Preliminary Application of an I-O Economic Impact Model to US Federal laboratory Inventions: 2008–2015,* prepared for NIST, July 2018, https://www.nist.gov/sites/default/files/documents/2018/09/20/prelimappioeconimpactmodelfedlabinventions2008-2015.pdf.

[21] Carol A. Robbins and Carol E. Moylan, 2007, "Research and Development Satellite Account Update: Estimates for 1959–2004, New Estimates for Industry, Regional, and International Accounts," *Survey of Current Business* 87 (October): 49–92.

AUTM member institutions typically license early-stage technology requiring a lot more development by their licensees. There is considerable evidence that nonprofit technology is developed by its licensees for years after it is licensed but before products are sold. This additional development often requires sizable private sector investment.

Elapsed time from license to product introduction: Roger Ditzel, from the University of California, plotted the amount of earned royalty income received in the year ending June 30, 1989, against the year in which an invention accounting for that income was received. Figure 5 of that article shows that 95% of this type of income is generated by inventions reported eight years before or earlier.[22] A team from MIT[23] presented unpublished data on the timing of licensees' product sales relative to license execution at an American Association for the Advancement of Science meeting, visible here[24] on slide 3. For 150 products associated with 850 MIT patent licenses executed between 1980 and 1998, most sales occur five years after the license was executed.

See also Figure 6A of "DNA Patent Licensing Under Two Policy Frameworks,"[25] which shows commercialization timelines of products covered by patents having DNA sequences in their claims, "DNA Patents." This group of patents was selected for study because of the interest in commercialization timelines for diagnostics, often thought to be easier and thus faster to commercialize than therapeutics. Looking only at the 20 products associated with university exclusive or partly exclusive licenses, the average time the products were in development by the private sector after licensing but before they were sold is about four years and highly variable. The standard deviation of the distribution which peaks at four years is about three years. Some of these products first became available for sale more than a decade after the license was executed. As the licenses were either exclusive or partly exclusive, they likely had contractual requirements to actively work on commercializing invention, implying that the licensee would have introduced the product more quickly if it had been able to do so.

Commercialization timelines and costs in the biological sciences: Many nonprofit licenses are to life science companies. AUTM data from 1996 and 1997,[26] copied into Tables S-3 and S-4 as a convenience, suggest that for Universities, about 80% of the income is from licenses in the life sciences. For Hospitals and Research Institutes, 90% or more of the income is from licenses in the life sciences. In addition, public anecdotal information about high economic impact inventions places many, though not all, of them in the biological sciences.

Because of the preponderance of health-related inventions, timelines in biotech are also relevant to a consideration of how long it takes, after invention, to produce a commercial product. Studies on these

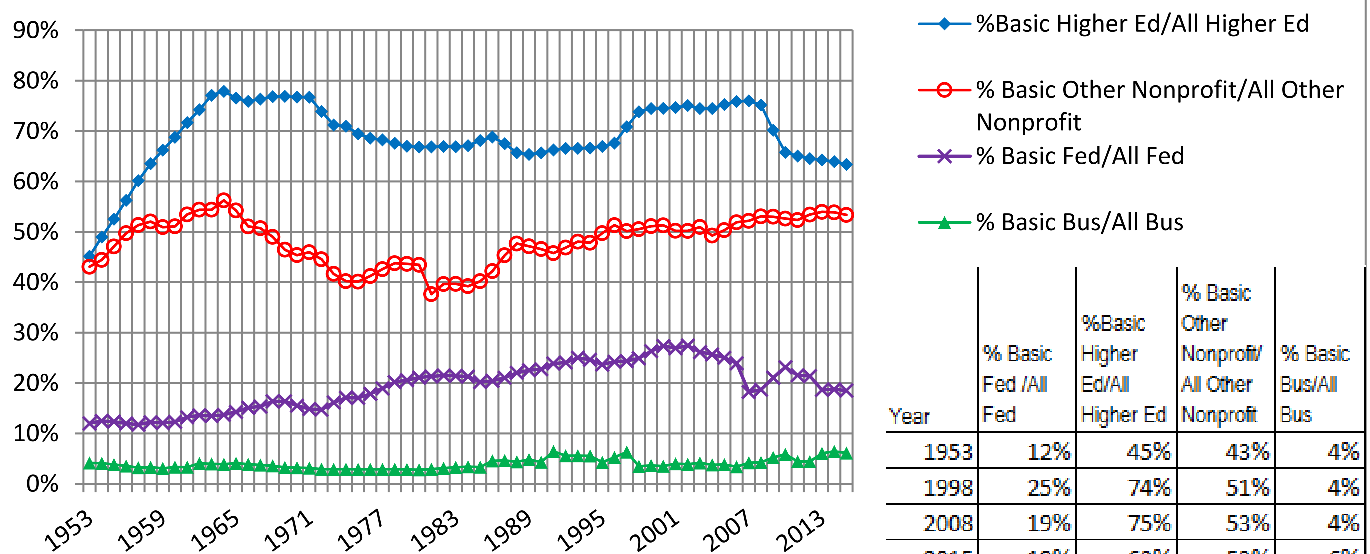
[22] See figure 5 of Roger G. Ditzel, 1991, "Public Law 96-517 and Risk Capital: The Laboratory-Market Connection," *Journal of the Association of University Technology Managers,* Volume 3 (September): 1–21.
[23] Lori Pressman and Don Kaiser, "Measuring Product Development Outcomes of Patent Licensing at M.I.T.," AAAS Annual Meeting, Washington, D.C., February 17–20, 2000, Session 4201.
[24] Slide 3, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.198.3934&rep=rep1&type=pdf . Originally presented at an AAAS meeting: "Measuring Product Development Outcomes of Patent Licensing at M.I.T.," AAAS Annual Meeting, February 7, 2000, Washington, D.C.
[25] Lori Pressman, 2012, "DNA Patent Licensing Under Two Policy Frameworks: Implications for Patient Access to Clinical Diagnostic Genomic Tests and Licensing Practice in the Not-For-Profit Sector," *Life Sciences Law & Industry Report* (March), https://www.uspto.gov/sites/default/files/aia_implementation/gene-comment-pressman.pdf.
[26] FY1996 AUTM Survey, pp 9–10, and FY 1997 AUTM Survey, p. 10.

timelines[27] show that many inventions are developed for years if not decades before a first sale, and require hundreds of millions, if not more, to shepherd from lab to bedside for commercial distribution.

Complementary cultures: Per the Science and Engineering (S&E) Indicators, and standard practice among those who study research, research has been divided into three types: Basic Research, Applied Research, and Experimental Development. Most research done at AUTM Survey respondents is categorized as Basic Research.[28] See Figure 1. The Universities are in the "Higher Ed" category,[29] and the Hospital and Research Institutes fall under "Other Nonprofit."[30]

Figure 1: Basic R&D Expenditures *By % by Performer*: Higher Ed, Other Nonprofit, Federal, and Business.

Source Appendix Tables 4-02 and 04-03 2018 S&E Indicators



Year	% Basic Fed /All Fed	%Basic Higher Ed/All Higher Ed	% Basic Other Nonprofit/ All Other Nonprofit	% Basic Bus/All Bus
1953	12%	45%	43%	4%
1998	25%	74%	51%	4%
2008	19%	75%	53%	4%
2015	19%	63%	53%	6%

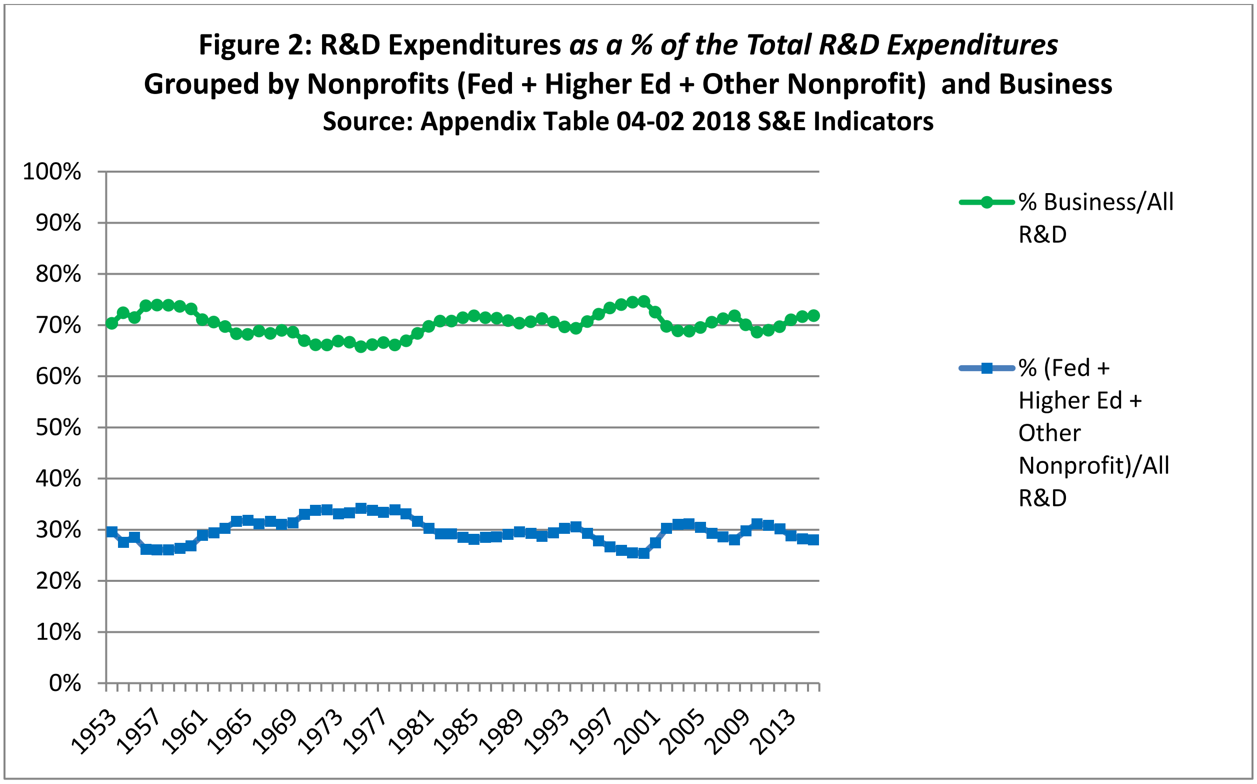
Figure 2 shows that about 70% of all U.S. R&D (composed of Basic Research, Applied Research and Experimental Development) is performed by businesses, and Figure 3 shows that 70% to 80% of Basic Research in the U.S. is performed by nonprofits.

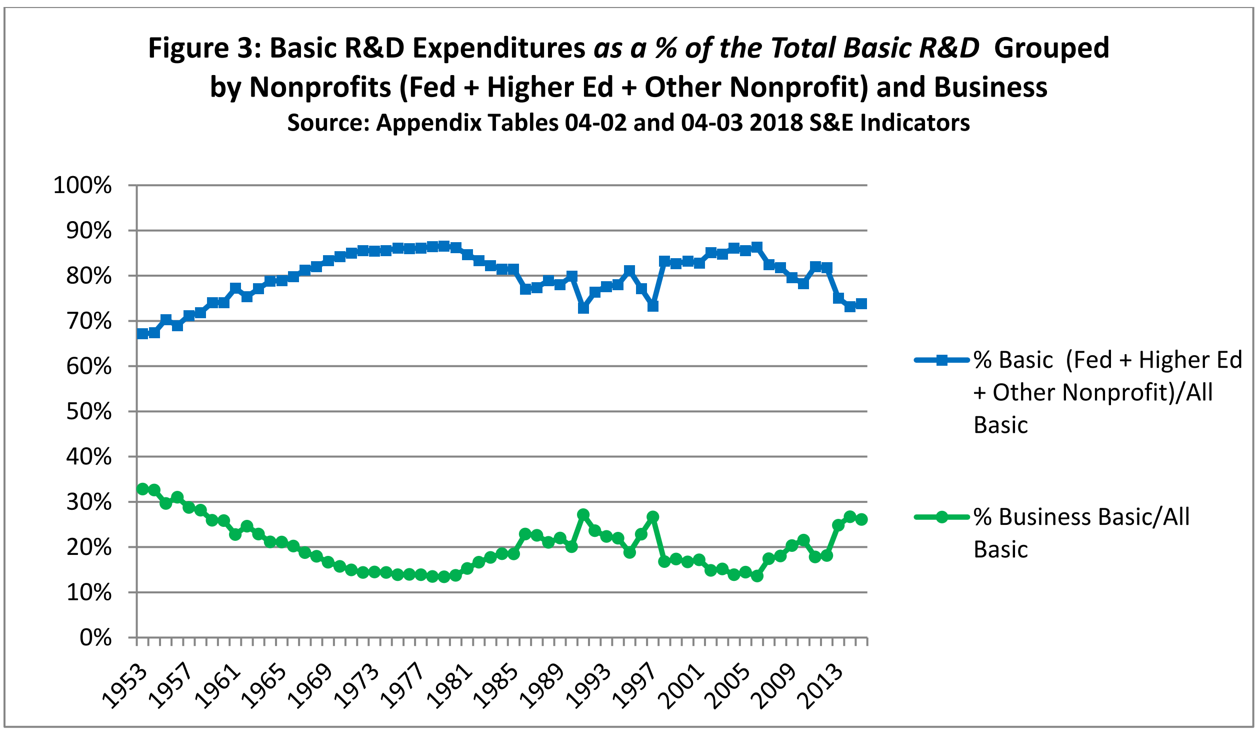
[27] Joseph A. DiMasi, Henry G. Grabowski, and Ronald W. Hansen, 2016, "Innovation in the Pharmaceutical Industry: New Estimates of R&D costs," *Journal of Health Economics* 47 (February 12): 20–33; Steven M. Paul, Daniel S. Mytelka, Christopher T. Dunwiddie, Charles C. Persinger, Bernard H. Munos, Stacy R. Lindborg, and Aaron L. Schacht, 2010, "How to Improve R&D Productivity: The Pharmaceutical Industry's Grand Challenge," *Nature Reviews Drug Discovery* 9 (March): 203–214.

[28] The S&E indicators provide definitions for "Basic Research," "Applied Research," and "Experimental Development," copied in the Glossary as a convenience. https://www.nsf.gov/statistics/2018/nsb20181/report/sections/overview/glossary.

[29] In this report, the terms "higher ed" and "academic" are used interchangeably as is done in the Science and Engineering Indicators 2008 (NSB-2018-1).

[30] The National Science Foundation has conducted a new survey of the nonprofit research activities that include hospital research institutes and other nonprofit foundations for FY2016. It will be forthcoming in fall 2019. The survey includes organizations that receive federal R&D funds including those familiar with the names of AUTM HRI Survey respondents, such as Massachusetts General, Mayo Clinic, Fred Hutchinson, Memorial Sloan Kettering, Brigham and Women's Hospital, Boston Children's Hospital, City of Hope Cleveland Clinic, and St. Jude Children's Research Hospital. It will only have total categories and will not single out R&D expenditures by individual institution.





These data suggest that maturation of early stage academic technology occurs outside of academia by commercial partners willing and able to continue the Applied Research and Experimental Development needed to bring products to market. Certain industries do proportionally more research relative to their revenue than others. The BEA identified, studied, and tracks such "research intensive" industries. See in particular Robbins and Moylan 2007,[31] which shows that about three-quarters of U.S. business research is done by an identifiable group of industries. Patterns of research expenditures by character of work and by performer, combined with

[31] Carol A. Robbins and Carol E. Moylan, 2007, "Research and Development Satellite Account Update: Estimates for 1959-2004, New Estimates for Industry, Regional, and International Accounts," *Survey of Current Business* 87 (October): 49–92.

long product development timelines, are the basis for assuming that the licensees of nonprofit inventions are predominantly in these research intensive industries.

The move to the more complex model, where some production is assumed to occur outside the United States, is more realistic in this era of globalization. The complex model also captures intermediate transactions leading to and associated with a final sale, which is more realistic for products that are part of multi-step value chains. As AUTM licensing managers know, they are often asked to take such value chains into account as they negotiate royalty bases. The question is not only what percent, but what percent of what. The last "what" may or may not be the last transaction price.

Brief Background on the National Input-Output Accounts

This section provides definitions and concepts underlying the I-O framework[32] to facilitate understanding the assumptions used when applying it to model the economic impact of nonprofit licensing. Several paragraphs and sentences, but not all paragraphs and sentences, in this section are taken verbatim from the above noted references. As always, the primary source is the preferred reference.

The terms "input" and "output," but not "cost" and "revenue," are apt, as the same economic transaction is "output" to one party, the seller, and "input" to the other, the buyer. When the buyer is the last buyer, they are the "final user" in I-O parlance. The sum of all purchases by "final users" is "final demand." When the buyer uses input to produce its own, or his or her own, output, then such input is called "intermediate input." Output multipliers can only be applied to final demand.

The word "commodity" in BEA explanatory material aligns with its use in economics as any marketable item, whether goods or services, that is the subject of a transaction. In contrast, the everyday meaning of "commodity" means goods that are supplied without differentiation such as salt or copper. Thus, it is useful to keep in mind the economic meaning, not the everyday meaning, of "commodity" while reading about I-O models.

The largest single source of U.S. I-O data is the Economic Census, which is conducted every five years by the U.S. Bureau of the Census. The models start with two basic tables: the "make" and "use" tables. A make table shows the value of each I-O commodity produced by each industry in a given year. Before such tables can be produced, classifications are needed for "commodities" and "industries."

For the I-O accounts, BEA uses a classification system that is based on the North American Industry Classification System (NAICS). The I-O classification system is consistent with that used by the principal agencies that provide the source data used in the I-O accounts and by the preparers of the national accounts and other economic series that are used for analysis in conjunction with the I-O accounts. In I-O accounting, each industry is associated with a commodity that is considered the primary product of that industry. The 20 major industry classes and their two-digit NAICS codes are found in supplementary Table S-4.

---

[32] See Mary L. Streitwieser, 2009, "BEA Briefing: A Primer on BEA's Industry Accounts," accessible at http://www.bea.gov/scb/pdf/2009/06%20June/0609_indyaccts_primer_a.pdf; and Karen J. Horowitz and Mark A. Planting, 2006, *Concepts and Methods of the Input-Output Accounts*, accessible at http://www.bea.gov/papers/pdf/IOmanual_092906.pdf. Chapter 12 discusses Input-Output modeling and applications.

The coefficients used in this report assume the AUTM licensors are in industry class 61, "educational services." The updated model places the AUTM Survey respondents' licensees' products in research intensive industries: For Universities, the research intensive industries and corresponding NAICS codes are chemical products (325), computer and electronic products (334), motor vehicles, bodies and trailers, and parts (3361MV), other transportation equipment (3364OT), publishing industries, except internet (includes software) (511), miscellaneous professional, scientific, and technical services (5412OP), and computer systems design and related services (5415). For Hospitals, the research intensive industries and corresponding NAICS codes are chemical products (325) and miscellaneous professional, scientific, and technical services (5412OP).

The use table shows the uses of commodities by industries as intermediate inputs and by final users. "Use of commodities by industries as intermediate inputs" is roughly analogous, for manufacturers, to cost of goods sold (COGS) in financial statements,[33] and the "use by final users" would be understood in everyday parlance as the sum of purchases by persons and by government, business investment, and exports less imports.[34] For the economy as a whole, the total of all final uses of commodities equals the sum of all value added by all industries, or GDP.

Table A from the BEA Primer is copied below to illustrate that some observations are consistent with intuition or at least not intuitively surprising. First, it supports the often-heard truism that "The U.S. is a service economy," as more of the GDP is characterized as "service" than as "manufacturing." That individuals directly consumed more services ($7.9 trillion) than manufactured goods ($1.7 trillion) in 2007 is another unsurprising observation. The single largest intermediate input to service industries was services (5,030,294 ÷ 6,373,425 = 79%) and the single largest intermediate input to manufacturing industries was manufactured commodities (1,609,532 ÷ 3,417,099 = 47%).

Table A. The Use of Commodities by Industries, 2007 (Millions of Dollars)

Commodities/industries	Agriculture, mining, and construction[1]	Manufacturing		Services[2]	Government[3]	**Total intermediate use**	Personal consumption expenditures	Private fixed investment	Change in private inventories[4]	Net trade	Government Consumption expenditures and gross investment[3]	Total final uses (GDP)	**Total commodity output**
		Total	Computer and electronic products										
Agriculture, mining, and construction[1]	154,402	595,776	944	248,419	89,143	**1,087,739**	59,605	1,011,206	11,099	–271,109	293,340	1,104,141	**2,191,880**
Manufacturing	415,614	1,609,532	105,397	929,547	317,079	**3,271,773**	1,681,597	689,338	34,532	–779,107	114,238	1,740,597	**5,012,370**
Computer and electronic products	4,401	108,822	66,881	79,778	26,520	**219,521**	73,990	186,349	2,938	–148,523	40,576	155,331	**374,852**
Services[2]	464,515	1,135,150	123,225	5,030,294	720,891	**7,350,850**	7,904,854	527,305	10,205	441,528	53,167	8,937,059	**16,287,909**
Government[3]	1,579	3,170	269	69,801	9,904	**84,454**	63,599	...	...	314	2,214,174	2,278,087	**2,362,541**
Total intermediate inputs[5]	**1,038,805**	**3,417,099**	**241,727**	**6,374,425**	**1,171,034**	**12,001,363**	...	...	...	...	...	...	...
Compensation of employees	549,340	969,412	139,114	4,823,282	1,477,338	**7,819,371**	...	...	...	...	...	...	...
Taxes on production and imports less subsidies	28,529	57,178	4,483	893,320	–15,874	**963,153**	...	...	...	...	...	...	...
Gross operating surplus	475,893	590,236	2,697	3,677,424	281,462	**5,025,015**	...	...	...	...	...	...	...
Total value added	**1,053,761**	**1,616,826**	**146,294**	**9,394,025**	**1,742,926**	...	...	...	...	...	...	**13,807,538**	...
Total industry output	**2,092,567**	**5,033,925**	**388,021**	**15,768,450**	**2,913,960**	...	**9,710,168**	**2,133,993**	**–3,642**	**–707,810**	**2,674,830**	...	**25,808,901**

1. Agriculture consists of agriculture, forestry, fishing, and hunting.
2. Consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.
3. Consists of federal, state, and local governments.
4. Includes inventory valuation adjustment.
5. Includes non-comparable imports; inventory valuation adjustment; rest-of-the-world; and scrap, used, and secondhand goods.

[33] The analogy fails for wholesalers and retailers in the I-O accounts, where "intermediate input" is equivalent to the cost of running the retail or wholesale operation excluding labor.

[34] The word "investment" is used in a manufacturing context, not a financial one, and refers to investment in new fixed assets or inventories, or for replacing depreciated fixed assets. It does not mean venture investment or stock purchases. Imports are used in the United States but produced abroad.

Note that “total value added” is a measure of the value of factors of production – in textbook economics, land, labor and capital. It is not the same as profit. It includes compensation of employees, taxes on production and imports minus subsidies, and gross operating surplus. This surplus can be used, in the case of industries, to build more capacity, to pay shareholders or owners, for income taxes, or for their own R&D. By definition, this study assumes that all AUTM Survey respondent license income contributes to GDP through its use to fund operating expenses. Within the national accounts, the output of nonprofits is treated as consumption and thus is part of GDP.

Four “requirements” tables are derived from the make and use tables. These are used to relate final demand to gross output. If final demand is known, for example, or there is a change in final demand, then the requirements tables can be used to show the inputs required by an industry to produce a given output. When only the direct requirements are considered (the inputs needed to produce the inputs are not included), the table is called a “direct requirement” table. When all inputs needed to make the inputs are considered, then the table is called the “total requirements table.” The total requirements table accounts for all interactions required by industries to support a given level of final demand. Note that output multipliers can be used only when final demand is known.

The total requirements table is used in conjunction with employment by industry and value added by industry to derive multipliers that related final demand sales to changes in economy-wide employment and value added (GDP). Additionally, estimates of commodity imports by industry can be combined with the use and make tables to derive a domestic total requirements table that relates final demand sales to domestic production, employment and value added.

In the I-O accounts, nonprofit output is all sold to final demand. Thus, even in the simple model, an output multiplier *is* applied to license income received by the licensors, since all of their output is consumed by final demand. In the simple model, all sales of licensees are assumed to be sold to other intermediate industries and it is therefore not appropriate to apply multipliers. In the updated and more complex model, the share of sales to final demand is based on industry specific patterns, and an output multiplier is applied to this share of sales.

Assumptions Used in the Models

Table B shows the three sets of assumptions used to estimate nonprofit contributions to GDP, gross output, and employment in this 10th anniversary report:

Table B: Summary of assumptions in the three estimates, and abbreviations used to describe them in this report:

<table>
<tr><th></th><th>Simple Model:
9 Industries, Selected from Manufacturing Industries 31-33 for Both Universities and Hospitals</th><th>Simple Model:
7 Research Intensive Industries for Universities, 2 Research Intensive Industries for Hospitals</th><th>Complex Model 7 Research Intensive Industries for Universities. 2 Research Intensive Industries for Hospitals</th></tr>
<tr><td>Shorthand Reference</td><td>A: Simple 9 (U+H)</td><td>B: Simple 7U, 2H</td><td>C: Complex 7U, 2H</td></tr>
<tr><td>Years of AUTM data</td><td>1996–2017</td><td>1996–2017</td><td>1996–2017</td></tr>
<tr><td>Base Year for Inflation Adjusted Dollars</td><td>2012</td><td>2012</td><td>2012</td></tr>
<tr><td>The Licensees' Production Occurs Entirely in the U.S.</td><td>Yes</td><td>Yes</td><td>Half of the licensees' sales are made by companies employing > 500 people. BEA data on the location of the production of U.S. multinational companies relative to all large U.S. companies are used to estimate the fraction made in the U.S., which changes year to year.</td></tr>
<tr><td>None of the Licensees' Sales Are Final Sales</td><td>Yes</td><td>Yes</td><td>BEA industry-specific patterns on the fraction of sales that are final sales are used.</td></tr>
<tr><td>All of the Intermediate Inputs to Production Are Domestic</td><td>Yes</td><td>Yes</td><td>Not all intermediate inputs are domestic. The domestic requirements tables are used.</td></tr>
<tr><td>Industries of the Licensees</td><td>The licensees are in a subgroup (chemical products [325], plastics and rubber [326], nonmetallic minerals [327], fabricated metals [332], machinery (333), computer and electronics [334], electrical equipment, appliances and components [335], other transportation equipment [3364OT], miscellaneous manufacturing and machinery [339]) of industry classes 31-33: "Manufacturing."</td><td colspan="2">The licensees are in a subset of research intensive industries as identified by Robbins and Moylan.

For Universities: chemical products (325), computer and electronic products (334), motor vehicles, bodies and trailers, and parts (3361MV), other transportation equipment (3364OT), publishing industries, except internet (includes software) (511), miscellaneous professional, scientific, and technical services (5412OP), computer systems design and related services (5415)

For Hospitals: chemical products (325), miscellaneous professional, scientific, and technical services (5412OP))</td></tr>
</table>

Simple model assumptions

General:

i) The AUTM licensors will be treated as though in industry class 61, educational services, and their licensees' production is in a defined set of industry classes listed in Table B. The simple model was run for the nine manufacturing industry classes in Column A of Table B, the set of industries used in prior I-O reports using AUTM data, and also for the research intensive industries in Column B, where seven were used to model the industries of the university licensors and a two industry subset of the seven were used to model the industries of the HRI licensors.

ii) The value-added ratio, the output multiplier, and the employment to output ratio are all applied to current dollars. GDP and gross output are then normalized to 2012 dollars.

iii) Sales of the licensees' products are estimated using the reported earned royalty income (ERI) on product sales divided by an assumed royalty rate.
iv) The relevant sales are captured by the royalty base.

For the GDP calculation:
i) 100% of AUTM licensors' expenditures contribute to GDP.
ii) 100% of licensees' sales are from goods and services produced domestically.

For the gross output calculation:
i) The license income received by AUTM licensors is all spent in the U.S., and is treated as final demand. The effect of this revenue on gross output is increased by one iteration of purchases of intermediate inputs, so-called direct requirements, plus the output required by all other industries to produce inputs for the licensors, the indirect requirements.
ii) 100% of licensees' sales are by domestic producers, and 100% of the intermediate inputs for this production are also domestic.
iii) Since the fraction of the licensees' sales that are final sales is unknown, no output multipliers are applied. Gross output is simply total licensees' sales.

Simple model schematic block diagram and equations
GDP:

A: A portion associated with the license income received by the licensors	+	B: A portion associated with licensed product sales by the licensees

A_{GDP} = (license income received in 2012 dollars) = (license income received)[35] / (price index for GDP, index numbers, 2012 = 1.00)[36]

B_{GDP} = ((modeled sales by licensees[37]) x (value-added ratio from U.S. I-O tables)) / (price index for GDP, index numbers, 2012 = 1.00)

Gross industry output:

A: A portion associated with the license income received by the licensors	+	B: A portion associated with licensed product sales by the licensees

A_{GO} is made up of two parts, and = $A1_{GO} + A2_{GO}$
$A1_{GO}$: the effect of the license income received by the licensors, and $A2_{GO}$: the effect outside the licensor when the licensor spends that income.

[35] Total license income received (as reported).
[36] The multipliers are applied to current dollar license income and current dollar modeled sales. The result is adjusted to 2012 U.S. dollars.
[37] ((Earned Royalty Income "ERI" in current dollars) ÷ (royalty rate))

$A1_{GO}$ = (license income received) / (price index for GDP, index numbers, 2012 = 1.00)
$A2_{GO}$ = ((license income received in current U.S. dollars) × (NAICS 61 output multiplier from U.S. I-O tables)[38]) / price index for GDP, index numbers, 2012 = 1.00)

B_{GO} = (modeled sales by licensees[39]) / (price index for GDP, index numbers, 2012 = 1.00)

Employment supported by final purchases associated with AUTM Survey respondent licensing:

A: A portion associated with the license income received by the licensors	+	B: A portion associated with licensed product sales by the licensees

A_{YES} = (employment multiplier for licensors) x (current license income received)

B_{YES} = (employment multiplier for selected industries) x (modeled sales by licensees)

Complex model assumptions:

General:

i) The AUTM licensors will be treated as though in industry class 61, educational services. The University licensed products are in seven research intensive industries, and the Hospital licensed products are in two research intensive industries. See Columns B and C in Table B.
ii) The value-added ratio, the output multiplier, and the employment to output ratio are all applied to current dollars. GDP and gross output are then normalized to 2012 dollars.
iii) Sales of the licensees' products are estimated using the reported earned royalty income (ERI) on product sales divided by an assumed royalty rate.
iv) The relevant sales are captured by the royalty base.

For the GDP calculation:

i) 100% of licensors' expenditures contribute to GDP.
ii) Half of the product sales that generate earned royalties are made by large companies. The fraction of large company products made domestically is inferred from BEA data on places of operations by industry for large companies. Other product sales that generate earned royalties are made by small companies, and 100% of these small company licensees' sales are modeled as being produced domestically. In practice, for the set of conditions described as "C," 82% of the production was estimated to occur domestically in 1996 and 75% in 2017 was modeled as being produced domestically.

For the gross output calculation:

i) The license income received by AUTM licensors is all part of U.S. output. To account for imports to industries supplying AUTM licensors, the domestic requirements multiplier is applied to license income to obtain the total output changes of all industries because of the spending of the AUTM licensors. The effect of this revenue on gross output of all industries after adjusting for imports is to increase the production of other industries.

[38] See Table S-5.
[39] ((Earned Royalty Income "ERI" in current dollars) ÷ (royalty rate))

ii) The domestic requirement tables are used to exclude the impact of imported intermediate inputs.
iii) The share of the licensees' sales to final demand is calculated from BEA documented patterns by industry, and varies somewhat each year based on the data from the annual input-output accounts. For the basket of research intensive industries it is approximately 50%.

Complex model schematic block diagram and equations

GDP:

A: A portion associated with the license income received by the licensors	+	B: A portion associated with licensed product sales by the licensees

A_{GDP} = (license income received in 2012 dollars) = (license income received)[40] / (price index for GDP, index numbers, 2012 = 1.00)[41]

B_{GDP} = ((modeled domestically produced sales by licensees[42]) x (value-added ratio from U.S. I-O tables)) / (price index for GDP, index numbers, 2012 = 1.00) + (an additional share of domestically produced sales attributable to final demand) x (domestic value added multiplier) / (price index for GDP, index numbers, 2012 = 1.00)

Gross industry output:

A: A portion associated with the license income received by the licensors	+	B: A portion associated with licensed product sales by the licensees

A_{GO} is made up of two parts, and = $A1_{GO}$ + $A2_{GO}$
$A1_{GO}$: the effect of the license income received by the AUTM licensors, and $A2_{GO}$: the effect outside the licensor when the licensor spends that income.

$A1_{GO}$ = (license income received) / (price index for GDP, index numbers, 2012 = 1.00)
$A2_{GO}$ = ((license income received) × (domestic NAICS 61 output multiplier from U.S. I-O tables)) / price index for GDP, index numbers, 2012 = 1.00)

B_{GO} = ((modeled domestically produced sales by licensees[43]) + (the additional share of domestically produced sales attributable to domestic final demand)) x (domestic output multiplier)

Employment supported by final purchases associated with AUTM Survey respondent licensing:

A: A portion associated with the license income received by AUTM licensors	+	B: A portion associated with licensed product sales by the licensees

[40] Total license income received (as reported).
[41] The multipliers are applied to current dollar license income and current dollar modeled sales. The result is adjusted to 2012 U.S. dollars.
[42] ((Earned royalty income as reported) ÷ (royalty rate)) x (an industry and year specific fraction, from .82 to .75)
[43] ((ERI as reported) ÷ (royalty rate)) x (an industry and year specific fraction, from .82 to .75)

A_{YES} = (domestic employment multiplier for the licensors) x (current license income received)

B_{YES} = ((modeled domestically produced sales by licensees) x (ratio of employment to output for research intensive industries))

+ ((the additional share of domestically produced sales attributable to final demand) x (domestic employment multiplier for research intensive industries))

Comments on data sources

Federal data definitions and collection

The definitions and demarcations of the industry accounts needed to calculate the estimates in this report started at least as early as 1941.[44] The U.S. data on research expenditures and performers began to be gathered in the early 1950s.

> "In 1953, NSF established the Survey of Federal Funds for Research and Development, which collects data on R&D obligations made by federal agencies. NSF also began to collect data on R&D performance in 1953 when it funded the first Survey of Industrial Research and Development. The Bureau of Labor Statistics (BLS) fielded the first Industrial R&D Survey for NSF; administration of the survey was later transferred to the U.S. Census Bureau."[45]

In 2004, the National Academies' Committee on National Statistics recommended the redesign of the Survey of Industrial Research and Development. After this review, the Census Bureau and the NSF collaborated to understand what type of data was now needed and the availability of data. They solicited input from data providers, including company executives, and from data users, including the BEA. As a result, the Census Bureau broke the new survey into four parts so that each part could be sent to the most appropriate responders in a company.

The result of this thorough effort was the replacement in 2010 of the Survey of Industrial Research and Development with the new Business R&D and Innovation Survey, "BRDS."[46] In 2015, over 40,000 companies received the BRDS survey; nearly 80% responded. BRDS data enabled the change in treatment of R&D in the national accounts, which increased the value-added ratios used to estimate GDP in this model.

AUTM data

AUTM's Statistics Access for Technology Transfer (STATT) database, a multi-institution, multiyear database, is available to subscribers. For the most part, the data are provided by named institution. There is an option to report confidentially which most respondents do not use. The remarks in this section use this visible-to-subscriber information and information easily findable by internet searching. The calculations were done using the available data as reported, with no attempt to fill in or adjust for missing data.

---

[44] Martin C. Kohli, "Leontief and the U.S. Bureau of Labor Statistics, 1941–54: Developing a Framework for Measurement," *History of Political Economy Annual Supplement to Volume 33* (2001): 190–212.

[45] *Measuring the Science and Engineering Enterprise: Priorities for the Division of Science Resources Studies*, 2000, National Academies Press, Washington, D.C.: 23.

[46] https://www.census.gov/brdshelp

The data fluctuate considerably, especially when disaggregated by University and HRI, and especially when considering the fraction of license income that is characterized as earned royalty income. See Supplementary Figures S-1 and S-2.

Missing data: While as many as 31 HRIs and as many as 167 Universities have responded in any one year, there are only 8 and 61, respectively, recurrent respondents between 1996 and 2017. The AUTM website reports that for fiscal year 2017, 312 research institutions were invited to participate in the 2017 U.S. Survey. AUTM received 193 completed surveys, for a response rate of 61.9 percent. Respondents included 167 Universities, 25 HRIs, and one third-party technology investment firm. When some frequent survey responders drop out from time to time, it is possible to infer[47] (to repeat, no changes to the data as received were made) the order of magnitude of missing license income or earned royalty income. Missing income is nine figures, that is, on the order of a hundred million to a few hundreds of millions of dollars in particular years.

Inconsistently categorized data: Most, roughly 95%, assuming a 2% royalty rate, of the impact of the model derives from the licensees' product sales as inferred from reported earned royalties, not from the more general category "license income." Thus, missing or mischaracterized data are potentially a significant source of inaccuracy.

In addition to lack of response by institutions in certain years, not all institutions respond to the earned royalty question in every year. This may be in part due to AUTM's decision to emphasize the "big six" data elements, which unfortunately do not include earned royalties on product sales. Electing not to characterize "license income"[48] by type of income results in zero being recorded in the earned royalty category. Royalty buyouts have also been inconsistently categorized. Sometimes they are reported as "Running Royalties" and sometimes default to "Other Income", as calculated by the Survey software by subtracting reported royalty income and cashed-in equity income from total reported license income. When they are reported as "Running Royalties", they account for some of the marked peaks in the data.

Legal settlements pursuant to patent enforcement litigation are characterized on an ad hoc basis. At least one high nine-figure example was reported as "other income." Litigation may weaken the case for causation — that the invention caused, at least in part, the product to be made and sold. It may also be considered evidence for demand of the innovative product.

<u>Inferences on royalty rates</u>

The AUTM Survey reported an average royalty rate of 1.7% in FY2011 and 1.8% in FY2012.[49] These rates were calculated by asking respondents to report the product sales their licensees provided in royalty reports to AUTM member licensors and the earned royalties AUTM members received:[50]

> "Further, these organizations said that 3,014 licensees reported $36.8 billion in sales, implying average sales of $12.2 million per license and paid $657.7 million in royalties, implying an average royalty rate of 1.8 percent. In contrast, FY2011 data indicated that 2,281 licensees achieved $36.9 billion in product

---

[47] Values can be inferred by looking at data from surrounding years, particularly if the institution is a long-term responder and its data on either side of the missing year or years are consistent. Sometimes the institution appears to have decided not to report when there was a high revenue event in that year. The missing number can often be seen by "Googling" the name of the institution and the year.

[48] AUTM asks survey respondents to put license income in three categories: the total, the portion that is earned royalties, and the portion that results from cashed-in equity. "Other income" is calculated by subtracting royalties and equity from the total.

[49] FY2012 AUTM Survey, page 40.

[50] These data apply to the subset of all AUTM Survey respondents, including patent management firms and Canadian respondents, not only U.S. Universities and U.S. Hospitals and Research Institutes that responded to the question on their licensees' net sales. In 2011, there were 9,113 licenses generating Running Royalties of $1.429 billion in current dollars. In 2012, there were 9,613 licenses generating Running Royalties of $1.961 billion in current dollars.

sales, implying average sales of $16.2 million per license, and paid $661.6 million in royalties, implying an average royalty rate of 1.7 percent."

Exhibit A of the 2018 NIST report shows the basis of inferring a weighted average royalty rate for 2009–14 NIH OTT license data of 1.37%, reasonably consistent with the AUTM results.

BioSciBD Advisors[51] posted information obtained from Securities and Exchange Commission filings, sometimes under Freedom of Information Act requests, on effective royalty rates by tiers of product sales volumes. There are data for 163 licenses where a research institution was the licensor from 1997 to 2006. Their analysis suggests that effective average royalty rate by sales volume for research institutions is 3% to 4%. There is no additional information on how the royalty base was calculated, or allowed offsets, such as combination product language, common in university license agreements.

The above noted average royalty rate numbers from AUTM and Exhibit A of the 2018 NIST report may be consistent with some apparently higher public numbers, such as those in the BioSciBD Advisors documents when combined with royalty offsets and debundling provisions often found in license agreements, examples of which can be found in template license agreements and in numerically, but not structurally, redacted SEC filings.[52, 53] Rates disclosed in SEC filings may be higher than those that are not disclosed in SEC filings since only information deemed material to an evaluation of the business is required to be disclosed.

It is not uncommon to see high rates in surveys of royalty rates, though surveys that do parse by nonprofit and for profit licensee show that the nonprofit licenses have lower rates. For these reasons, it was deemed reasonable to run this model on the economic impact of nonprofit licensing for a 2% and 5% hypothetical weighted average royalty rate, and to omit running the model for the 10% rate, as has been done in all prior publications using AUTM data.

Discussion of Assumptions Used in the I-O Estimates and Their Effects

Appendix A summarizes certain key assumptions and their effects. All implementations of an I-O approach depend on approximating the licensees' sales of licensed products by dividing reported earned royalty income by a royalty rate.

Not all licenses even contain earned royalty terms. The license exhibit Google filed with its S-1, for example, contains an equity provision for Stanford, but no apparent earned royalty. The MIT license to Akamai, per its S-1, similarly had an equity provision for MIT and no earned royalty. Some licenses contain royalties on tangible products, but not on services.[54] The obligation to report may terminate before licensed product sales do. These examples illustrate the limitation of a model that relies on product sales as imputed from reported earned royalties as the key input for estimating economic impact.

Even when royalty rates are public, royalty offsets and combination product language (discussed above in "Inferences on Royalty Rates") can, by reducing the royalty base, contribute to an effective royalty rate lower than the one stated in the license contract. Using the stated rate then would underestimate sales.

---

[51] https://bioscibd.com/effective-royalty-rates
[52] https://www.sec.gov/Archives/edgar/data/1110803/0001012870-00-001863.txt, accessed May 6, 2019.
[53] https://www.sec.gov/Archives/edgar/data/1424740/000095013508002207/b68098btexv10w1.htm, accessed May 6, 2019.
[54] http://www.sec.gov/Archives/edgar/data/1110803/0001012870-00-001863.txt, accessed July 10, 2018.

Intermittent and missing data also lead to underestimating product sales as discussed in the section "AUTM Data."

The multipliers (output, value added, employment) vary considerably across all categories of industries; the selection of a particular set of industries to use in the model can affect the resulting economic impacts. See, for example, Columns 1 and 2 in Table C (page 22), which illustrate that changing only the industries and staying with the simple model for illustrative purposes, the cumulative GDP and jobs figures increase.

Research intensive industries as a group tend to have higher value added ratios than the group of manufacturing industries used previously. They produce more value added per input. Because of the inclusion of research intensive service industries, 5412OP (miscellaneous professional, scientific, and technical services) and 5415 (computer systems design and related services), the employment to output ratios for the research intensive industries as a whole are slightly higher than for the prior model, which used nine manufacturing industries.

Thus, using incorrect industries, or weighting them incorrectly,[55] could cause either an over- or an under-estimate. Currently, as discussed earlier in the report, for reasons including the early stage of licensed inventions made in academia, selecting as the likely licensees a group of industries that represent the major producers of business R&D seems reasonable and appropriate.

The complex model uses a domestic production factor (see Table S-6). In this time of global production and supply chains, it seems unrealistic to assume 100% domestic production. Factors considered leading to this estimate pending more actual data are discussed below.

There are reasonably inferable patterns of production outside the U.S. (OUS) by NAICS code for firms with more than 500 employees. AUTM has data on the size of their licensees at the time the licenses or option agreements are signed, but not at the time products are sold.[56] A domestic production factor was derived for AUTM member licensees assuming half were large entities at the time the royalties were received. For AUTM, this hypothetical domestic production factor was .82 in 1996, .79 in 2006, and .75 in 2017, and essentially the same for the seven research intensive industries used to model the impact of university licensing and the two research intensive industries used to model HRI licensing. Note that using the percentage of large company licensees will understate the share of large company licensed product *sales* since average sales per firm are higher for large firms than small firms.

It has been suggested that an assumed product substitution rate should be used to reduce overall estimates. There is not sufficient information to estimate substitution, but to the extent that substitution maintains or increases U.S. domestic production, or use of U.S. intermediate inputs, then it is not a subtraction.

Since economies grow through renewal and replacement, to assure growth, renewal and replacement must exceed loss. Thus, the caveat on product substitution is written as assuming "no detrimental product substitution effects."

[55] The coefficients used in these estimates are simply weighted by each industry's contribution to GDP as a whole.

[56] Between 1996 and 2017, 60% to 70% were either small companies or start-ups. Starting in 2004, AUTM tracked licenses and options separately. Previously, they were counted together. Between 2004 and 2017, 16% to 21% of the licenses/options were options.

I-O Coefficients and Results

The AUTM license data and price index deflator are in Appendix B. Selected I-O coefficients are in supplementary Table S-5. The calculations were run for two assumed royalties, 2% and 5%, and for all three of the models shown in Table B. The results by year, for all three models, both royalty rates, for Universities and HRIs separately and then together, are in Appendices C-H. These calculations were done in part to illustrate the importance of assumptions to the overall results. The most current evolution of the model assumes that (i) the licensees are in research intensive industries, (ii) there is some nondomestic production of licensed products, (iii) some of the licensed products are final sales, and (iv) some of the intermediate inputs to those final sales are produced outside the U.S. The most current GDP, gross output, and jobs figures, those calculated using the most current model, have been **bolded** in Appendices C-H. They have also been **bolded** in Supplementary Tables S-7, S-8, and S-9.

Empirical information on (i) the licensees' industries and (ii) where the licensed products are made and their position in a value chain are needed for more accurate estimates. It is also important to have either systematic weighted average royalty rate information so earned royalty income can reliably be used to estimate sales, or actual cumulative product sales information. More complete license income and earned royalty data will also be helpful.

Using the updated, more complex, and most current I-O approach to estimating the economic impact of academic licensing, assuming no detrimental product substitution effects, and summing that impact over 22 years of available data for academic U.S. AUTM Survey respondents, the total contribution of these academic licensors to industry gross output ranges from $723 billion to $1.7 trillion, in 2012 U.S. dollars; and contributions to GDP range from $374 billion to $865 billion, in 2012 U.S. dollars. Estimates of the total number of person years of employment supported by these academic licensors' licensed-product sales range from 2.676 million to 5.883 million over the 22-year period. The high end of the range, in particular the $1.7 trillion contribution to gross output, $865 billion contribution to GDP, and providing support for 5.883 million jobs over the 22-year period, is based on an assumption of a 2% earned royalty rate on licensees' product sales. The low end of the range, in particular the $723 billion contribution to gross output, $374 billion contribution to GDP, and providing support for 2.676 million jobs over the 22-year period, is based on an assumption of a 5% earned royalty rate on licensees' product sales.

The 22-year cumulative data for the three models described in Table B using a 2% royalty rate are shown in Table C.

Table C: Cumulative 22-Year GDP, GO and jobs estimates for three implementations of the I-O model. All assume a 2% earned royalty rate, and all are in 2012 dollars.

	Simple Model: 9 Manufacturing Industries for both Universities and Hospitals	Simple Model: 7 Research intensive Industries for Universities, 2 Research intensive Industries for Hospitals	Complex Model: 7 Research intensive Industries for Universities, 2 Research Intensive Industries for Hospitals
Short reference to model	A: Simple 9 (U+H)	B: Simple 7U 2H	C: Complex 7U 2H
GDP 1996–2017 $2012 2% ERI	$699,019,000	$809,831,000	$865,058,000
GO 1996–2017 $2012 2% ERI	$1,576,362,000	$1,576,362,000	$1,698,823,000
Jobs 1996–2017 2% ERI	4,732,000	5,052,000	5,883,000

It is not surprising that the cumulative numbers for the same method used previously, the simple model with nine manufacturing industries, are higher than in the previous report[57] as there are two more years of data, and the figures are given now in 2012 dollars and thus depreciated, relative to 2009 dollars.

As discussed above, starting on page 20, in the section on assumptions and their effects, the research intensive industries have, as a whole, somewhat higher value added and employment to output multipliers, resulting in higher GDP and jobs estimates. Allowing some final sales, as is done in the most current and complex model, permits using output multipliers for the gross output calculation, which, as a whole, more than offsets the modeled reduction in domestic production. However, in 2016 and 2017, as can be seen in Appendices C-G, the complex model yields about the same results as the simpler one. This means that the additional indirect gross output and the additional value added from final demand sales is roughly offset by the decreasing domestic production factor in recent years.

To look at relative contributions to GDP growth, AUTM associated contributions to GDP, calculated using the I-O approach (red lines), are compared with (i) U.S. GDP as a whole (black line) and (ii) selected industries'[58] contributions to GDP in Figure 4 (blue lines). The data for Figure 4 are in Table S-7, all were done assuming a 2% royalty rate, and all were normalized to themselves in 1997.

[57]GDP: 1996–2015 $2009 2% ERI, $1.33T, GO: 1996–2015 $2009 2% ERI $591B. Jobs 1996–2015 2% ERI, 4.272 million.

[58] As defined by North American Industry Classification System (NAICS) codes.

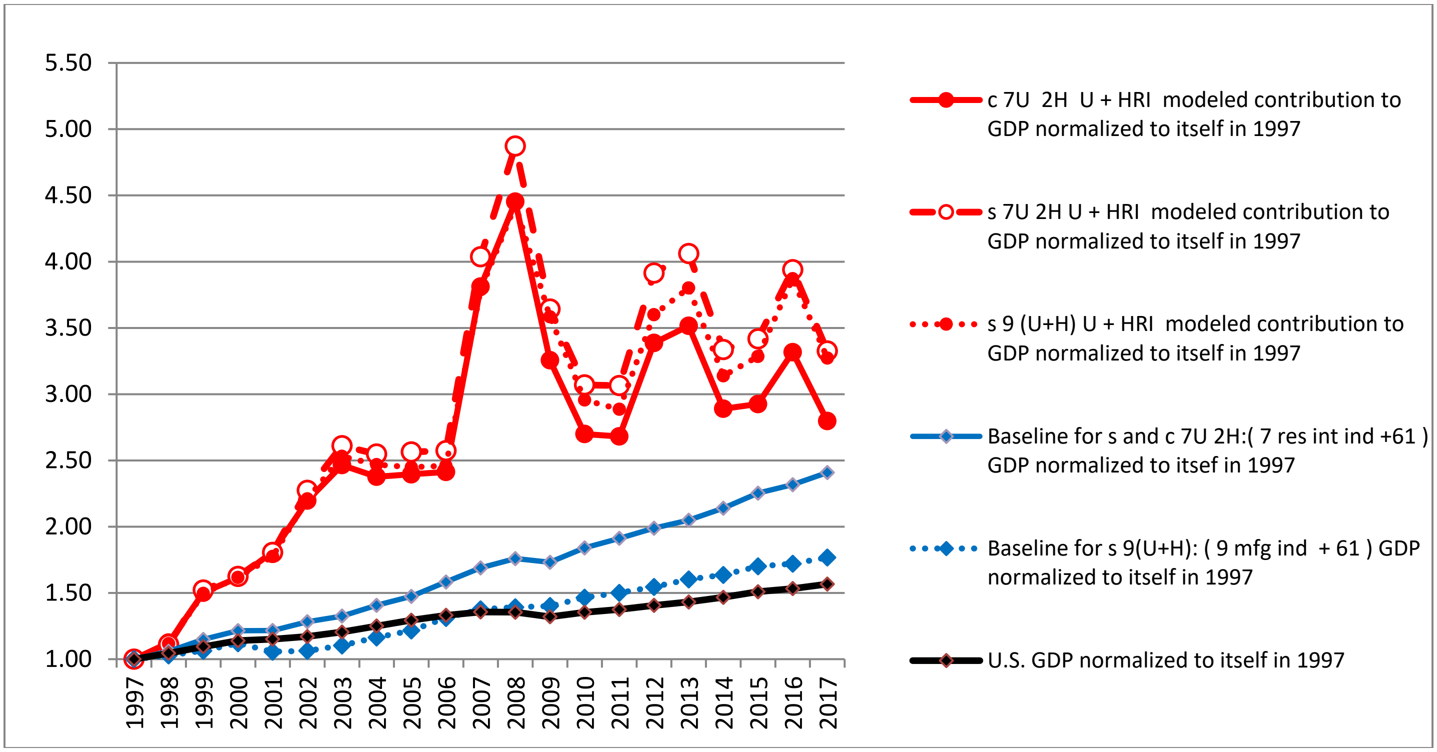


Figure 4. Selected GDP Trends, 1997–2017: Comparison of (i) U.S. GDP normalized to itself in 1997, (ii) (a) selected manufacturing industries + educational services (dotted), and (b) research intensive industries + educational services (solid) contribution to GDP, each normalized to themselves in 1997, and (iii) I-O model calculated AUTM Survey respondent contribution to U.S. GDP, simple manufacturing (dotted), simple research intensive (dashed, open circles), and complex research intensive (solid line, solid circles), all normalized to themselves in 1997. Data are in Supplementary Table S-7.

Under all three models (red lines, dotted, dashed, and solid), the modeled AUTM contribution to GDP as a whole appears to be growing faster than U.S. GDP as a whole (black line), and faster than the manufacturing industries used in prior reports (dotted blue line). However, when considering the research intensive industries (solid blue line), the modeled AUTM contribution to GDP appears to be growing, in relative terms, about as quickly as these research intensive industries.

The AUTM data fluctuate considerably, and the differential contribution to GDP growth will be sensitive to the time period in question. The fluctuations are particularly pronounced when University and HRI data are disaggregated. Supplementary Figures S-3 and S-4 illustrate, respectively, (i) the normalized, relative to itself, I-O modeled University contribution to GDP compared with the seven research intensive industry contribution to GDP, and (ii) the normalized, relative to itself, I-O modeled HRI contribution to GDP compared with the two research intensive industry contribution to GDP.

Discussion

Cumulative impact is considerable. More accurate estimates require more consistent and nuanced data on the actual industries of the licensed products and where they are made and for what use.

Depending on the language in the patent claims and the license, sales of products not made domestically can still contribute to the U.S. economy via license income to the licensor. A public example of this phenomenon is Carnegie Mellon University's $750 million settlement with Marvell Technology[59] for Marvell's importation of chips said to infringe the Kavcic and Moura Viterbi detector patents US6201839 and US6438180. Products made *and* sold or used outside the U.S. can also lead to payments to U.S. licensors when the licensors own foreign patents. There appear to be some AUTM Survey respondent related public royalty buyout examples of this phenomenon, where sales of OUS royalty streams are reported separately from U.S. royalty streams. For a macroeconomic view of international intellectual property transfers, see also "Measuring Payments for the Supply and Use of Intellectual Property."[60] Also of interest, the BEA tracks "Charges for the use of intellectual property" royalty payments as a category of service in international trade. See, for example, BEA International Trade Data Table 2.1, "U.S. Trade in Services, by Type of Service."[61]

Year to year, the AUTM data, and thus, the modeled impact fluctuate considerably. Scherer and Harhoff[62], in "Technology policy for a world of skew-distributed outcomes" explicitly describe the distribution of value of new technologies as being so skewed that the average will not smooth.

> "The outcome distributions are sufficiently skewed that, even with large numbers of projects, it is not possible to diversify away substantial residual variability through portfolio strategies."

This emphasizes the importance of multi-decade commitments to data collection and management, which then enable studies of trends in our innovation ecosystem. The overarching national account data infrastructure that makes this model possible dates at least to 1947 (United Nations 1947), more than 70 years ago. By comparison, academic technology transfer, and data about it, is a relatively new phenomenon. Additional insights may be found in due course by continued tracking of nonprofit licensing and research commercialization outcomes, including studying the data in iEdison.

Kelvin Droegemeier, director of the White House Office of Science and Technology Policy, has called for increased public-private partnerships on R&D.[63]

> "Yes, the federal government still has an important role, but the context is very different than it was 30 or 40 years ago," he explained. "Trillion-dollar companies are investing huge amounts of research dollars in autonomous vehicles and other new technologies. Foundations are investing millions in areas of great importance. And then the major research universities are putting a lot of skin in the game as well. …

[59] https://www.reuters.com/article/us-marvell-technlgy-carnegiemellon/marvell-technology-to-pay-carnegie-mellon-750-million-over-patents-idUSKCN0VQ2YE

[60] Carol A. Robbins, "Measuring Payments for the Supply and Use of Intellectual Property," in *International Trade in Services and Intangibles in the Era of Globalization,* edited by Marshall Reinsdorf and Matthew J. Slaughter (Chicago: University of Chicago Press), 139–171. https://www.nber.org/chapters/c11608.

[61] https://apps.bea.gov/iTable/iTable.cfm?reqid=62&step=9&isuri=1&6210=4

[62] F.M. Scherer and Dietmar Harhoff, 2000, "Technology Policy for a World of Skew-Distributed Outcomes," *Research Policy* 29: 559–566.

[63] See Jeffrey Mervis, "The First Interview with Trump's New Science Adviser," *Science*, Feb. 14, 2019, doi:10.1126/science.aax0186, https://www.sciencemag.org/news/2019/02/exclusive-first-interview-trump-s-new-science-adviser.

> “I think we need much greater connective tissue” among all of the players — government, industry, academia and philanthropy — that comprise the U.S. research establishment. “We need more efficiency, more interaction, more collaboration. No other country comes close to having what we have.”

The sales of licensed products, and the resulting economic impact, are examples of the benefits of such collaborations. Analyses of research impacts also may benefit from public-private collaborations.

By definition, royalties payable when a product reads on a patent claim end upon patent expiration. Thus, AUTM respondent Running Royalties are associated with newer or younger products or newer or younger parts of products than U.S. products as a whole. These data support the proposition that new products arising at academic institutions support growth greater than the growth of U.S. GDP as a whole, and on a par with the growth seen in research intensive industries overall.

Research intensive industries were identified a priori by their research expenditures, not by any other property. Recall that in I-O accounting, each industry is associated with a commodity that is considered the primary product of that industry. Research can be done on any product or service, creating perhaps additional opportunities for public-private partnerships, research synergies, and contributions to GDP from the production of the research intensive industries of tomorrow.

Appendix A: Complex Model Assumptions and Effects

Assumption	Effect of Assumption on Complex Model: + means causes an overestimate relative to the estimates in this report – means causes an underestimate relative to the estimate in this report	Potential Improvements
Relevant sales = (Earned Royalty Income) ÷ royalty rate	+ / – no way to predict, absent empirical information on weighted average royalty rates. – Since not all sales generate ERI, this assumption leads to an underestimate.	Acquire empirical data.
Missing data	– Underestimate.	Request missing data, especially when already public. Expand "big six." Explain result of omitting ERI.
Inconsistently reported data or mischaracterized data	+/– Underestimate or over estimate, depending on how mischaracterized.	Develop a consensus on how to handle royalty buyouts and legal settlements.
University products are in 7 research intensive industries: chemical products, (325), computer and electronic products (334), motor vehicles, bodies and trailers, and parts (3361MV), other transportation equipment (3364OT), publishing industries, except internet (includes software) (511), miscellaneous professional, scientific, and technical services, (5412OP), computer systems design and related services (5415). **Hospital products are in 2 research intensive industries:** chemical products (325), miscellaneous professional, scientific, and technical services (5412OP))	+/– If the selected industries are incorrect, this could result in either an over- or an underestimate. The selection of the industries also affects the differential GDP analysis. Selecting research intensive industries as the likely licensees increases the overall calculated impact, but reduces the apparent difference in GDP growth rate of the AUTM modeled contribution to GDP growth relative to the contribution of research intensive industries.	Acquire data on the actual industries.
The licensees' production of ERI generating commodities is modeled by industry and by assuming that half the royalty-generating products are sold by large companies, and then by using what is known about locations of production of large companies.	+/– If the selected industries are incorrect, or the fraction of sales by large companies is incorrect, this could result in either an over- or an underestimate.	Acquire data on the location manufacture of the licensed products. Data on the sizes of the companies actually selling and reporting the products could also be helpful, as would more accurate data on the actual industries.[64]
The fraction of sales that are final sales is modeled by industry.	+/– If the selected industries are incorrect, this could result in either an over- or an underestimate.	Acquire data on the actual industries.
The fraction of intermediate inputs to gross output that are made domestically is modeled by industry.	+/– If the selected industries are incorrect, this could result in either an over- or an underestimate.	Acquire data on the actual industries.
Substitution effects.	+ If a new product actually displaces a current product, unaccounted for substitution effects will result in an overestimate. If it maintains U.S. economy activity that would otherwise have been lost, then not a factor.	Case-by-case considerations
Impact ends when earned royalty payments end.	– Likely results in an underestimate of impact.	Studies of product lifetimes, relative to license duration.

[64] See text of report.

Appendix B: AUTM Data and BEA Deflator

Source of data	AUTM	AUTM	AUTM	AUTM	BEA
Year	Current Dollar University Total License Income	Current Dollar University Running Royalties	Current Dollar HRI Total License Income	Current Dollar HRI Running Royalties	Price index for GDP, 2012 = 100
1996	$365	$282	$135	$84	73.178
1997	$483	$315	$129	$81	74.446
1998	$614	$390	$113	$60	75.267
1999	$675	$475	$152	$139	76.346
2000	$1,100	$559	$132	$111	78.069
2001	$868	$637	$171	$131	79.822
2002	$998	$787	$259	$151	81.039
2003	$1,032	$829	$314	$249	82.567
2004	$1,088	$810	$346	$277	84.778
2005	$1,775	$856	$346	$278	87.407
2006	$1,512	$969	$653	$198	90.074
2007	$2,099	$1,807	$576	$125	92.498
2008	$2,397	$1,946	$1,037	$351	94.264
2009	$1,782	$1,351	$525	$257	94.999
2010	$1,790	$1,092	$587	$276	96.109
2011	$1,814	$1,097	$620	$333	98.112
2012	$1,955	$1,306	$638	$555	100
2013	$2,090	$1,426	$627	$554	101.773
2014	$2,223	$1,358	$460	$294	103.687
2015	$1,946	$1,371	$513	$288	104.757
2016	$2,117	$1,402	$784	$518	105.899
2017	$2,246	$1,052	$822	$592	107.932

Appendix C: Universities 1996–2017 GDP, Employment, and Gross Output 2% ERI, 3 Models

	Universities 9 mfg ind Contribution to GDP Simple Model 2% ERI	Universities 7 res int ind Contribution to GDP Simple Model 2% ERI	Universities 7 res int ind Contribution to GDP Complex Model 2% ERI	Universities 9 mfg ind Contribution to Person Yrs of Employment Simple Model 2 % ERI	Universities 7 res int ind Contribution to Person Yrs of Employment Simple Model 2 % ERI	Universities 7 res int ind Contribution to Person Yrs of Employment Complex Model 2 % ERI	Universities 9 mfg ind Contribution to Gross Output Simple Model 2 % ERI	Universities 7 res int ind Contribution to Gross Output Simple Model 2 % ERI	Universities 7 res int ind Contribution to Gross Output Complex Model 2 % ERI
	2012 Dollars	2012 Dollars	2012 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2012 Dollars	2012 Dollars	2012 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	Millions	Millions
1996	$8,595	$9,182	**$11,299**	71	68	**94**	$20,096	$20,096	**$24,174**
1997	$9,462	$10,171	**$12,443**	81	77	**106**	$22,205	$22,205	**$26,560**
1998	$11,527	$12,456	**$15,215**	101	96	**131**	$27,310	$27,310	**$32,465**
1999	$13,846	$15,027	**$18,194**	117	110	**151**	$32,577	$32,577	**$38,699**
2000	$16,169	$17,563	**$21,181**	136	132	**176**	$38,213	$38,213	**$45,100**
2001	$17,541	$19,187	**$23,400**	152	145	**196**	$41,726	$41,726	**$49,711**
2002	$22,015	$24,532	**$28,676**	178	170	**222**	$50,670	$50,670	**$58,486**
2003	$23,186	$25,880	**$29,673**	175	170	**218**	$52,310	$52,310	**$59,562**
2004	$21,940	$24,563	**$27,787**	161	158	**198**	$49,864	$49,864	**$56,224**
2005	$22,235	$25,446	**$28,665**	166	169	**207**	$52,336	$52,336	**$58,717**
2006	$24,012	$27,613	**$31,071**	170	179	**220**	$56,595	$56,595	**$63,575**
2007	$41,763	$49,352	**$55,223**	284	308	**376**	$101,594	$101,594	**$113,815**
2008	$44,152	$53,673	**$58,566**	301	334	**391**	$107,580	$107,580	**$118,798**
2009	$35,703	$39,931	**$42,591**	219	239	**277**	$74,100	$74,100	**$80,145**
2010	$28,008	$32,080	**$33,613**	165	182	**209**	$59,830	$59,830	**$63,725**
2011	$26,331	$30,893	**$32,173**	159	176	**202**	$58,979	$58,979	**$62,550**
2012	$30,224	$36,290	**$37,384**	183	206	**234**	$68,456	$68,456	**$72,069**
2013	$32,741	$38,589	**$39,691**	196	221	**251**	$73,446	$73,446	**$76,955**
2014	$30,758	$36,090	**$36,976**	187	208	**236**	$69,009	$69,009	**$72,050**
2015	$32,265	$37,060	**$37,475**	190	209	**236**	$68,428	$68,428	**$70,460**
2016	$33,684	$37,919	**$38,011**	197	215	**240**	$69,363	$69,363	**$70,774**
2017	$25,210	$28,288	**$28,432**	151	162	**181**	$52,109	$52,109	**$53,091**
Total	$551,368	$631,782	**$687,740**	3,743	3,934	**4,751**	$1,246,796	$1,246,796	**$1,367,704**

Appendix D: Universities 1996–2017 GDP, Employment, and Gross Output 5% ERI, 3 Models

	Universities 9 mfg ind Contribution to GDP Simple Model 5% ERI	Universities 7 res int ind Contribution to GDP Simple Model 5% ERI	Universities 7 res int ind Contribution to GDP **Complex Model** 5% ERI	Universities 9 mfg ind Contribution to Person Yrs of Employment Simple Model 5% ERI	Universities 7 res int ind Contribution to Person Yrs of Employment Simple Model 5% ERI	Universities 7 res int ind Contribution to Person Yrs of Employment **Complex Model** 5 % ERI	Universities 9 mfg ind Contribution to Gross Output Simple Model 5% ERI	Universities 7 res int ind Contribution to Gross Output Simple Model 5% ERI	Universities 7 res int ind Contribution to Gross Output **Complex Model** 5% ERI
	2012 Dollars	2012 Dollars	2012 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2012 Dollars	2012 Dollars	2012 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	millions	millions
1996	$3,737	$3,972	**$4,819**	33	31	**42**	$8,530	$8,530	**$10,132**
1997	$4,174	$4,457	**$5,366**	38	37	**48**	$9,522	$9,522	**$11,225**
1998	$5,100	$5,472	**$6,575**	48	46	**59**	$11,752	$11,752	**$13,742**
1999	$6,069	$6,541	**$7,809**	54	52	**68**	$13,911	$13,911	**$16,325**
2000	$7,313	$7,871	**$9,318**	66	65	**82**	$16,734	$16,734	**$19,359**
2001	$7,669	$8,327	**$10,013**	70	67	**87**	$17,802	$17,802	**$20,927**
2002	$9,545	$10,552	**$12,209**	81	78	**99**	$21,546	$21,546	**$24,580**
2003	$10,024	$11,102	**$12,619**	80	78	**97**	$22,179	$22,179	**$25,049**
2004	$9,546	$10,596	**$11,885**	74	73	**89**	$21,195	$21,195	**$23,705**
2005	$10,112	$11,397	**$12,685**	82	83	**98**	$22,958	$22,958	**$25,346**
2006	$10,612	$12,052	**$13,435**	81	84	**100**	$24,336	$24,336	**$26,996**
2007	$18,066	$21,102	**$23,450**	130	140	**167**	$42,989	$42,989	**$47,675**
2008	$19,187	$22,995	**$24,952**	138	151	**174**	$45,643	$45,643	**$49,973**
2009	$15,407	$17,098	**$18,162**	100	108	**123**	$31,429	$31,429	**$33,842**
2010	$12,321	$13,949	**$14,563**	78	85	**95**	$25,753	$25,753	**$27,173**
2011	$11,642	$13,467	**$13,979**	76	82	**93**	$25,437	$25,437	**$26,708**
2012	$13,263	$15,689	**$16,127**	86	95	**106**	$29,280	$29,280	**$30,629**
2013	$14,328	$16,668	**$17,108**	92	102	**114**	$31,397	$31,397	**$32,645**
2014	$13,590	$15,723	**$16,077**	89	97	**108**	$29,704	$29,704	**$30,791**
2015	$14,021	$15,939	**$16,105**	88	96	**106**	$29,171	$29,171	**$29,887**
2016	$14,673	$16,367	**$16,404**	92	99	**109**	$29,645	$29,645	**$30,137**
2017	$11,333	$12,564	**$12,622**	74	79	**86**	$22,857	$22,857	**$23,114**
Total	$241,732	$273,897	**$296,281**	1,752	1,828	**2,149**	$533,770	$533,770	**$579,959**

Appendix E: HRI 1996-2017 GDP, Employment, and Gross Output 2% ERI, 3 Models

	HRI 9 mfg ind Contribution to GDP Simple Model 2% ERI	HRI 2 res int ind Contribution to GDP Simple Model 2% ERI	HRI 2 res int ind Contribution to GDP Complex Model 2% ERI	HRI 9 mfg ind Contribution to Person Yrs of Employment Simple Model 2 % ERI	HRI 2 res int ind Contribution to Person Yrs of Employment Simple Model 2 % ERI	Hos Res Inst 2 res int ind Contribution to Person Yrs of Employment Complex Model 2 % ERI	HRI 9 mfg ind Contribution to Gross Output Simple Model 2 % ERI	HRI 2 res int ind Contribution to Gross Output Simple Model 2 % ERI	HRI 2 res int ind Contribution to Gross Output Complex Model 2 % ERI
	2012 Dollars	2012 Dollars	2012 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2012 Dollars	2012 Dollars	2012 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	millions	millions
1996	$2,587	$3,195	**$3,286**	22	23	**24**	$6,023	$6,023	**$6,212**
1997	$2,452	$3,050	**$3,125**	21	22	**23**	$5,750	$5,750	**$5,907**
1998	$1,783	$2,236	**$2,291**	16	17	**17**	$4,208	$4,208	**$4,307**
1999	$3,983	$5,094	**$5,186**	33	36	**37**	$9,414	$9,414	**$9,659**
2000	$3,093	$3,912	**$3,976**	25	28	**28**	$7,381	$7,381	**$7,596**
2001	$3,613	$4,690	**$4,766**	31	33	**34**	$8,602	$8,602	**$8,861**
2002	$4,307	$5,543	**$5,521**	35	37	**38**	$9,865	$9,865	**$9,948**
2003	$6,973	$8,637	**$8,703**	53	57	**57**	$15,730	$15,730	**$16,011**
2004	$7,472	$9,129	**$9,218**	55	59	**60**	$17,003	$17,003	**$17,322**
2005	$6,947	$8,453	**$8,626**	51	56	**57**	$16,534	$16,534	**$16,927**
2006	$5,293	$6,411	**$6,494**	40	44	**45**	$12,219	$12,219	**$12,418**
2007	$3,362	$4,031	**$4,113**	25	29	**29**	$7,850	$7,850	**$7,959**
2008	$8,603	$10,747	**$10,749**	62	71	**71**	$20,496	$20,496	**$20,668**
2009	$6,992	$8,224	**$8,100**	44	50	**50**	$14,417	$14,417	**$14,389**
2010	$7,215	$8,509	**$8,409**	43	50	**50**	$15,342	$15,342	**$15,339**
2011	$8,057	$9,627	**$9,566**	49	57	**58**	$18,005	$18,005	**$18,102**
2012	$12,658	$15,455	**$15,338**	76	89	**91**	$28,795	$28,795	**$29,039**
2013	$12,542	$15,102	**$15,040**	74	89	**91**	$28,244	$28,244	**$28,473**
2014	$6,632	$8,021	**$8,014**	40	48	**49**	$14,893	$14,893	**$15,063**
2015	$6,869	$8,129	**$8,069**	41	48	**49**	$14,518	$14,518	**$14,535**
2016	$12,438	$14,173	**$13,623**	73	84	**84**	$25,612	$25,612	**$24,730**
2017	$13,778	$15,683	**$15,108**	80	93	**92**	$28,666	$28,666	**$27,653**
Total	$147,651	$178,049	**$177,318**	989	1,118	**1,132**	$329,566	$329,566	**$331,119**

Appendix F: HRI 1996–2017 GDP, Employment, and Gross Output 5% ERI, 3 Models

	HRI 9 mfg ind Contribution to GDP Simple Model 5% ERI	HRI 2 res int ind Contribution to GDP Simple Model 5% ERI	HRI 2 res int ind Contribution to GDP Complex Model 5% ERI	HRI 9 mfg ind Contribution to Person Yrs of Employment Simple Model 5% ERI	HRI 2 res int ind Contribution to Person Yrs of Employment Simple Model 5 % ERI	HRI 2 res int ind Contribution to Person Yrs of Employment Complex Model 5% ERI	HRI 9 mfg ind Contribution to Gross Output Simple Model 5% ERI	HRI 2 res int ind Contribution to Gross Output Simple Model 5% ERI	HRI 2 res int ind Contribution to Gross Output Complex Model 5% ERI
Year	2012 Dollars Millions	2012 Dollars Millions	2012 Dollars Millions	Person Yrs of Employment Thousands	Person Yrs of Employment Thousands	Person Yrs of Employment Thousands	2012 Dollars Millions	2012 Dollars Millions	2012 Dollars Millions
1996	$1,145	$1,389	**$1,425**	10	11	**11**	$2,591	$2,591	**$2,656**
1997	$1,085	$1,324	**$1,354**	10	10	**11**	$2,471	$2,471	**$2,524**
1998	$803	$984	**$1,006**	8	8	**8**	$1,835	$1,835	**$1,861**
1999	$1,713	$2,157	**$2,193**	15	16	**16**	$3,963	$3,963	**$4,053**
2000	$1,339	$1,666	**$1,692**	12	13	**13**	$3,126	$3,126	**$3,197**
2001	$1,574	$2,004	**$2,035**	14	15	**15**	$3,660	$3,660	**$3,750**
2002	$1,914	$2,409	**$2,400**	17	18	**18**	$4,278	$4,278	**$4,287**
2003	$3,017	$3,683	**$3,709**	24	26	**26**	$6,674	$6,674	**$6,777**
2004	$3,234	$3,896	**$3,932**	25	27	**27**	$7,198	$7,198	**$7,315**
2005	$3,017	$3,619	**$3,688**	23	25	**26**	$7,008	$7,008	**$7,133**
2006	$2,552	$2,999	**$3,033**	21	23	**23**	$5,622	$5,622	**$5,644**
2007	$1,719	$1,986	**$2,019**	15	16	**16**	$3,786	$3,786	**$3,774**
2008	$4,101	$4,959	**$4,959**	33	36	**36**	$9,328	$9,328	**$9,329**
2009	$3,128	$3,621	**$3,571**	21	24	**24**	$6,293	$6,293	**$6,281**
2010	$3,252	$3,770	**$3,736**	21	24	**24**	$6,733	$6,733	**$6,699**
2011	$3,602	$4,230	**$4,220**	24	27	**27**	$7,833	$7,833	**$7,848**
2012	$5,446	$6,565	**$6,554**	35	40	**41**	$12,137	$12,137	**$12,276**
2013	$5,387	$6,411	**$6,433**	34	40	**40**	$11,904	$11,904	**$12,043**
2014	$2,919	$3,475	**$3,503**	19	22	**23**	$6,392	$6,392	**$6,496**
2015	$3,041	$3,545	**$3,551**	20	22	**23**	$6,281	$6,281	**$6,320**
2016	$5,419	$6,113	**$5,893**	34	39	**38**	$10,949	$10,949	**$10,569**
2017	$5,968	$6,730	**$6,500**	37	42	**42**	$12,203	$12,203	**$11,748**
Total	$65,376	$77,535	**$77,407**	471	522	**527**	$142,265	$142,265	**$142,579**

Appendix G: University + HRI 1996–2017 GDP, Employment, and Gross Output 2% ERI, 3 Models

	U + HRI 9 mfg ind Contribution to GDP, Simple Model 2% ERI	U + HRI 7, 2 res int ind Contribution to GDP Simple Model 2% ERI	U + HRI 7, 2 res int ind Contribution to GDP Complex Model 2% ERI	U + HRI 9 mfg ind Contribution to Person Yrs of Employment Simple Model 2 % ERI	U + HRI 7, 2 res int ind Contribution to Person Yrs of Employment Simple Model 2 % ERI	U + HRI 7, 2 res int ind Contribution to Person Yrs of Employment Complex Model 2 % ERI	U + HRI 9 mfg ind Contribution to Gross Output Simple Model 2 % ERI	U + HRI 7, 2 res int ind Contribution to Gross Output Simple Model 2 % ERI	U + HRI 7, 2 res int ind Contribution to Gross Output Complex Model 2 % ERI
	2012 Dollars	2012 Dollars	2012 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2012 Dollars	2012 Dollars	2012 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	Millions	Millions
1996	$11,182	$12,376	**$14,585**	93	91	**118**	$26,119	$26,119	**$30,386**
1997	$11,914	$13,220	**$15,568**	102	99	**129**	$27,955	$27,955	**$32,468**
1998	$13,311	$14,693	**$17,505**	117	113	**148**	$31,518	$31,518	**$36,772**
1999	$17,829	$20,120	**$23,380**	151	146	**187**	$41,992	$41,992	**$48,358**
2000	$19,262	$21,475	**$25,157**	162	160	**204**	$45,594	$45,594	**$52,696**
2001	$21,154	$23,876	**$28,166**	183	179	**230**	$50,328	$50,328	**$58,573**
2002	$26,322	$30,076	**$34,197**	213	207	**260**	$60,535	$60,535	**$68,434**
2003	$30,159	$34,517	**$38,376**	228	226	**276**	$68,040	$68,040	**$75,573**
2004	$29,412	$33,692	**$37,005**	216	217	**258**	$66,867	$66,867	**$73,546**
2005	$29,182	$33,898	**$37,292**	217	225	**264**	$68,870	$68,870	**$75,643**
2006	$29,305	$34,024	**$37,564**	210	223	**265**	$68,815	$68,815	**$75,993**
2007	$45,125	$53,382	**$59,336**	309	336	**405**	$109,445	$109,445	**$121,774**
2008	$52,755	$64,419	**$69,315**	363	404	**462**	$128,076	$128,076	**$139,467**
2009	$42,696	$48,154	**$50,692**	263	289	**326**	$88,517	$88,517	**$94,533**
2010	$35,224	$40,588	**$42,022**	208	232	**259**	$75,172	$75,172	**$79,064**
2011	$34,387	$40,520	**$41,739**	208	233	**260**	$76,983	$76,983	**$80,651**
2012	$42,882	$51,745	**$52,722**	259	295	**325**	$97,250	$97,250	**$101,108**
2013	$45,283	$53,691	**$54,732**	270	310	**342**	$101,690	$101,690	**$105,428**
2014	$37,391	$44,111	**$44,989**	227	256	**285**	$83,902	$83,902	**$87,113**
2015	$39,134	$45,189	**$45,544**	231	257	**285**	$82,945	$82,945	**$84,995**
2016	$46,122	$52,091	**$51,634**	270	299	**323**	$94,975	$94,975	**$95,503**
2017	$38,989	$43,971	**$43,540**	231	255	**273**	$80,774	$80,774	**$80,744**
Total	$699,019	$809,831	**$865,058**	4,732	5,052	**5,883**	$1,576,362	$1,576,362	**$1,698,823**

Appendix H: University + HRI 1996–2017 GDP, Employment, and Gross Output 5% ERI, 3 Models

	U + HRI 9 mfg ind Contribution to GDP, Simple Model 5% ERI	U + HRI 7, 2 res int ind Contribution to GDP Simple Model 5% ERI	U + HRI 7, 2 res int ind Contribution to GDP **Complex Model** 5% ERI	U + HRI 9 mfg ind Contribution to Person Yrs of Employment Simple Model 5% ERI	U + HRI 7, 2 res int ind Contribution to Person Yrs of Employment Simple Model 5 % ERI	U + HRI 7, 2 res int ind Contribution to Person Yrs of Employment **Complex Model** 5% ERI	U + HRI 9 mfg ind Contribution to Gross Output Simple Model 5 % ERI	U + HRI 7, 2 res int ind Contribution to Gross Output Simple Model 5% ERI	U + HRI 7, 2 res int ind Contribution to Gross Output **Complex Model** 5% ERI
	2012 Dollars	2012 Dollars	2012 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2012 Dollars	2012 Dollars	2012 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	Millions	millions
1996	$4,883	$5,361	**$6,244**	43	42	**53**	$11,122	$11,122	**$12,788**
1997	$5,259	$5,782	**$6,721**	48	47	**59**	$11,993	$11,993	**$13,749**
1998	$5,903	$6,456	**$7,581**	55	54	**68**	$13,588	$13,588	**$15,603**
1999	$7,782	$8,698	**$10,002**	70	68	**84**	$17,874	$17,874	**$20,378**
2000	$8,652	$9,537	**$11,010**	78	77	**94**	$19,860	$19,860	**$22,556**
2001	$9,243	$10,332	**$12,047**	84	82	**102**	$21,461	$21,461	**$24,677**
2002	$11,459	$12,961	**$14,609**	98	96	**116**	$25,823	$25,823	**$28,867**
2003	$13,041	$14,785	**$16,328**	104	103	**123**	$28,853	$28,853	**$31,825**
2004	$12,780	$14,492	**$15,817**	99	100	**116**	$28,394	$28,394	**$31,020**
2005	$13,129	$15,015	**$16,373**	105	109	**124**	$29,966	$29,966	**$32,479**
2006	$13,164	$15,052	**$16,468**	102	108	**124**	$29,958	$29,958	**$32,640**
2007	$19,785	$23,088	**$25,470**	145	156	**183**	$46,774	$46,774	**$51,448**
2008	$23,288	$27,953	**$29,912**	171	188	**210**	$54,971	$54,971	**$59,302**
2009	$18,535	$20,719	**$21,734**	122	132	**147**	$37,722	$37,722	**$40,123**
2010	$15,573	$17,719	**$18,299**	100	109	**119**	$32,486	$32,486	**$33,872**
2011	$15,244	$17,697	**$18,199**	99	109	**120**	$33,270	$33,270	**$34,555**
2012	$18,709	$22,254	**$22,680**	121	135	**147**	$41,417	$41,417	**$42,905**
2013	$19,715	$23,078	**$23,541**	126	142	**154**	$43,301	$43,301	**$44,688**
2014	$16,509	$19,198	**$19,580**	108	119	**131**	$36,096	$36,096	**$37,287**
2015	$17,062	$19,484	**$19,656**	108	118	**129**	$35,452	$35,452	**$36,208**
2016	$20,092	$22,480	**$22,297**	126	137	**147**	$40,594	$40,594	**$40,705**
2017	$17,301	$19,294	**$19,121**	111	121	**127**	$35,060	$35,060	**$34,862**
Total	$307,108	$351,433	**$373,688**	2,222	2,350	**2,676**	$676,035	$676,035	**$722,539**

Supplementary Tables and Figures

Table S-1: 10-Year Evolution of the Application of Input-Output Models to Nonprofit License Data
The deflator is for the U.S. economy as a whole and not industry specific.

→ a change relative to an earlier report

Source of Data	AUTM 2009 Report	AUTM 2012 Report	AUTM 2013 Res Policy Paper	AUTM 2015 Report	AUTM 2017 Report	**NIST 2018 Report**	AUTM 2019 report
Years	1996–2007	1996–2010	1996–2010	1996–2013	1996–2015	2008–15	1996–2017
Licensees of **both HRIs and** Universities	No →	**Yes**	No	Yes	Yes	NA: 11 Agencies[65]	Yes
Licensees' sales used in jobs est.	No →	**Yes**	No	Yes			
Updated BEA value added ratios	No	No	No →	**Yes**	Yes	Yes	Yes
Base year for inflation adj $	2005	2005	2005 →	**2009**	2009	2009 →	**2012**
The licensees' production of earned royalty bearing products occurs entirely in the U.S.	Yes	Yes	Yes	Yes	Yes →	i) Yes, **A** ii) No, **B** →	i) Yes, using the original 9 industries "**A**" ii) Yes, using the new mix of industries "**C**" iii) No, using the new mix of industries "**C**"
None of the licensees' sales are final sales.	Yes	Yes	Yes	Yes	Yes →	i) Yes, **A** ii) No, **B** →	i) Yes, using the original 9 industries "**A**" ii) Yes, using the new mix of industries "**C**" iii) No, using the new mix of industries "**C**"
All of the intermediate inputs to gross output are domestic.	Yes	Yes	Yes	Yes	Yes →	i) Yes, **A** ii) No, **B**: →	i) Yes, using the original 9 industries "**A**" ii) Yes, using the new mix of industries "**C**" iii) No, using the new mix of industries "**C**"
Industries	**A**[66]				→	**B**[67] →	**C**[68]

[65] USDA, DOC, DOD, DOE, HHS, DHS, DOI, DOT, VA, EPA, NASA

[66] **A: Products are in a subgroup of 9 industry classes within 31-33 "Manufacturing"**: chemical products (325), plastics and rubber (326), nonmetallic minerals (327), fabricated metals (332), machinery (333), computer and electronics (334), electrical equipment, appliances, and components (335), other transportation equipment (3364OT), miscellaneous manufacturing and machinery (339).

[67] **B: Products are in a subgroup of 9 industry classes within 31-33 "Manufacturing"**: chemical products (325), plastics and rubber (326), nonmetallic minerals (327), fabricated metals (332), machinery (333), computer and electronics (334), electrical equipment, appliances, and components (335), other transportation equipment (3364OT), miscellaneous manufacturing and machinery (339) of industry classes 31-33; **and in 3 other IT-related classes:** publishing industries, except internet (includes software) (511); data processing, internet publishing, and other information services (514); computer systems design and related services (5415).

[68] **C: University products are in 7 research intensive industries**: chemical products (325), computer and electronic products (334), motor vehicles, bodies and trailers, and parts (3361MV), other transportation equipment (3364OT), publishing industries, except internet (includes software) (511), miscellaneous professional, scientific, and technical services (5412OP), computer systems design and related services (5415). **Hospital products are in 2 research intensive industries:** chemical products (325), miscellaneous professional, scientific, and technical services (5412OP).

Table S-2: Industries Used in Various Implementations of the I-O Model to Nonprofit Licensing

	Industries	AUTM Reports: 2009, 2012, 2015, 2017, 2019 2013 Research Policy Paper Rev 1 of the 2018 report for NIST	Rev 2 of the 2018 report for NIST	This 2019 Report for AUTM: Universities 7 industries	This 2019 Report for AUTM: Hospitals and Research Institutes 2 industries
325	Chemical products	X	X	X	X
326	Plastic and rubber products	X	X		
327	Nonmetallic mineral products	X	X		
332	Fabricated metal products	X	X		
333	Machinery	X	X		
334	Computer and electronic products	X	X	X	
335	Electrical equipment, appliances, and components	X	X		
3361MV	Motor vehicles, bodies and trailers, and parts			X	
3364OT	Other transportation equipment	X	X	X	
339	Miscellaneous manufacturing	X	X		
511	Publishing industries, except internet (includes software)		X	X	
514	Information and data processing services		X		
5412OP	Miscellaneous professional, scientific, and technical services			X	X
5415	Computer systems design and related services		X	X	

Table S-3. Figures 4 and 5 from the FY 1996 AUTM Survey

Figure 4: Cumulative Active Licenses & Options Life Science v. Physical Sciencefor Institutions Providing Detailed Dat (Respondents that Provided Detailed Data, N= 151: U.S. Univs., N= l 13; Hosps. & Res. Insts., N=24; Canadian Insts., N=l2; Pat. Mng. Firms, N=2)

FY 1996	Total Cumulative Active Licenses & Options	Cumulative Active Licenses & Options: Life Science	% of Total	Cumulative Active Licenses & Options: Physical Science	% of Total
U.S. Universities	8,626	5,536	64%	3,090	36%
U.S. Hospitals & Research Institutes	1,331	1,223	92%	108	8%
Canadian Institutions	652	374	57%	278	43%
Patent Management Firms	292	208	71%	84	29%
All Respondents	10,901	7,341	67%	3,560	33%

Detailed information by field or discipline was provided for 78% ($463.0 million) of the gross license income received ($591.7 million) reported for all respondents. The remaining 22% of gross license income received was not classified according to these disciplines. Percentages of the total reflect the portions of gross license income received that are related to life science and physical science classifications, respectively. These data are shown in Figure 5.

Figure 5: Gross License Income Received Life Science v. Physical Science for Institutions Providing Detailed Data(Respondents that Provided Detailed Data, N=l56:U.S. Univs., N=l19; Hosps. & Res. Insts., N=24; Canadian Insts., N=l l; Pat Mng. Firms, N=2)

FY 1996	Total Gross License Income Received	Gross License Income Received: Life Science	% of Total	Gross License Income Received: Phvsical Science	% of Total
U.S. Universities	$242,057,513	$194,199,551	80%	$47,857,962	20%
U.S. Hospitals & Research Institutes	$131,741,920	$118,242,472	90%	$13,499,448	10%
Canadian Institutions	$9,589,867	$8,089,750	84%	$1,500,117	16%
Patent Management Firms	$79,643,112	$76,735,550	96%	$2,907,562	4%
All Respondents	$463,032,412	$397,267,323	86%	$65,765,089	14%

Canadian institutions report in Canadian dollars. These responses are then converted to U.S. dollars

Table S-4. Figures 4 and 5 cut and pasted from the FY1997 AUTM Survey

Figure 4: Cumulative Active Licenses and Options, Life Science vs. Physical Science, for Institutions Providing Detailed Data (Respondents that Provided Detailed Data, N = 155: U.S. Univs., N = 116; HRIs, N = 25; Canadian Insts., N = 13; Pat. Mng. Firms, N = 1)

FY1997	Total Cumulative Active Licenses and Options	Cumulative Active Licenses and Options: Life Science	Share of Total	Cumulative Active Licenses and Options: Physical Science	Share of Total
U.S. Universities	9,306	6,153	64%	3,153	34%
U.S. HRIs	1,630	1,550	95%	80	5%
Canadian Institutions	750	483	64%	267	36%
Patent Management Firms	217	163	75%	54	25%
All Respondents	11,903	8,349	70%	3,554	30%

Detailed information by field or discipline was provided for 72% ($502.1 million) of the gross license income received ($698.5 million) reported for all respondents. The remaining 28% of gross license income received was not classified according to these disciplines. Percentages of the total reflect the portions of gross license income received that are related to life science and physical science classifications, respectively. These data are shown in Figure 5.

Figure 5: Gross License Income Received, Life Science vs. Physical Science, for Institutions Providing Detailed Data (Respondents that Provided Detailed Data, N = 160: U.S. Univs., N = 122; HRIs, N = 25; Canadian Insts., N = 12; Pat Mng. Firms, N = 1)

FY1997	Total Gross License Income Received	Gross License Income Received: Life Science	Share of Total	Gross License Income Received: Physical Science	Share of Total
U.S. Universities	$293,179,801	$230,686,494	79%	$62,493,307	21%
U.S. HRIs	$124,578,601	$124,502,601	99.9%	$76,000	.1%
Canadian Institutions	$9,279,493	$7,629,518	82%	$1,649,975	18%
Patent Management Firms	$75,044,599	$73,844,599	98%	$1,200,000	2%
All Respondents	$502,082,494	$436,663,212	87%	$65,419,282	13%

Canadian institutions report in Canadian dollars. These responses are then converted to U.S. dollars.

Table S-4 The 20 Major Industry Classes and Their NAICS Codes

11	Agriculture, forestry, fishing, and hunting
21	Mining
22	Utilities
23	Construction
31–33	Manufacturing
42	Wholesale trade
44–45	Retail trade
48–49	Transportation and warehousing
51	Information
52	Finance and insurance
53	Real estate and rental and leasing
54	Professional, scientific, and technical services
55	Management of companies and enterprises
56	Administrative and waste management services
61	Educational services
62	Health care and social assistance
71	Arts, entertainment, and recreation
72	Accommodation and food services
81	Other services (except public administration)
92	Government

Table S-5 I-O Coefficients and Ratios for Selected Groups of Industries

Source of data	BEA I-O Tables	BEA I-O Tables	BEA I-O Tables	BEA I-O Tables	BEA I-O Tables	BEA I-O Tables	BEA I-O Tables	BEA I-O Tables
Year	Value added ratio for **9 mfg. industries**[69]	Value added ratio for **7 research intensive industries**	Value added ratio for **2 research intensive industries**	Output multiplier for Total Lic Inc **educational services,** 1 ind [70]	Employment to output ratio for **educational services**, 1 ind [71]	Employment to output ratio for **9 mfg. industries**	Employment to output ratio for **7 research intensive industries**	Employment to output ratio for **2 research intensive industries**
1996	0.42	0.45	0.53	0.64	0.019	0.0046	0.0043	0.0048
1997	0.42	0.45	0.53	0.64	0.019	0.0046	0.0043	0.0048
1998	0.41	0.45	0.53	0.69	0.019	0.0046	0.0043	0.0048
1999	0.42	0.45	0.54	0.66	0.019	0.0044	0.0041	0.0048
2000	0.41	0.45	0.53	0.71	0.018	0.0042	0.0040	0.0046
2001	0.41	0.45	0.54	0.70	0.017	0.0043	0.0041	0.0046
2002	0.43	0.48	0.56	0.73	0.017	0.0041	0.0039	0.0044
2003	0.44	0.49	0.55	0.67	0.016	0.0038	0.0037	0.0042
2004	0.43	0.49	0.53	0.62	0.015	0.0036	0.0035	0.0039
2005	0.41	0.48	0.51	0.66	0.015	0.0033	0.0033	0.0037
2006	0.42	0.48	0.52	0.69	0.014	0.0031	0.0033	0.0035
2007	0.40	0.48	0.50	0.73	0.013	0.0028	0.0031	0.0033
2008	0.40	0.50	0.52	0.71	0.013	0.0028	0.0031	0.0033
2009	0.48	0.54	0.57	0.59	0.012	0.0029	0.0032	0.0034
2010	0.46	0.53	0.55	0.63	0.011	0.0027	0.0030	0.0031
2011	0.44	0.52	0.53	0.66	0.011	0.0025	0.0028	0.0030
2012	0.43	0.53	0.53	0.62	0.011	0.0025	0.0028	0.0030
2013	0.44	0.52	0.53	0.64	0.011	0.0024	0.0028	0.0030
2014	0.44	0.52	0.53	0.63	0.011	0.0024	0.0027	0.0029
2015	0.46	0.54	0.56	0.61	0.010	0.0025	0.0028	0.0030
2016	0.48	0.54	0.55	0.58	0.010	0.0025	0.0027	0.0029
2017	0.47	0.54	0.54	0.61	0.010	0.0024	0.0026	0.0028

[69] This applies to the licensees' sales only. 100% of license income received by the academic licensors contributes to GDP.

[70] This is applied to the license income received by the academic licensors only, and is effectively (1+.64, etc.). It was deemed reasonable to look at one level of intermediate inputs since all of nonprofit expenses by definition are consumed by persons and thus are final demand. There is no output multiplier applied to the licensees' sales in the simple model. Gross output = 1 x (licensees' sales).

[71] The number of employees required in all industries to meet the academic institutions' level of final demand.

Table S-6: Domestic Production Factor

Source of Data	Modeled from BEA Based on 7 and 2 Selected Industries
Year	Modeled Domestic Production Factor [72]
1996	**0.82**
1997	**0.82**
1998	**0.81**
1999	**0.81**
2000	**0.81**
2001	**0.80**
2002	**0.80**
2003	**0.80**
2004	**0.79**
2005	**0.79**
2006	**0.79**
2007	**0.78**
2008	**0.78**
2009	**0.78**
2010	**0.77**
2011	**0.77**
2012	**0.76**
2013	**0.76**
2014	**0.75**
2015	**0.75**
2016	**0.75**
2017	**0.75**

[72] For research intensive industries. (There was little difference between the domestic production factor for the 7 industries versus the 2 industries, so for simplicity the same domestic production factor is used.)

Table S-7: Data for Figure 4

Year	BEA U.S. GDP real gross domestic product, billions of chained 2012 dollars	U.S. GDP normalized itself in 1997	For s 9 GDP in 2012 $M selected manufacturing industries 327+ 332+333+ 334 + 335 + 3364OT + 339 + 325 + 326 + 61	9 ind + 61 GDP baseline normalized itself in 1997	For s 7U 2H and c 7U and 2H GDP in 2012 $M 2*325 +334 + 3364OT 3361 MV+ 511 + 5415 + 2* 5412OP +61	s and c 7U 2H +61 Industry-specific baseline GDP normalized to itself in 1997	s 9 U + HRI modeled contribution to GDP, 2% royalty rate, n millions of 2012 dollars	s 9 U + HRI modeled contribution to GDP normalized to itself in 1997	s 7U 2H U + HRI contribution to GDP, 2% royalty rate, in millions of 2012 dollars	s 7U 2H U + HRI modeled contribution to GDP normalized to itself in 1997	c 7U 2H U + HRI modeled contribution to GDP, 2% royalty rate in millions of 2012 dollars	c 7U 2H U + HRI modeled contribution to GDP normalized to itself in 1997
1996							$11,182		$12,376		**$14,585**	
1997	$11,522	1.00	$917,086	1.00	$1,606,842	1.00	$11,914	1.00	$13,220	1.00	**$15,568**	1.00
1998	$12,038	1.04	$943,399	1.03	$1,702,247	1.06	$13,311	1.12	$14,693	1.11	**$17,505**	1.12
1999	$12,611	1.09	$975,307	1.06	$1,846,713	1.15	$17,829	1.50	$20,120	1.52	**$23,380**	1.50
2000	$13,131	1.14	$1,027,08	1.12	$1,952,280	1.21	$19,262	1.62	$21,475	1.62	**$25,157**	1.62
2001	$13,262	1.15	$968,776	1.06	$1,954,856	1.22	$21,154	1.78	$23,876	1.81	**$28,166**	1.81
2002	$13,493	1.17	$974,828	1.06	$2,061,062	1.28	$26,322	2.21	$30,076	2.27	**$34,197**	2.20
2003	$13,879	1.20	$1,011,83	1.10	$2,129,301	1.33	$30,159	2.53	$34,517	2.61	**$38,376**	2.47
2004	$14,406	1.25	$1,067,19	1.16	$2,260,073	1.41	$29,412	2.47	$33,692	2.55	**$37,005**	2.38
2005	$14,913	1.29	$1,115,43	1.22	$2,368,693	1.47	$29,182	2.45	$33,898	2.56	**$37,292**	2.40
2006	$15,338	1.33	$1,202,20	1.31	$2,543,300	1.58	$29,305	2.46	$34,024	2.57	**$37,564**	2.41
2007	$15,626	1.36	$1,262,09	1.38	$2,714,016	1.69	$45,125	3.79	$53,382	4.04	**$59,336**	3.81
2008	$15,605	1.35	$1,276,34	1.39	$2,826,284	1.76	$52,755	4.43	$64,419	4.87	**$69,315**	4.45
2009	$15,209	1.32	$1,284,99	1.40	$2,781,603	1.73	$42,696	3.58	$48,154	3.64	**$50,692**	3.26
2010	$15,599	1.35	$1,342,89	1.46	$2,956,190	1.84	$35,224	2.96	$40,588	3.07	**$42,022**	2.70
2011	$15,841	1.37	$1,376,52	1.50	$3,071,709	1.91	$34,387	2.89	$40,520	3.06	**$41,739**	2.68
2012	$16,197	1.41	$1,417,49	1.55	$3,195,581	1.99	$42,882	3.60	$51,745	3.91	**$52,722**	3.39
2013	$16,495	1.43	$1,469,16	1.60	$3,292,591	2.05	$45,283	3.80	$53,691	4.06	**$54,732**	3.52
2014	$16,900	1.47	$1,500,52	1.64	$3,437,764	2.14	$37,391	3.14	$44,111	3.34	**$44,989**	2.89
2015	$17,387	1.51	$1,559,37	1.70	$3,620,665	2.25	$39,134	3.28	$45,189	3.42	**$45,544**	2.93
2016	$17,659	1.53	$1,577,59	1.72	$3,722,743	2.32	$46,122	3.87	$52,091	3.94	**$51,634**	3.32
2017	$18,051	1.57	$1,620,79	1.77	$3,869,769	2.41	$38,989	3.27	$43,971	3.33	**$43,540**	2.80

Table S-8: Data for Figure S-3

Year	BEA U.S. GDP real gross domestic product, billions of chained 2012 dollars	U.S. GDP normalized to itself in 1997	Seven research intensive industries: GDP in 2012 $M : 325 +334 + 3364OT + 3361 MV+ 511 + 5415 + 5412OP +61	Seven research intensive industries + 61 baseline GDP : normalized to itself in1997	University only simple model, contribution to GDP , 2% royalty rate, in millions of 2012 dollars s 7	University simple model seven industry U.S. GDP normalized to itself in 1997	University only contribution to GDP 2% royalty rate, in millions of 2012 dollars c 7	University complex model 7 industries U.S. GDP normalized to itself in 1997
1996					$9,182		**$11,299**	
1997	$11,522	1.00	$1,113,227	1.00	$10,171	1.00	**$12,443**	1.00
1998	$12,038	1.04	$1,180,920	1.06	$12,456	1.22	**$15,215**	1.22
1999	$12,611	1.09	$1,285,788	1.16	$15,027	1.48	**$18,194**	1.46
2000	$13,131	1.14	$1,355,758	1.22	$17,563	1.73	**$21,181**	1.70
2001	$13,262	1.15	$1,333,104	1.20	$19,187	1.89	**$23,400**	1.88
2002	$13,493	1.17	$1,397,891	1.26	$24,532	2.41	**$28,676**	2.30
2003	$13,879	1.20	$1,458,314	1.31	$25,880	2.54	**$29,673**	2.38
2004	$14,406	1.25	$1,544,580	1.39	$24,563	2.42	**$27,787**	2.23
2005	$14,913	1.29	$1,623,251	1.46	$25,446	2.50	**$28,665**	2.30
2006	$15,338	1.33	$1,725,924	1.55	$27,613	2.71	**$31,071**	2.50
2007	$15,626	1.36	$1,845,879	1.66	$49,352	4.85	**$55,223**	4.44
2008	$15,605	1.35	$1,900,694	1.71	$53,673	5.28	**$58,566**	4.71
2009	$15,209	1.32	$1,863,123	1.67	$39,931	3.93	**$42,591**	3.42
2010	$15,599	1.35	$1,996,877	1.79	$32,080	3.15	**$33,613**	2.70
2011	$15,841	1.37	$2,082,496	1.87	$30,893	3.04	**$32,173**	2.59
2012	$16,197	1.41	$2,172,656	1.95	$36,290	3.57	**$37,384**	3.00
2013	$16,495	1.43	$2,237,514	2.01	$38,589	3.79	**$39,691**	3.19
2014	$16,900	1.47	$2,332,956	2.10	$36,090	3.55	**$36,976**	2.97
2015	$17,387	1.51	$2,462,329	2.21	$37,060	3.64	**$37,475**	3.01
2016	$17,659	1.53	$2,542,614	2.28	$37,919	3.73	**$38,011**	3.05
2017	$18,051	1.57	$2,646,671	2.38	$28,288	2.78	**$28,432**	2.28

Table S-9: Data for Figure S-4

Year	BEA U.S. GDP real gross domestic product, billions of chained 2012 dollars	U.S. GDP normalized to itself in 1997	Two research intensive industries baseline GDP in 2012 $M 325 + 5412OP +61	Two research intensive industry baseline +61 GDP in 2012 $M normalized to itself in 1997	HRI only contributi on to GDP 2% royalty rate in millions of 2012 dollars s 2	HRI simple Model 2 industries U.S. GDP normalized to itself in 1997	HRI only contribution to GDP 2% royalty rate in millions of 2012 dollars c 2	HRI complex model 2 industries U.S. GDP normalized to itself in 1997
1996					$3,195		**$3,286**	
1997	$11,522	1.00	$570,693	1.00	$3,050	1.00	**$3,125**	1.00
1998	$12,038	1.04	$601,270	1.05	$2,236	0.73	**$2,291**	0.73
1999	$12,611	1.09	$648,594	1.14	$5,094	1.67	**$5,186**	1.66
2000	$13,131	1.14	$691,757	1.21	$3,912	1.28	**$3,976**	1.27
2001	$13,262	1.15	$723,457	1.27	$4,690	1.54	**$4,766**	1.53
2002	$13,493	1.17	$769,662	1.35	$5,543	1.82	**$5,521**	1.77
2003	$13,879	1.20	$787,762	1.38	$8,637	2.83	**$8,703**	2.79
2004	$14,406	1.25	$844,566	1.48	$9,129	2.99	**$9,218**	2.95
2005	$14,913	1.29	$878,670	1.54	$8,453	2.77	**$8,626**	2.76
2006	$15,338	1.33	$960,299	1.68	$6,411	2.10	**$6,494**	2.08
2007	$15,626	1.36	$1,019,665	1.79	$4,031	1.32	**$4,113**	1.32
2008	$15,605	1.35	$1,093,373	1.92	$10,747	3.52	**$10,749**	3.44
2009	$15,209	1.32	$1,106,811	1.94	$8,224	2.70	**$8,100**	2.59
2010	$15,599	1.35	$1,158,184	2.03	$8,509	2.79	**$8,409**	2.69
2011	$15,841	1.37	$1,195,261	2.09	$9,627	3.16	**$9,566**	3.06
2012	$16,197	1.41	$1,236,808	2.17	$15,455	5.07	**$15,338**	4.91
2013	$16,495	1.43	$1,272,539	2.23	$15,102	4.95	**$15,040**	4.81
2014	$16,900	1.47	$1,330,998	2.33	$8,021	2.63	**$8,014**	2.56
2015	$17,387	1.51	$1,392,789	2.44	$8,129	2.67	**$8,069**	2.58
2016	$17,659	1.53	$1,424,185	2.50	$14,173	4.65	**$13,623**	4.36
2017	$18,051	1.57	$1,468,654	2.57	$15,683	5.14	**$15,108**	4.83

Figure S-1: Data from AUTM STATT and Appendix B of the Report

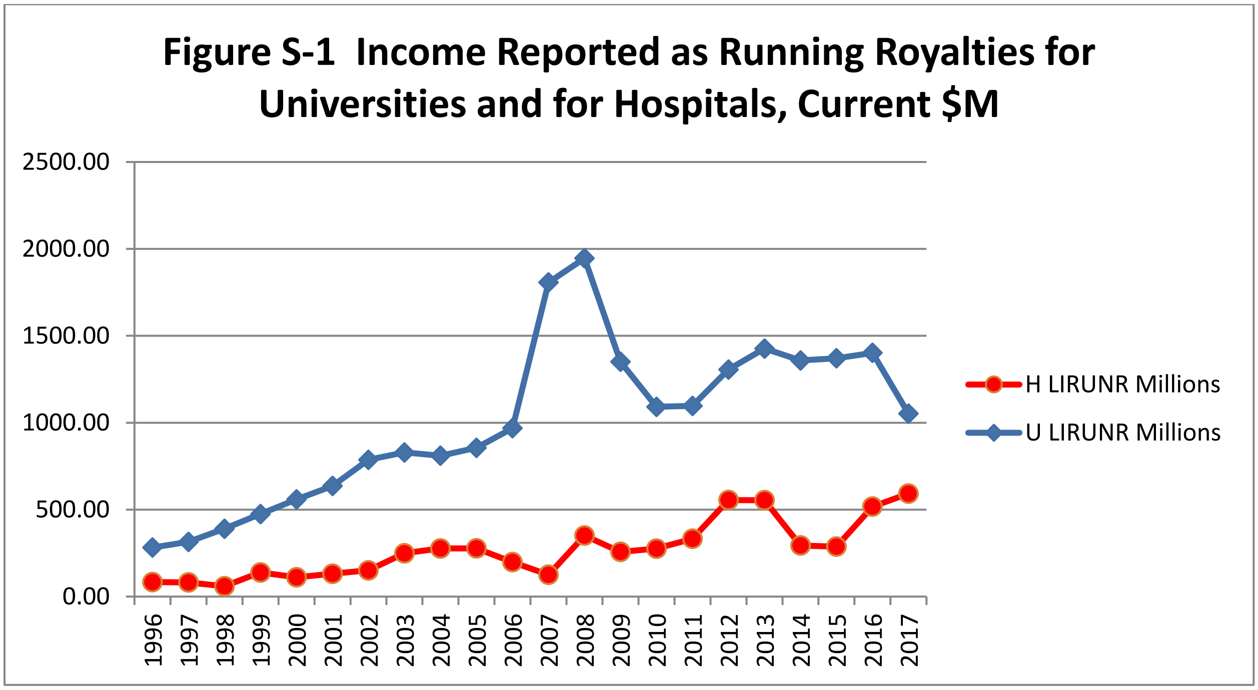
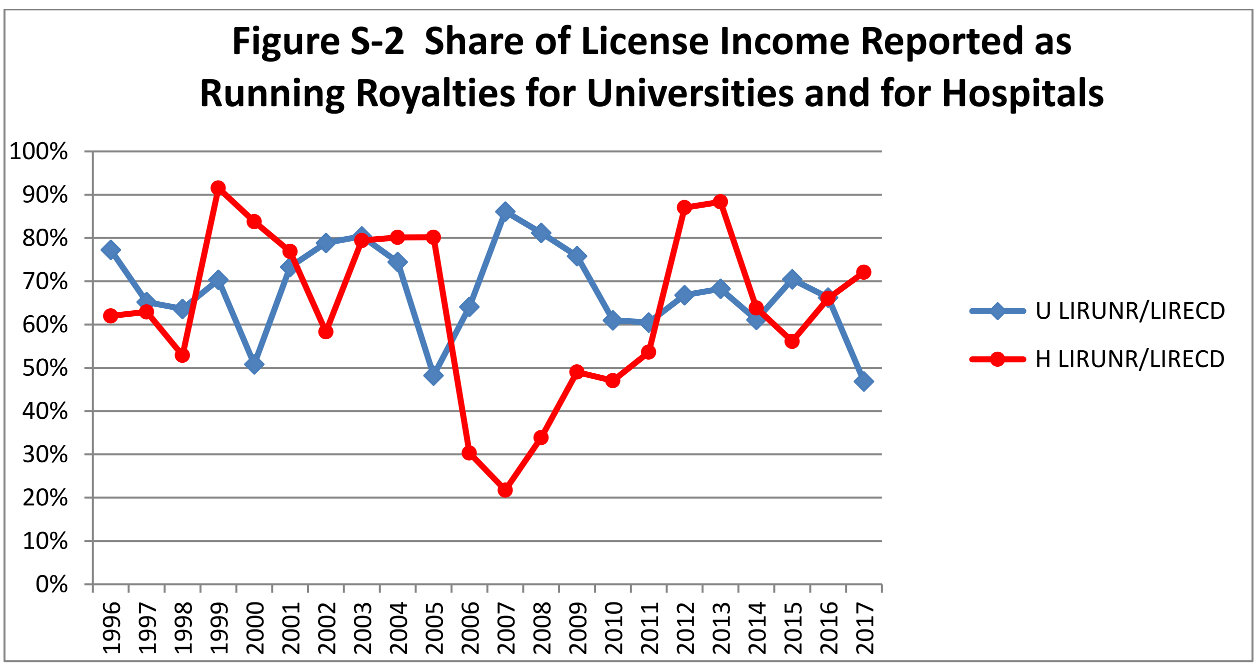


Figure S-2 Data from ATUM STATT and Appendix B of the Report



.

Figure S-3: Data are in Table S-8

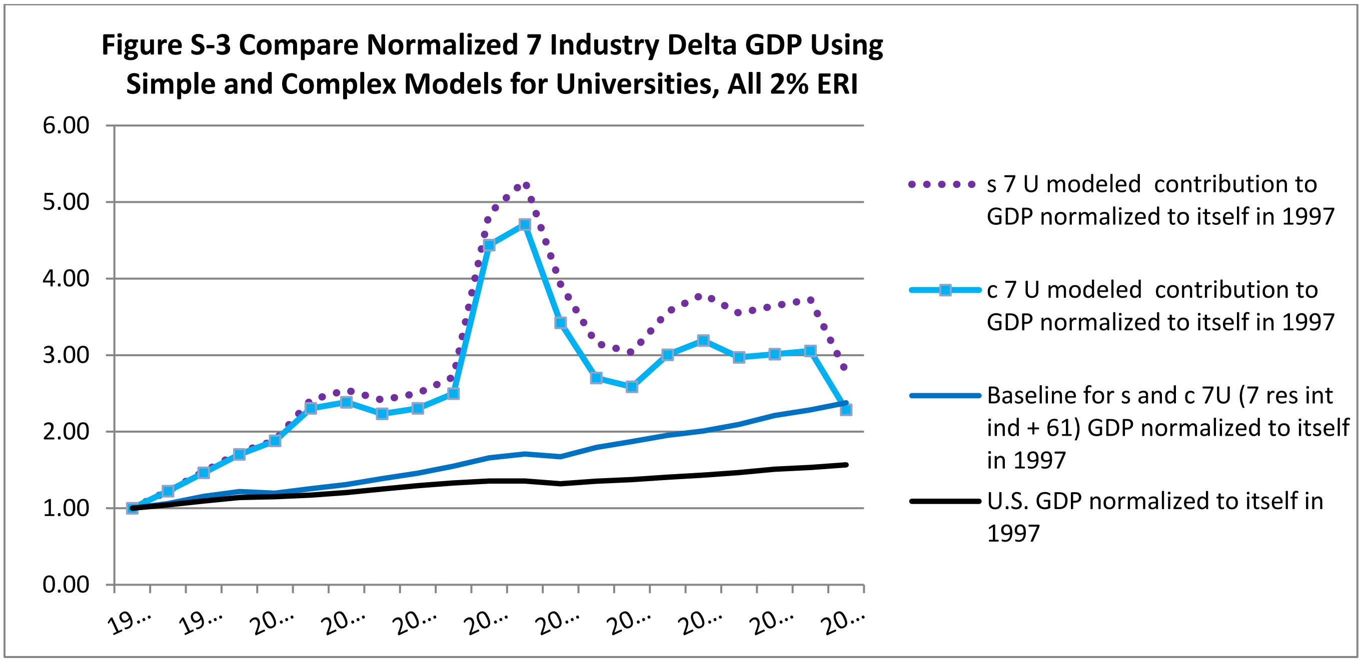
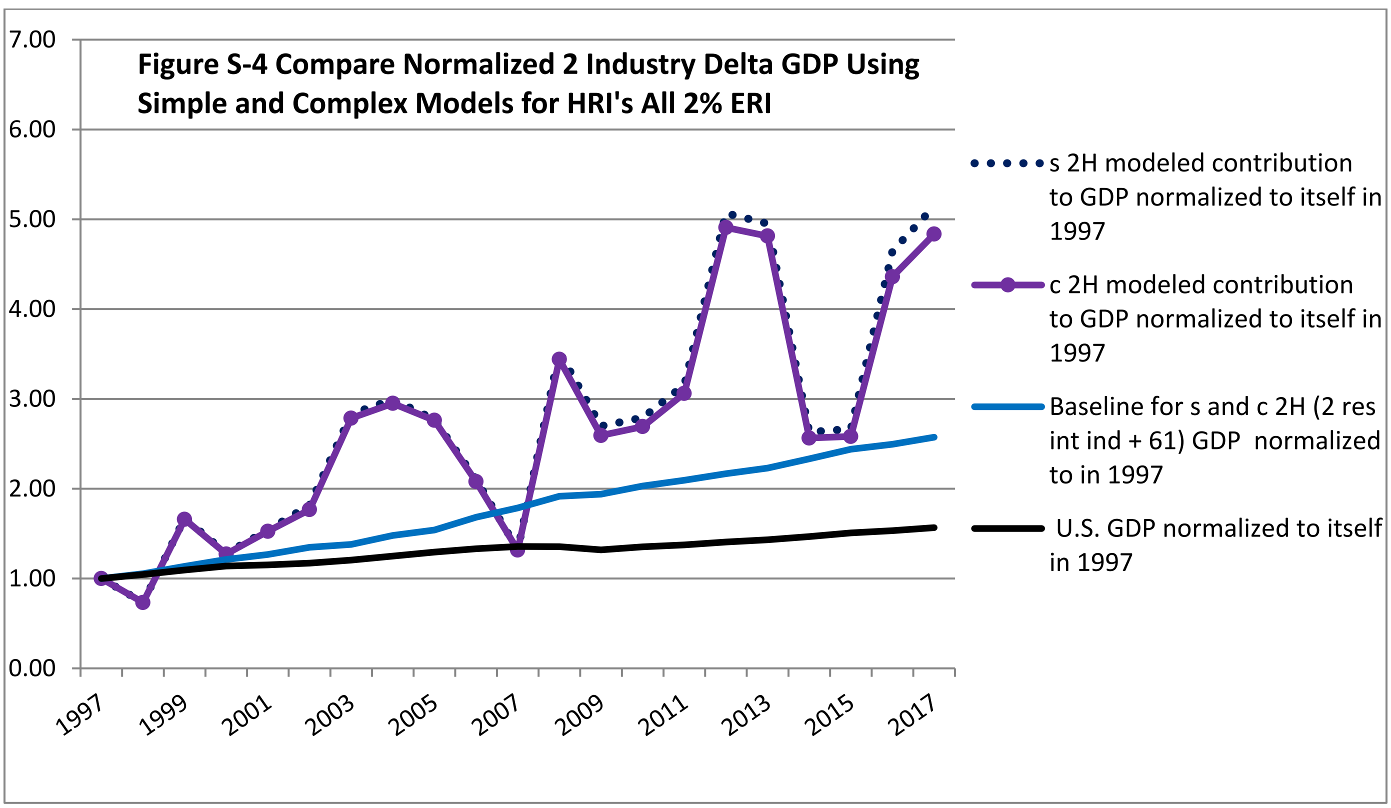


Figure S-4: Data Are in Table S-9



Glossary: Definitions and Abbreviations

•Defined terms and abbreviations in this report

Complex model: The model assumes that some sales are final sales. The proportion is determined by BEA data on patterns of final sales in the industries used in the model. The model also assumes that some production of earned royalty generating licensed products occurs outside the United States.

ERI: Earned Royalty Income. Income characterized as Running Royalties in the AUTM Survey.

Hospitals, capitalized: Hospitals and Research Institutes.

HRI: Hospitals and Research Institutes.

Simple model: The model assumes that (i) no sales are final sales, (ii) all production is domestic, and (iii) all intermediate inputs are domestic.

•Selected definitions from the FY1996 and FY1997 AUTM Survey and field names in STATT

Life science: All works derived from such disciplines as biology, medicine, chemistry (basic), pharmacy, medical devices, and those involving human physiology and psychology, including discipline-related inventive subject matter such as software and educational material.

LIRECD: The abbreviation in STATT for License Income Received (defined below)

LIRUNR: The abbreviation used in STATT for Running Royalties (defined below), or License Income Received which has been further characterized as Running Royalties.

Physical science: All works derived from such disciplines as engineering, software, and business systems.

STATT: The short name for AUTM's Statistics Access for Technology Transfer database.

•Selected definitions excerpted verbatim from the AUTM 2017 Survey: http://www.autmsurvey.org/id_2017.pdf

CASHED-IN EQUITY: This includes the amount received from cashing in equity holdings, resulting in a cash transfer to the institution. The amount reported should be reduced by the cost basis, if any, at which the equity was acquired. Excluded from this amount is any type of analysis or process whereby a value for the equity holdings is determined but a cash transaction does not take place through the sale of these holdings. An internal sale (e.g., to the endowment) will constitute cashing in if the transaction results in cash being made available for internal distribution. (See Question 11B2.)

DATA ACCESS AGREEMENTS: A dataset associated with an invention disclosure, and made commercially available through an "access agreement," may be counted as a license or option. In addition, the revenue derived from that agreement may be counted as license income received. (See Questions 9A1, 9A1, 11B with sub-parts.)

LICENSE INCOME PAID TO OTHER INSTITUTIONS: The amount paid to other institutions under inter-institutional agreements. (See Question 11C.) The Survey subtracts it from the TOTAL LICENSE INCOME of your institution to avoid double counting LICENSE INCOME when the receiving institution reports it to the Survey.

LICENSE INCOME RECEIVED: Includes: license issue fees, payments under options, annual minimums, Running Royalties, termination payments, the amount of equity received when cashed-in, and software and biological material end-user license fees equal to $1,000 or more, but not research funding, patent expense reimbursement, a valuation of equity not cashed-in, software and biological material end-user license fees less than $1,000, or trademark licensing royalties from university insignia. License Income also does not include income received in support of the cost to make and transfer materials under Material Transfer Agreements. (See Questions 11B.)

LICENSES/OPTIONS: Count the number of LICENSE or OPTION AGREEMENTS that were executed in the year indicated for all technologies. Each agreement, exclusive or non-exclusive, should be counted separately. Licenses to software or biological material end-users of $1,000 or more may be counted per license, or as 1 license, or 1/each for each major software or biological material product (at manager's discretion) if the total number of end-user licenses would unreasonably skew the institution's data. Licenses for technology protected under U.S. plant patents (U.S. PP) or plant variety protection certificates (U.S. PVPC) may be counted in a similar manner to software or biological material products as described above, at manager's discretion. Material Transfer Agreements are not to be counted as Licenses/Options in this Survey. (See Questions 9 and 11.)

LICENSE/OPTION AGREEMENTS: A LICENSE AGREEMENT formalizes the transfer of TECHNOLOGY between two parties, where the owner of the TECHNOLOGY (licensor) permits the other party (licensee) to share the rights to use the TECHNOLOGY. An OPTION AGREEMENT grants the potential licensee a time period during which it may evaluate the technology and negotiate the terms of a license agreement. An OPTION AGREEMENT is not constituted by an Option clause in a research agreement that grants rights to future inventions, until an actual invention has occurred that is subject to that Option. (See Questions 9 and 11.)

RUNNING ROYALTIES: For the purposes of this Survey, RUNNING ROYALTIES are defined as royalties earned on and tied to the sale of products. Excluded from this number are license issue fees, payments under options, termination payments, and the amount of annual minimums not supported by sales. Also excluded from this amount is CASHED-IN EQUITY, which should be reported separately. (See Question 11B1.)

•Selected definitions from the Science and Engineering Indicators

These excerpts are provided as a convenience. The 2018 Science and Engineering Indicators can be found here: https://www.nsf.gov/statistics/2018/nsb20181/report/sections/research-and-development-u-s-trends-and-international-comparisons/glossary

R&D: Research and experimental development comprise creative and systematic work undertaken in order to increase the stock of knowledge — including knowledge of humankind, culture, and society — and its use to devise new applications of available knowledge.

> **Basic research:** Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.
>
> **Applied research:** Original investigation undertaken in order to acquire new knowledge; directed primarily, however, toward a specific, practical aim or objective.
>
> **Experimental development:** Systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes (OECD 2015).

Selected Bibliography

Cleary, Ekaterina Galkina, Jennifer M. Beierlein, Navleen Surjit Khanuja, Laura M. McNamee, and Fred D. Ledley. 2018. "Contribution of NIH Funding to New Drug Approvals 2010–2016," *PNAS* 115, no.10 (March 6): 2329–2334. http://www.pnas.org/content/115/10/2329.

Crawford, Marissa J., Jennifer Lee, John E. Jankowski, and Francisco A. Moris. 2014. "Measuring R&D in the National Accounting System," *Survey of Current Business* (November): 1-15. https://apps.bea.gov/scb/pdf/2014/11%20November/1114_measuring_r&d_in_the_national_economic_accounting_system.pdf.

DiMasi, Joseph A., Henry G. Grabowski, and Ronald W. Hansen. 2016. "Innovation in the Pharmaceutical Industry: New Estimates of R&D costs," *Journal of Health Economics* 47 (February 12): 20–33.

Ditzel, Roger G., 1991. "Public Law 96-517 and Risk Capital: The Laboratory-Market Connection," *Journal of the Association of University Technology Managers,* Volume 3 (September): 1–21.

Fraumeni, Barbara M., and Sumiye Okubo. 2005. "R&D in the National Income and Product Accounts: A First Look at Its Effect on GDP," in *Measuring Capital in the New Economy*, National Bureau of Economic Research, Studies in Income and Wealth, V. 65, edited by Carol Corrado, John Haltiwanger, and Daniel Sichel, 275–322. Chicago: University of Chicago Press.

Kramer, Peter B., Sandy Scheibe, Donyale Reavis, and Louis Berneman. 1997. "Induced Investments and Jobs Produced by Exclusive Patent Licenses: A Confirmatory Study," *Journal of the Association of University Technology Managers,* Volume IX: 79–97.

Li, Wendy C. Y., and Bronwyn Hall. 2018. "Depreciation of Business R&D Capital," *Review of Income and Wealth,* DOI: 10.1111/roiw.12380, https://onlinelibrary.wiley.com/doi/10.1111/roiw.12380.

OECD. 2015. *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*. Paris: OECD Publishing.

Paul, Steven M., Daniel S. Mytelka, Christopher T. Dunwiddie, Charles C. Persinger, Bernard H. Munos, Stacy R. Lindborg, and Aaron L. Schacht. 2010. "How to Improve R&D Productivity: The Pharmaceutical Industry's Grand Challenge," *Nature Reviews Drug Discovery* 9 (March): 203–214.

Pressman, Lori, Sonia K. Gutterman, Irene Abrams, David E. Geist, and Lita Nelsen. 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,* Volume VII: 49–82.

Pressman, Lori, and Don Kaiser. 2000. "Measuring Product Development Outcomes of Patent Licensing at M.I.T.," AAAS Annual Meeting (February 7), Washington, D.C.

Pressman, Lori. 2012. "DNA Patent Licensing Under Two Policy Frameworks: Implications for Patient Access to Clinical Diagnostic Genomic Tests and Licensing Practice in the Not-For-Profit Sector," *Life Sciences Law & Industry Report* (March): https://www.uspto.gov/sites/default/files/aia_implementation/gene-comment-pressman.pdf.

Pressman, Lori, Mark Planting, Robert Yuskavage, Sumiye Okubo, Carol Moylan, and Jennifer Bond. 2017. "The Economic Contribution of University/Nonprofit Inventions in the United States 1996–2015," June, Report for BIO and AUTM: https://www.autm.net/AUTMMain/media/Advocacy/Documents/June-2017-Update-of-I-O-Economic-Impact-Model.pdf.

Robbins, Carol A., and Carol E. Moylan. 2007. "Research and Development Satellite Account Update: Estimates for 1959–2004, New Estimates for Industry, Regional, and International Accounts," *Survey of Current Business* 87 (October): 49–92.

Robbins, Carol A. 2009 "Measuring Payments for the Supply and Use of Intellectual Property," in *International Trade in Services and Intangibles in the Era of Globalization*, edited by Marshall Reinsdorf and Matthew J. Slaughter, 139–171. Chicago: University of Chicago Press. https://www.nber.org/chapters/c11608.

Roessner, David, Jennifer Bond, Sumiye Okubo, and Mark Planting. 2013. "The Economic Impact of Licensed Commercialized Inventions Originating in University Research," *Research Policy* 42(1): 23–34.

Scherer, F.M., and Dietmar Harhoff. 2000. "Technology Policy for a World of Skew-Distributed Outcomes," *Research Policy* 29: 559–566.

United Nations. 1947. *Measurement of National Income and the Construction of Social Accounts*, Geneva: United Nations.

United Nations. 1953. *A System of National Accounts and Supporting Tables*. New York: United Nations.

United Nations. 1968. *System of National Accounts, Revision.* New York: United Nations.

United Nations. 2009. *System of National Accounts 2008*. New York: United Nations, ST/ESA/STAT/SER.F/2/Rev.5.

Biotechnology Innovation Organization

1201 Maryland Avenue, SW, Suite 900
Washington, DC 20024
+1-202-962-9200
info@bio.org

autm
Transforming Ideas into Opportunities

One Parkview Plaza, Suite 800
Oakbrook Terrace, IL 60181
+1.847.686.2244
info@autm.net